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THE IDENTIFICATION AND RECALL OF RAPIDLY DISPLAYED LETTERS AND DIGITS

by

ADAM REEVES

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Pscyhology, The City University of New York.

1977

APPROVAL PAGE

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor in Psychology.

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ABSTRACT

This thesis is a study of how Subjects (Ss) process two streams of visual information, that arrive in two distinct locations, when the task requires them to "shift attention" between the streams. "Attention," in quotes, here denotes a nontechnical usage, as an instruction to S or as an introspective report. Unquoted, attention shift will denote a change in the allocation of processing capacity from one stream to the other that can be inferred from objectively measured responses.

A stream of randomly chosen letters was presented in a location one degree left of fixation, with each letter on top of the last one; and a stream of randomly chosen digits was presented similarly in a second location one degree right of fixation. The stimulus onset asynchrony (SOA) was 214 msec for the letters, and was varied over trial blocks from 75 to 214 msec for the digits. S monitored the letter stream for the occurrence of one of three possible 'critical characters' (CCs), which were the letters C and U, and an outline square. On detection of a CC, S released a RT key, "shifted attention" to the digits, and noted for subsequent report the first digit in the

digit stream that he could identify.

The two measures taken on every trial were RT, the time from CC onset to release of the key, and T, the time from CC onset to the onset of the noted digit. Results for RT and T were: (1) The noted digits were almost always later in time than the CC, so that T was positive, and mean T ranged from 250 to 550 msec in different conditions. (2) Mean RT and mean T both increased proportionately with the difficulty of detecting the CC. (3) Mean RT was almost independent of digit SOA, but mean T decreased as digit SOA increased. (4) Within every condition of digit SOA and CC, RT and T covaried slightly. (5) Even after extensive practice and full feedback, Ss were very inaccurate in estimation the position of the noted digit in the digit stream. (6) In an additional task, Ss reported the noted digit and also attempted to report the next three digits. At the faster SOAs, the order of the four response digits was almost random with respect to the presentation order.

Result (1) suggests that Ss were truly unable to process both letter and digit streams at once, but rather had to change the allocation of processing capacity (shift attention) from one stream to the other. Results (2) and (3) suggest that both mean RT and mean T depend on the detection latencies of the CCs, but that only mean T depends on the processing times of the digits. Result

(4) suggests that the detection latency of the CC contributes a small amount of common variance to RT and T. Results (5) and (6) both suggest that S's perception of the presentation order of the digits is very poor. This is explained by the mechanism of coding order information in short-term visual memory (STVM), not by forgetting from verbal memory. (Introspection suggests that the order is lost early in the visual processing: Ss reported seeing the digits out of order.) A model for this STVM was successfully tested, in which digits are assumed to enter the STVM in an order determined, primarily by the amount of attention that they receive, and only secondarily by their presentation order. This model of order supports a model of latency in which it is assumed that mean T, like mean RT, can be used to measure CC detection latencies. If Ss had tried to 'improve upon', and thus bias, their digit noting responses by using their memory for the digit sequence, then they could have increased the variance of T, but could not have changed mean T, on the assumption of no memory for presentation order. The latency model assumed that T and RT measure the same early detection stage, but different later stages, of CC processing.

In conclusion, attention shifts between streams of stimuli can be used to measure stimulus processing times. In conditions of rapid sequential presentation, attention shifts determine the order in which stimuli are seen to a greater extent than does presentation order.

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Tables and Figures are presented in Appendix 4.

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No Tables or Figures are given in the text.

CHAPTER I

INTRODUCTION

1. Overview of the Thesis

The time taken to detect a visually presented alphanumeric character was studied by a new method; the 'modified complication'. This method is based upon the traditional complication experiment of Wundt (1874), which was also used to measure sensory detection latencies. The purpose of the Introduction to the Thesis is to provide a general rationale for the use of the complication to measure latency; to explain the problems of the traditional complication and the methods used in the modified complication to overcome them; and to motivate the present experimental work, in which the modified complication procedure was extended to include a motor reaction time, in order to provide two distinct methods of measuring detection latency at the same time. The Procedure and Results chapters give the details and the results of this experimentation. The Discussion chapter has two purposes: to develop a model for latency that incorporates the findings from both the motor reaction times and an "attentional reaction time" derived from the modified complication; and to offer a

model of S's short-term visual memory for the stimuli on which the attentional reaction time is assumed to be based.

2. Rational for the Research

a. Summary of purpose

In many situations the environment provides two or more distinct sources of information to a human observer. If the observer is unable to process all the sources at once, he may allocate his capacity between them, processing first one and then the other. The transfer of processing capacity between sources will be termed a change in the direction of attention. For example, a listener in a cocktain party may pay attention first to one conversation, and then to another, if he cannot process both conversations simultaneously (Cherry, 1953).

In this research I asked two questions about the observer's ability to direct attention from one source of visual input to another. First: how long does it take? Second: how does the re-direction of attention affect visual processing? The answers allow one to choose between a switch model and a shift model for directing attention. In the switch model, attention is re-directed instantaneously. This is analogous to a telephone line, which can be immediately switched from one input line to another, without reduction in the transmission capability of the telephone. In the shift model, attention is slowly shifted

between the two sources, and processing efficiency is reduced during the shift. This is analogous to a slow movement of a mechanical selector between two telephone lines, in which intervening positions of the selector produce noise.

Clearly, an 'instantaneous' switch on one time scale might look like a slow shift on another time scale. One relevant time scale is provided by the unit of time necessary for the detection of the stimuli presented by the various sources. An attentional shift that took considerably less time than the stimulus detection time would, on this scale, be indistinguishable from a switch. For example, suppose that attention takes zero to 50 msec to re-direct, as deemed typical by Kristofferson (1967). This might be termed a shift between sources of pulsed light, where lights 30 msec or so apart can be discriminated, but a switch between sources of speech with individual words .1 sec or more apart (as in Ladefoged and Broadbent, 1960). In the visual tasks used in the present research, alphanumeric characters were used as stimuli, and two nearly adjacent spatial locations on a display oscilloscope acted as two independent sources of visual input. The results of the experiments to be described support a shift model, in which the alphanumerics could be detected much faster than attention could be shifted.

In order to measure the times taken to detect stimuli and to shift attention, a 'modified complication

experiment' was used. In this method, the subject observes the two sources of visual input, and is instructed to monitor a stream of stimuli that issues from one of them, until he detects a 'critical character' (CC). As soon as he detects a CC, he (a) generates a motor reaction time (RT) by lifting his finger; and (b) "shifts attention" to the second source of visual input. The second source issues a stream of 'comparison stimuli', and S's task is to take note of the first comparison stimulus that he can for subsequent report. The attentional reaction time (T) is defined objectively as the time from the temporal onset of the CC to the onset of the noted comparison stimulus (the 'noted stimulus'). (Other slightly different ways of objectively defining T will also be used). In analyzing motor and attentional reaction times, it is assumed that both represent the time at which a discrete all-or-none process is triggered by a continuously varying process. In the case of the RT, the continuous process is a finger movement, and the triggered process is a switch closure. In the case of T, the continuous process is a shift of attention, and the triggered process is the identification of the noted stimulus. (Since identification may be a more complex process, this analogy between RT and T is imperfect, as will be discussed later).

Given the assumptions presented in the Introduction (section 3), RT and T may be used to measure the time

necessary to detect the CC, and the time taken to shift attention. In the next few sections, the measurement of CC detection time by T will be detailed. The separation of CC detection time and attention shifting time will be discussed further in section 2 of the Discussion. The second main question in this research, the effect of shifting attention on the processing of the stimuli in the second stream (the 'comparison' stimuli) will be taken up in section 3e of the Introduction and in section 3 of the Duscussion.

In what follows, the convention will be maintained that "attention" (in quotes) refers to non-technical uses such as instructions to S and introspective reports. Unquoted, attention shift will refer to a change in the allocation of processing from one stream to the other, that can be inferred from objective measurements of the attentional reaction time, T.

b. The attentional reaction time

The prototype of the attentional reaction time (T) is a latency measure derived from the distribution of simultaneity judgements (SJs) in the traditional complication (Wundt, 1874). In the traditional experiment, S is presented with two streams of input stimuli, not necessarily in the same sense modality. One stream contains the CC, and the other contains comparison stimuli. S's task is judge which of the comparison stimuli is simultaneous with

the CC. The latency for detection of the CC, L_C, is estimated from the onset of the mean comparison stimulus judged to be simultaneous, minus the onset time of the CC.

This traditional measure of latency, derived from the mean of the SJs, suffers from several problems outlined below in section 3. The relevant problem is that "attention," in the Wundtian sense of something discoverable by introspection, may shift between the stream containing the CC and the streams of comparison stimuli. Such "attentional shifts" may strongly bias the distributions of SJs. Indeed, it was the study of such effects of "attention" that led Titchener to formulate his 'Law of Prior Entry': "The stimulus for which we are prepared requires less time than a like stimulus, for which we are unprepared, to produce its full conscious effect" (Titchener, 1908). (Prior entry effects were also found (by Stone, 1926, for example) in the distribution of temporal order judgements (TOJs), as discussed in section 1.3d of Chapter 4.)

In the modified complication, the same method of presentation of the two streams of input stimuli is used. However, the task is changed, so that S no longer performs a simultaneity judgement. Rather, after detection of the CC, S "shifts attention" to the comparison stimuli and takes note of the first stimulus that he can identify. The distribution of the noted stimuli is then used in estimating latency. In the modified procedure, S is

instructed to pay "full attention" first to one stream and then to the other. What S does under such instructions, will be considered later (Discussion, section 1).

c. The subtraction method

Neither the attentional nor the motor reaction times can be used to estimate the detection latency, but only differences in latencies, because T and RT are assumed to result from several processes, of which the process of interest, the detection of the CC, is just one. Let the latency of this process be denoted L_c. In Donders' subtraction method, the mean observed reaction time for a task which is assumed not to include L_c is subtracted from the mean reaction time for a task which does include L_c. This difference is assumed to be an exact measure of L_c.

Since it is often not possible to find two such tasks, Sternberg (1969a) has introduced a weaker assumption of 'selective influence'. This assumption is that the change of tasks changes the latency of just the process of interest. The application of this idea to the present research is as follows. Consider two CCs, c and c', which are assumed to have different detection latencies L_c and $L_{c'}$. It is assumed further that the measured reaction time when Cc=c, $T_{c'}$, is the sum of L_c and some residual latency T_o. (For example, T_o might be, in the modified complication, the time to "shift attention"). Then

$$T_C = L_C + T_O$$

where L_O and T_O are assumed to be independently distributed random variables that take on just one value each on each trial. It follows from the assumption of additivity that

$$E(T_C) = E(L_C + T_O) = E(L_C) + E(T_O)$$

where E denotes expectation. It folows by subtraction that

$$E(L_C) - E(L_{C'}) = E(T_C) - E(T_{C'});$$

that is, the difference in reaction times equals the difference between the latencies of interest. Further, this subtraction idea applies to higher cumulants of the distributors, such as variances (see Discussion section 2), under the assumption of independence.

To justify the use of the subtraction method in the modified complication method, we define two stages of processing: 'detection' and 'post-detection'. By detection is meant all those processes that lead up to detection of the CC, the combined latency of which is denoted L_C. By post-detection is meant all those processes subsequent to detection that influence the observed reaction times. In the ideal case it can be assumed that post-detection processing, including memory for prior stimuli, is equivalent for any two different CCs that are being compared, and that the only variations in processing that influence the

observed reaction times are due to differing detection times of the CCs. Variations in post-detection processing between CCs could distort estimates of latency that were derived from S's responses under the assumption of the ideal case. Therefore, in order to better estimate the detection latency L_C of various CCs, the present research tested several methods of controlling, measuring, and eliminating the potential variations of post-detection processing that might influence the observed reaction times. The purpose of Part 1 of the Discussion will be to evaluate the success of these methods in meeting these requirements.

d. Analysis of the data in these experiments

The data obtained are the observed proportions of events, conditioned on the CC (conditional proportions), which are used to estimate conditional probabilities. The events of interest are the following: when the critical character is c, the event is denoted CC=c; when the time from CC onset to the motor response is less than or equal to t msec, the event is denoted RT $\leq$ t; and when S notes that the first comparison stimulus (digit) that he could identify after the "attention shift" was i, the event is denoted NP=i. Here, and subsequently, i refers to the position of the digit in the digit stream, not the actual digit name, so 'NP' means noted position).

The conditioned proportions (the data) are then as follows:

$$P(RT \leq t \mid CC=c)$$

$$P(NP=i \mid CC=c)$$

Let t_c denote the presentation time of the CC, and let t_i denote the presentation time of the comparison stimulus in the i^{th} position of the stream of compsrison stimili. In analyzing the data for the NP, it is assumed that the NP depends not on the actual presentation time of the CC, but on the difference in presentation times $t_i - t_c$. That is, the data of interest are now the proportion of trials in which NP=i, conditioned on the choice of CC and on the presentation time difference. Let $f_c(t)$ denote this proportion. Then,

$$f_c(t) = P(NP=i \mid CC=c \ \& \ t_i - t_c = t)$$

from which the cumulated proportions $F_c(t)$ may be found:

$$F_c(t) = P(NP=i \mid CC=c \ \& \ t_i - t_c = t)$$

The statistics used to describe $F_c(t)$ in the Results will be the mean and standard deviation (s.d.). The skews of the distributions that were obtained were so small, that the means and medians did not differ appreciably; and this was also the case for the RT distributions. For cases in which $F_c(t)$ is normally distributed, the mean and median are equal, and measure the so-called 'point of subjective simultaneity', or PSS (Sternberg,

1972), of the usual temporal order judgement (TOJ) experiment. In these cases, the s.d. of F_c (t) is equal of 1.47 times the difference limen, or DL which is the inter-quartile range of F_c (t). (In section 2 of the Dicsuccion F_c (t), is found to be quite well fit by a normal distribution, and so the means and standard deviations may be converted to PSSs and DLs for an approximate comparison with other studies.)

To simply notation, and because trials with different values of t_c will be averaged together, presentation times will be defined such that $t_c = 0$ on every trial. Thus, $t_i - t_c$ will equal t_i. Since the comparison stimuli (digits) are presented with fixed stimulus onset asynchronies (SOAs) in every trial, we have

$$t_i = d.i$$

where d is the SOA of the digits.

CHAPTER II

METHOD

1. General Method

1. The Choice of Stimuli

Stimuli were chosen that were distinct and easily identifiable by S. Letters, digits, and two other characters, an outline square and an arrow, were chosen as fulfilling these criteria. CCs were chosen that could be assumed to be of increasing difficulty of detection; these were the arrow (designated A), the outline square (designated S), the letter C (designated C) and the letter U (designated U). CCs of greater difficulty were assumed to take longer to process, so that the obtained L_Cs would be ordered similarly.

2. The Presentation of the CC

The CC was presented in a stream of 'noise' stimuli, which were other letters. The noise stimuli were presented fast enough so that (a) S had to pay full attention to them to detect the CC, and (b) implicit naming was prevented. They were presented slowly enough so that, given full attention, the CCs were virtually always detected correctly.

The actual presentation rates were chosen for each S on the basis of pilot work with that S. In order to ensure that Ss did not develop a set for a particular CC, or t_c, the CC was chosen at random on each trial, and presented at a random point in the noise stream (excluding the beginning and end of the stream).

3. Stream Separation

The comparison stimuli were presented in a location about two deg to the right of the noise stimuli. The separation into letters and digits was motivated by the need to use distinctly identifiable categories of stimuli. It had to be clear that S's responses belonged to the correct stream of stimuli. However, it is not clear whether the use of both a two deg lateral separation and a category separation to define the two input streams is necessary in order to satisfy the assumptions of the method.

The presentation of the two streams of stimuli in two distinct spatial locations resembles the presentation of one stream to one sensory modality and the other to another modality, in the classical complication experiment, and the presentation of the two streams to the two different ears in Cherry's (1953) experiment. The two deg separation is sufficient to eliminate lateral interactions (Flom, Weymouth, & Kahneman, 1962), but small enough to make eye movements between the streams unnecessary. A pilot study of eye movements showed that subject AR did not move his eyes

by more than .5° until one second or more after the CC was presented. (The .5° limit was imposed by the noise level in the AC-coupled Dynograph amplification of the ERG used to measure the eye movement.) Thus eye movements that did occur were outside the temporal range studied in this research.

4. The Presentation of the Comparison Stimuli

Comparison stimuli were the ten digits, repeated as necessary to make a sequence longer than ten according to a method described in the Procedure section. This method ensured that at least six different digits occurred before any digit was repeated. The ten digits which began simultaneously with the CC (or just before it in some conditions)* comprised the 'critical set'. It was from the critical set of digit positions that S's responses were expected to come. The digits in the critical set were chosen to be all different, in the attempt to ensure that S's reports of digits from that set could have their positions in the digit stream assigned unambiguously.

The assumptions that the digits were distinctly seen, that set and attention were controlled, and that implicit naming was impossible, were met by selection of

---

*Placement of the critical set was based in pilot work according to criteria discussed in the Procedure.

presentation rates. Since a variety of different digit rates to be used in order to find those rates which satisfied these lower and upper bounds on the permissable digit rates were sought. The presentation rate is expressed as d msec, where d is the stimulus onset asynchony (SOA), and the rate in Hertz is 1000/d. The lower limit for the resolution of successive digits was found to be roughly 50 msec. The upper limit was set at 250 msec to avoid implicit naming; and also to avoid the problem that if the SOA is too long, the same digit position will be given as the response regardless of the L_c, because variations in L_c will be less than half the digit SOA. The actual SOAs chosen were approximate multiples of 36 msec, except that 36 msec itself was not used.

5. The S's task

The noting response is defined for the S as follows. S monitors the stream of letters until he identifies the CC. He then "shifts attention", and notes the first digit he can. In addition to this task, which is the essence of the modified complication, there were two additional tasks. In Recall 1, S also estimated the true position of the noted digit in the digit stream. In Recall 4, S identified the next three digits that followed the noted digit, and then reported all four digits. Thus, Recall 1 provides a test of S's knowledge of position in a way that generates minimal strain on memory. Recall 4 provides more

information about the temporal structure of the buffer memory, at the cost of requiring more retention: S has to retain 4 digits until he can name and report them at the end of the trial. Both tasks provide a measure of order memory, and thus can be used to test Assumption 14. Indeed, the results from two two tasks should convary strongly, since if S has better order information (in Recall 4), he should be able to use it to better estimate the objective position of the digit he notes as first (in Recall 1). The two tasks also provide a check that output interference and retention problems do not occur in Recall 4, as assumed, since in this case the distribution of the first response of Recall 4 should be the same as the distribution of the only response in Recall 1.

2. Experimental Procedure

Subjects

Ss were 3 graduate students, unpaid but well motivated. AR was highly practiced in this type of experiment, GL was experienced in similar experiments, and AK was naive. Ss' vision was normal (GL) or corrected to normal by spectacles (AR and AK). Ss were tested in sessions of between 1 and 1½ hours on different days. They were given about 10 hours of practice, followed by 40 hours of experimental trials for AR and GL and 30 hours for AK.

Apparatus

Alphanumeric stimuli were presented binocularly on the graphics display unit of a Digital Equipment Corporation PDP/15 computer. A teletype and RT key were interfaced with the computer to collect responses. The display unit provided a high quality image that appeared to be spatially continuous at the viewing distance of .68m. Phosphor decay time was less than 1 msec.

Stimuli

Characters comprised letters, digits, an outline square and a right-pointing arrow. The characters were 1° 27' high, except for the arrow, and between 6' and 1° 51' wide. Stroke width was varied from 2' to 6', and various serifs were added, in order to improve the discriminability of the characters. The arrow, square, letter C, and letter U are illustrated in Fig. 27. Characters were presented for 3.2 msec. The stimulus onset asynchrony (SOA) was varied by varying the duration of the inter-stimulus interval. Characters were quite bright: their "total luminous energy" varied from 1.92 cd-microsec (for the letter I) to 3.33 cd-microsec (for the letter W.) Room illuminance was about .93 meter-candles for AR and about .46 meter-candles for GL and AK. Further details of apparatus and stimuli are given in Appendix 1.

Presentation

On each trial S received a test sequence, responded, and was given feedback. The test sequence comprised two streams of alphanumeric characters, presented in two adjacent locations on the screen of the display unit. The stream of letters was presented in the left-hand location, and the stream of digits in the right-hand location, with a centre-to-centre separation of 1° 52' (2¼ cms) (Fig. 25).

The stream of 24 letters was a permutation of the alphabet excluding C and U, chosen at random on each trial. The position of the critical character (CC) in the letter stream was one of the positions 8 through 19 chosen at random on each trial with probability $\frac{1}{12}$. The CC was one of the following characters: the letter C, the letter U, or the outline square, here designated C, U, and S. The CC was chosen at random on each trial with probability $\frac{1}{3}$. In the Arrow condition, the stream of letters was switched off, so that S only saw a stream of digits. The CC, which was the arrow (designated A) on every trial, was presented in the same spatial location and in the same set of positions in the stream as described above for the C, U, and S condition.

The digit stream contained the digits 0 through 9, chosen by selecting digits at random on each trial with the restrictions that at least 6 different digits must occur between any particualr digit and its next appearance in the

digit stream, and that the 10 digits in the 'critical set' must be all different. The 'critical set' is defined as the set of 10 consecutive positions in the digit stream that begins at position 0 in conditions with a fast digit SOA (75, 109, and 144 msec), and at position -1 in conditions with a slow digit SOA (178 and 214 msec). The convention for indexing positions in the digit stream is that position 0 is the position of the digit presented simultaneously with the CC, and position -1 is the position of the digit presented before the CC. Figure 26 illustrates the indexing of digit positions and the locations of the critical sets for conditions of both fast (75 msec) and slow (214 msec) SOAs.

Presentation rates were chosen as follows. During practice, the letter SOA was decreased until S made occasional errors in identifying the CC; this letter SOA was then used without change during the experimental trials. The letter SOAs chosen were 214 msec for AR and for GL, and 270 msec for AK. The digit SOA chosen for initial practice was 324 msec. After the first practice session, Ss were given practice with each of the digit SOAs used in the experiment. These digit SOAs were approximate mulitplies of 36 msec. Digit SOAa varied by $\pm$ 3 msed during test sequences because of programming considerations. The digit SOAs, averaged over the slight variations, were 75, 109, 144, and 214 msec for AR and GL, and 109, 144 and 178 msec for AK. Exact values for the letter and digit

SOAs are given in Appendix 1. The onset time of the first digit presented was adjusted so that the CC would always be presented simultaneously with a digit (the first or second digit in the critical set, depending upon digit SOA). The SOAs were such that a letter was presented simultaneously with every n^{th} digit, where n was 3, 2, 3, and 1 for digit SOAa of 75, 109, 144, and 214 msec in AR and GL, and n was 5, 15 and 3 for digit SOAs of 109, 144, and 178 msec in AK.

Trial duration was in the region of 15 secs. The test sequence took between 2.8 and 8.4 secs, averaging 4.3 secs for AR and GL and 5.1 secs for AK. The teletype response that followed the test sequence was made in S's own time. Following the response, feedback was given for 2 secs, and then S initiated the next trial when he was ready. Ss averaged 4 to 5 trials per minute. Ss rested for about 1 minute between blocks of 50 trials.

The exact duration of the test sequence was a function of the RT. The computer terminated the sequence 900 msec after the RT key was lifted. In terms of characters, this means that 6 or more letters, and between 6 and 18 more digits, were presented after the CC.

Task

A 'positive set' of digit positions was defined, from which S's digit responses were expected to come. The positive set was embedded in the critical set. In slow conditions (with digit SOAs of 178 and 214 msec), where the

critical set began at position -1, the positive set was defined as positions -1 through 6. For the fast conditions, where the critical set began at position 0, the positive set was defined as positions 2 through 8 for AR and GL at 109 msec, and as positions 3 through 9 for AR and GL at 75 msec and for AK at 109 msec.

S's task was to monitor the letter stream until he detected the CC. He then:

a. lifted his finger from the RT key as quickly as possible, and

b. noted the first digit in the positive set that he could.

In the Recall 1 condition, S then:

c. estimated the position in the positive set of the noted digit.
(S gave estimate '4' for all positions after position 4.)

In the Recall 4 condition, S then:

d. remembered the next 3 digits and their order in the digit stream.

S waited for the end of the test sequence, and then typed the one digit and its estimate in Recall 1, or the 4 remembered digits in Recall 4, onto the teletype. If a conflict arose between b, the requirement to note the first digit that he could, and c, the requirement to either estimate its position or to remember the next 3 digits, S was told to do as

well as possible with task c but not at the expense of task b. After practice, such conflicts arose very rarely, according to S's introspections.

Feedback

RT feedback

The RT was measured as the interval of time between the onset of the CC and the lift of the RT key. If the RT was less than 170* msec, the message 'EARLY' was displayed as feedback after the test sequence. If the RT was more than 1.8* secs, the message 'Late' was displayed. (In both cases the trial was discarded in data analysis, and S knew this to be the case). No other RT feedback was given. The proportion of 'LATE' and 'EARLY' trials was made small by the manipulation of letter SOA during practice, by a method described below.

Digit feedback

After every trial sequence, the digits that had been presented in the first 6 positions of the 'positive set' of digit positions were displayed in order, from top to bottom of the screen, for 2 secs. Ss were told to use this feedback to improve their responses, by ensuring that all

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*In pilot work it was found that the vast majority of RTs lay well within these bounds. The exact values were chosen partly from programming considerations, and are therefore somewhat arbitrary. It is assumed that 'LATE' and 'EARLY' responses were not triggered by the CC.

their responses were on the screen; that their first response was as early as possible (i.e., as high up the screen as possible); and that their responses were in the same order as the stimuli (in Recall 4), or that the position of their first response had been correctly estimated (in Recall 1). The message 'WRONG' was displayed if S's first response was not in the positive set. Ss were told to avoid 'WRONG' trials, but knew that such trials would be included in the data analysis.

Purpose of the feedback

This feedback was designed so that S should treat both RT and the report of the first digit as subject to the same types of contraint upon performance: that is, that anticipations and late reactions should be avoided. The EARLY and LATE messages punished early and late RTs, respectively. The WRONG message was designed to keep S's responses within the bounds of the positive set and of the critical set. A response in a position outside the positive set but in the critical set would always generate a WRONG message. A response from outside the critical set would be at random with respect to the digits in the critical set, and so generate a digit in the positive set .7 of the time (the positive set has 7 positions, the critical set 10), and a WRONG message .3 of the time.

The 'positive set' was arranged during pilot work to include the positions of the great majority of S's

responses, including all of his earliest responses. Adjustments were made in the locations of the critical sets and the positive sets for conditions of different digit SOAs, in order to be sure that S's responses were correctly reinforced (by the 'WRONG' message), and correctly coded in data analysis. Because there are only ten different digits, it is important that the correct locations for these sets be found. If, for example, S saw a digit that had been presented before the critical set, and he reported that digit, then the position of that digit in the stream would be erroneously coded as the position of the same digit in the critical set (according to the response coding adopted in the Results). Again, if S reported the first digit that he saw, and that digit had been presented before the postiive set, the erroneous coding might on some trials lead to a 'WRONG' message, even though S had been following instructions correctly. These two problems may only be avoided by correctly locating the critical and positive sets.

Design

The experimental factors of recall type, digit SOA, and CC set (C, U, and S, or A), were varied between blocks of 100 trials. In the C, U, and S experiment, the CC was varied within the block. Conditions were run in randomized order, counterbalanced over 16 sessions of 300 trials each for AR and GL, and over 12 sessions of 300 trials each for

AK. The factors were not completely crossed. All digit SOAs were run in Recall 4, but only the two fastest SOAs were run in Recall 1, in the C, U, and S experiment. In A(Arrow), only the two fastest SOAs in Recall 4 were run. Arrow blocks were interspersed among the other blocks during the experiment.

The total number of trials per condition varied slightly over CC because of the random selection of CC. On average, there were 400 trials per condition of CC, SOA, and Recall type for AR and GL, and 300 such trials for AK. There were exactly 400 trials at each SOA in the Arrow experiment (300 for AK), since the Arrow was the only character presented in the Arrow experiment and was therefore not subject to random selection. The exact numbers of trials are presented in the first column of Table 1 for each S, SOA and CC in Recall 4, and in column 6 for each S, SOA and CC in Recall 1.

CHAPTER III

RESULTS

1. Overview

The Results chapter is arranged as follows. The data base (number of trials presented, and number of trials used in analysis) is given in section 2. The data concerning latency are given in section 3. The data on order are given in section 4.

Sections 3 and 4 are broken down as follows. Section 3 first gives the RT data, then the attentional latency (T) data, and finally gives a comparison of the two. The function of each sub-section of section 3 is explained in the overview to that section. Section 4 gives the order data in Recall 1, and then the order data in Recall 4. The Recall 4 order data are given in two parts. The first part considers the mean stimulus in each response position as an order measure. The second part considers measures, such as concordance and Tau, that are based on within-trial measures. These measures are more detailed in nature than those of the first part, but are also more complex, and complete consideration of Tau is delayed until Model 4 is presented in section 3 of the Discussion.

2. Number of trials

Data were obtained for approximately 400 trials per condition of CC and SOA for Ss AR and GL, and 300 trials per condition for AK. In Table 1, columns 1, 2, and 3 give the S, SOA, and CC respectively. The exact number of trials per each combination of S, SOA and CC is given in column 5 of the Table, under the heading 'N'.

Trials were discarded if the RT was less than 170 msec or greater than 1.8 sec. Of the N trials given per condition, the proportion in which the RT fell into either of these two classes is given in Table 1, in the 8^{th} and 9^{th} columns, under the headings 'RT $<$ .17' and 'RT $>$ 1.8' respectively. These proportions are small, and they show no consistent effect of condition. The total of discarded trials, which is the sum of the two RT classes, is 1.6%, when averaged over all conditions and Ss.

The trials included in the data analysis are given in columns 6 and 7 of Table 1, under the headings DATA + and DATA -. The + and - signs refer to those trials in which the first response was in the positive set, and those in which it was in the negative set, respectively. The - trials were those in which the 'WRONG' feedback message was given at the end of the trial. The proportion of - trials shows no clear CC effect, but does decrease slightly as SOA increases. There were rather too may (about 8%) of - trials for AR and GL in the 75 msec A

(Arrow) condition. This is evidence that the position of the positive set was not optimally chosen in these two conditions. The positive set should have been earlier.

The total number of trials used in data analysis, N, is not given directly in Table 1. It may be ontained by multiplying the total number of trials, N, by the sum of the proportions of N given in the DATA + and DATA - columns. For example, in the condition specified in the first row of Table 1 (AR, 75 msec, C), N = N(.948 + .038) = 420(.986) = 414. Notice that in this condition, the number of rejected trials is 420(1-.986) = 6. The number of trials used in data analysis is N for every analysis given in the Results section. Thus the proportions of trials on which the various events of interest occurred, are computed with N in the denominator. The sole exception to this rule was that in computing the SOA effect upon the mean RT, an interaction with the experimental session was obtained which severely biased the estimated SOA effect for AR and AK. Therefore, the data from some sessions were excluded for these two Ss in order to correct for the order-of-session effect and thus properly measure the SOA effect on RT. The details of this procedure are given in section 3 below.

The data so far considered in Table 1 refer to the Recall 4 condition. The right-hand half of the Table, columns 10 through 14, give the same type of data for the

Recall 1 condition. The points made above hold also for the Recall 1 data.

3. Latency Results

1. Overview

The latency results are arranged as follows. The RT data is given in secion 2; the attention shift (T), estimated from the digit recalls, is given in section 3; and both sets of data are given for the Arrow (A) condition in section 4. The RT and T results are compared with each other in section 5.

The main findings are as follows: First, T is nearly always positive, and mean T is always so. This is because Ss nearly always note digits as the first that they can see, which are in fact presented quite well after the CC. This is a fundamental result in favour of the idea that T measures the latency for processing the CC. The second main result is that the CC effects on RT and T were very similar to each other. Moreoever, CC effects were similar over Recall tasks, SOAs, and the different methods of measuring T that were used (these are explained in section 3 below). Third, there is a considerable SOA effect on T, but only a small SOA effect on RT. As SOA increases, RT increases slightly and T decreases sharply. Finally, RT and T are independent on each other, for a given condition of S, SOA, CC, and Recall task. This last findings is

given in section 5; the other findings are given in sections 2, 3, and 4. Other, subsidiary findings are also given in these sections.

2. Reaction Times

a. The RT distributions

There are $\underline{N}$ trials per condition, yielding $\underline{N}$ RTs per condition, once the trials in which RT $<$ 170 msec or RT $>$ 1.8 sec have been excluded. These $\underline{N}$ RTs were grouped into bins of t_o msec in order to compute a distribution P_t for every condition, where

$$P_t = N(t \leqslant RT < t + t_o) \quad / \underline{N} , \quad t = n.t_o, \; n \text{ integer},$$

and the notation N(x) means the number of trials of the $\underline{N}$ analyzed trials in which the event x occurred (this notation will be used again). When t_o was chosen to be 50 msec, the P_t distributions looked unimodal and suprisingly symmetrical. These P_t distributions are given in Table 46, for t_o = 50 msec and t between 150 and 600 msec. Columns are ts and rows are conditions. The symmetry of the P_t distributions suggested that the mean and variance of the RTs would provide a good picture of the RT behaviour. The RT means and variances, computed not from the grouped RT distributions P_t but directly from the RTs themselves, are given in Table 44. The arrangement of this Table conforms to the style of Table 1: that is, the rows are different

conditions, the columns different statistics, and the right-hand half of the table gives the Recall 1 data.

Evidence for the normality of the RT distributions was obtained by the following procedure. A computer program searched for the best-fitting normal distribution, N(M,V) with mean M and variance V, that would generate estimates P'_t of P_t such that

$$P'_t = \int_t^{t+t_o} N(M,V)dt$$

The best fit was obtained by minimizing $\sum(P_t - P'_t)^2$. The results of this procedure, shown in Table 48, were that the set of P_ts could not be statistically discriminated from the set of P'_ts at the 5% level by a Chi^2 test, for 40 out of the 56 conditions tested. The normal distribution therefore provides a good fit to most of the RTs. In this computation, t_o was set to 75 msec instead of 50 msec, in order to be closer to the typical value for 1 standard deviation. The columns headed 'D' in Table 48 give the difference between the mean of the RTs and the mean of the Normal (i.e., M) in each condition. These differences were very small, being 2 msec or less. The normal variances V were, on the other hand, somewhat less than the RT variances in every condition. This is consistent with the RT distributions being slightly skewed. For the purposes of further discussion, however, I will consider only the mean and the variance of the RTs, since the Normal fit is quite reasonable.

b. The session effect on RT

RT distributions were also conditionalized on block number, block being here defined as 25 consecutive trials. Mean RTs correlated strongly with block number (Table 45), showing a downward drift during the experiment. Mean RT over CC is plotted in Figure 21 for sessions of 300 trials, where a storng interaction of rate of drift and digit SOA may be observed in the top panel (AR) and bottom panel (AK). Investigation of these effects showed that AR's mean RT declined sharply after session 20 (Figure 21), while AK's mean RTs declined somewhat less sharply over the first 10 sessions. Due to the counterbalancing adopted, these changes did not have equal effects on the means for each SOA. Therefore RTs were corrected for these session effects by excluding the last 6 blocks from AR's RT data and the first 10 blocks from AK's RT data. Mean RTs corrected and uncorrected for the session effect are given in Tables 46 and 47 respectively. Mean RTs corrected for session are plotted in Figure 22.

c. SOA and CC effects on RT.

An analysis of variance (ANOVA) was performed on both the RTs corrected for seccion, and the uncorrected RTs. The ANOVA chosen was a Model 3 2-way analysis (Hays, 1963, p. 439), in which the fixed factor was the CC, and the random factor the digit SOA. Different ANOVAs were performed on the data from each S in each Recall task. (The

effects of S and Recall task were not analyzed by an ANOVA, but by a procedure described later.) Since RTs were clearly different between Ss, Recall tasks, SOAs, and CCs, it was expected that all these factors would have significant effects on mean RT. The value of the 2-way ANOVA was that it allowed a test of the CC x SOA interaction, for a given S and Recall task. (This interaction will be of importance in testing the assumption of partial independence (Assumption 7 of section 1 of the Discussion).)

The ANOVAs in fact showed that the main effects of SOA and CC were significant at .05, with the exception that the main effect of SOA was not significant in Recall 1 for GL and AK. This latter result is to be expected, since only 2 SOAs were tested in Recall 1, and these were close together (75 msec and 109 msec). The ANOVAs are given in Table 51, for the RTs corrected for the session effect. The upper panel of Table 51 shows the RT means, and the lower panel given the actual ANOVA. The left-hand half of the table gives the ANOVAs for each S in Recall 4; the right-hand half, for Recall 1. The last entry in each ANOVA is Omega^2; this is a correlation ration corrected for sample size (Hays, 1963, p. 325), and is an estimate of the 'amount of variance accounted for' by each source of variance.

The main effect of CC was significant in every case. Averaged over Ss and Recall tasks, the main effects are 7, 23, and -30 msec for C, U, and S respectively. These

effects were similar for each S and in each Recall task (Table 47, panels B and D).

The main effect of SOA on RT differs depending whether the RTs are corrected for the session effect or not (this is not the case for the CC effects, because CCs were varied within blocks). The main effect for the corrected RTs, averaged over Ss in Recall 4, is -13, -11, 10, and 9 msec for 75, 109, 144, and 178/214 msec SOAs respectively. This result suggests a nearly linear increase in mean RT with SOA. In fact, mean RT did rise monotonically with SOA for GL, and for the corrected RTs of AK. However, in AR, and in AK's uncorrected data, the SOA effect was curvilinear. This curvilinear effect was not constant over sessions, and may well represent between-session variability rather than a true effect. It is hard to imagine a reasonable explanation for the drop in mean RT for AR at 109 msec, for example, other than on the basis of between-session variability. Certainly the curvilinear effect is much less pronounced after the correction for session effect has been introduced.

The SOA x CC interaction effect on mean RT was insognificant in some cases and very small even when significant. The effect averaged 3 msec in Recall 4 and 2 msec in Recall 1. This interaction effect will be ignored when, in the Discussion section, various models for latency are presented. The small size of the

interaction may be appreciated visually by noting that the curves of Figure 22 are nearly parallel. In this figure, mean RT is plotted against SOA with CC as the curve parameter. The left half of the figure shows Recall 4 data; the right half, Recall 1 data.

d. The effect of Recall task on RT

The effect of Recall task upon mean RT was estimated by comparing mean RTs in Table 44 for the two tasks in each condition of CC and SOA for which a comparison could be made (i.e., SOAs of 75 and 109 msec for AR and AK, and SOAs of 109 and 144 msec for AK). Averaged over CCs, mean RT was greater in Recall 4 than in Recall 1 for AR at 75 msec and AK at 109 msec, approximately equal in the two tasks for AR and GL at 109 msec, and less in Recall 4 than in Recall 1 for GL at 75 msec and AK at 144 msec. These differences were significant at .05 by a two tailed t-test for every condition of CC and SOA, except AR at 109 msec for letter C, and GL at 109 for letters C and U. The overall differences between the mean RTs in the two Recall tasks, obtained by subtracting the Recall 1 mean from the Recall 4 mean, were 9, -16 and -2 msec for the uncorrected RTs, and -3, -16 and 3 msec for the corrected RTs, for AR, GL, and AK respectively. The average absolute differences between the mean RTs in the two Recall tasks were 17, 17, and 45 msec for the uncorrected RTs and 20, 17, and 8 msec for the corrected RTs, in AR, GL, and AK respectively.

Thus the effect of Recall task upon absolute mean RT differences was not inconsiderable. However, the direction of the effect was inconsistent in direction over SOAs and Ss. Within each SOA, the effects of Recall task upom mean RT were in the same direction for each CC. The obtained differences in mean RT between Recall tasks were not stable over sessions, and it may be that these differences were a result of between-session variability rather than a reflection of some underlying difference in processing of the CC in the two Recall tasks.

e. SOA and CC effects upon RT variance

The main result is that both CC and SOA effests on RT variance are small and erratic, with a few exceptions noted below.

The CC effect is very small for GL and AK, and is only large for AR because of an interaction with digit SOA. If AR's data at 144 and 214 msec are excluded, then the CCs have virtually no effect: the pooled s.d.s for this set of data are 72, 70, and 68 msec for C, U, and S respectively. The variances may be compared by inspecting Panel A of Table 28, under the row headed 'RT'. In order to test equality of variances over CCs exactly, a Chi^2 test was used. The hypothesis of equality was disconfirmed at 5% for 5 of 57 cases: they are AR at 144 and 214 in Recall 4 (these were the bad cases); GL at 75 msec in both Recall tasks; and AK at 109 in Recall 1 and 178 in Recall 4.

Since the disconfirmations were not systematically ordered over CCs, and since AR's data at 144 and 214 msec is subject to a problem mentioned in the next section (when the SOA effects are discussed), it is concluded that CC had essentially no effect on RT variance.

The effects of SOA upon RT variance may be seen in Panel B of Table 28 for the Recall 4 data, where RT variance may be seen to rise slightly with SOA in GL, rise considerably in AR, and be erratic in AK. In Recall 1 data, RT variance is reduced with SOA for AR and GL, but rises for AK. The hypothesis that the variances are equal is outside the 95% confidence limits for Chi^2 for AR and AK, but not for GL. The large increase in the variances of the RT distributions with SOA in AR's Recall 4 data was a reflection of the larger number of very long RTs in the slow SOA conditions, which also slightly increased the means; why such longer RTs should have occurred for AR is unclear.

f. The effect of Recall task on RT variance

The effect of Recall task upon the variances on the RT distributions was to increase variance in Recall 1. The geometric mean s.d.s, pooled over CCs and relevant SOAs, were 92 and 116 for AR, 70 and 81 for GL, and 106 and 122 for AK, for Recall 4 and Recall 1 respectively. These differences are outside the 95% confidence interval of Chi^2, for each S. Recall task, SOA, and S interacted strongly in

their effects upon variance (as in their effects upon the means), so that variance increased with SOA in Recall 4 but decreased with SOA in Recall 1 for AR and GL, and vice-versa for AK. The meaning of these effects of Recall task and of SOA upon variance is unclear, but it appears that in general, RT variance increased when the task involving the digits became easier (by increasing SOA or reducing memory load from 4 digits to 1 digit). (This may have been due to a motivational change--a feeling of relaxation of tension in the easier conditions).

3. Digit Recalls

a. Coding of the recalls

The digits that S reported on each trials were coded so that:

R = (i,j,k,l) if S reported the digit in position i of the positive* set, then the digit in position j, then the digit in position k, and finally the digit in position 1, in Recall 4.

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*Note: the 'positive' and 'critical' sets of positions are defined in the Procedure. Here, positions are defined by the positive set, not by the critical set. To convert positive set positions into positions of the critical set, add i. (Values of i_o for each condition are given in Table 1.) Recall that the critical set positions are defined with the position simultaneous with the CC equal to zero.

R = (i) if S reported the digit in position i in Recall 1.

For example, suppose in Recall 4 that the digit sequence (8,7,6,3,4,2,1) were presented in the positive set of positions. If S typed in (1,3,4,8), then R = (7,4,5,1), since the first digit (1) was in fact seventh in the positive set, and so on. The effect of this coding is to collapse responses over particular digits, and so reveal the effects of position in the digit sequence. In Recall 4 the coding reduces the number of S-R combinations from 10.9.8.7. [10!] to 10.9.8.7 = 5040. This coding collapses over the residual effects of particular digits.

The digit recalls are analyzed in the next two sections. The first section considers the 'noting responses' NP and EP, the 'noted position' and 'earliest position' respectively, which are used to measure CC latency. The second, shorter, section considers the order information in the Recall 4 responses. More detailed consideration of the order information is then deferred until the Discussion, in which particular order measures are motivated by the particular models being considered.

b. Definition of the noting response

The 'noting response' is assumed to be contained in the response R on each trial, where R = (i,j,k,l) in Recall 4, and R = (i) in Recall 1 (this assumption is

relaxed in Model 1 of the Discussion, section3). Two random variables are defined. The first is the 'noted position' NP, which is the position of the digit noted as first by S on a trial. The second is the 'earliest position' EP, which is the position of the earliest occurring of the digits reported by S. The following definitions make these ideas clear, for the Recall 4 task:

$$NP = i \quad \text{,if } R = (i,j,k,l)$$
$$EP = e \quad \text{,if } e = \text{Minimum } (R).$$

For example, if R = (3,4,1,2), then NP = 3 and EP = 1. If 'order information' were perfect, S would always report stimuli in the order of their presentation, and $i < j < k < l$ would occur on every trial. In this case, e must equal i. However, if order information is imperfect, as in the example of R just given, then S may report a digit that was presented laterm in an earlier response position, so that $e < i$. In all cases, $e \leqslant i$ by definition.

In the case of the Recall 1 task,

$$NP = i \quad \text{,if } R = (i).$$

(Since there is only one digit reported on each trial, EP must always equal NP, and so the notation EP is not used in Recall 1).

In section 3 of the Discussion, a guessing model

(Model 2) is presented, in which two more random variables will be introduced: NP' and EP', where NP = i if R = (i,j,k,l) and i was not guessed, and EP' = e if e = Min (R) and the digit in position e was not guessed. Justification of these measures will be delayed until the Discussion, but some of the data will be presented in the Results.

In defining the NP, the particular digit reported in each NP is collapsed over. Collapsing over digits is only justified if the NP is in fact independent of the digit reported. Because the mean noted position, $\overline{NP}$, will be of particular interest subsequently, the weaker condition that $\overline{NP}$ should be independent of the digit reported was demanded of the data. That is, let $\overline{NP} = \sum_i i \cdot P(NP = i)$, and let $\overline{NP}_x = \sum_i \cdot P(NP = i \mid DNP = x)$, where DNP = x if the digit reported NP is x. Then the condition for independence is that $\overline{NP}_x = \overline{NP}$, for all x. Values of $\overline{NP}_x$ are given in Table 71 under columns headed 0 through 9, and $\overline{NP}$ is given in the penultimate column, for the condition of S and SOA specified by the row. Recall 4 data are given in Panel A, and Recall 1 data in Panel B. In all conditions, $\overline{NP}_x$ is close to $\overline{NP}$ for every x. The hypothesis of equality (i.e., $\overline{NP}_x = \overline{NP}$) was tested by a Chi^2 test with 9 d.f., and was rejected in only 3 of the 17 experimental conditions. The ultimate column of Table 71 gives the Chi^2 values, and the conditions in which equality is rejected at 5% or better

are starred. (The Chi^2 test was constructed by taking

$$Chi^2 = \underline{N} \cdot \sum_x [(\overline{NP}_x - \overline{NP})^2 \cdot P(DNP = x) / \overline{NP}]$$

where $\underline{N}$ is the total number of trials at a given SOA (1200 for AR and GL, and 900 for AK). In the formula, the 'observed' number of cases is $\overline{NP}_x \cdot \underline{N} \cdot P(DNP = x)$, and the 'expected' number of cases is $\overline{NP} \cdot \underline{N} \cdot P(DNP = x)$. Despite the violations obtained, which are small and not systematic, independence of mean NP from the digit reported is assumed to hold in all conditions. That is, the procedure of collapsing over digits is assumed to be valid.)

c. The noting response distributions

The four variables, NP, EP, NP', and EP', take on probability distributions over positions. The distributions of NP' and EP' may be defective, in that trials may occur in which all the responses were guessed. The data provided estimations of the probabilities P(NP = i) and P(EP = e), where i and e range over the positions of the critical set. The distributions of P(NP' = i) and P(EP' = e) may be estimated by passing the data through Model 2 of the Discussion (section 3). The Model will be explained in that section, but the P' data will be presented in the Results section where relevant. (The ' symbol means "corrected for guessing by Model 2.") It

turns out that when Model 2 is applied, the distribution of NP is found to be virtually free of guessing, so that P(NP = i) = P(NP' = i) to a very close approximation. For this reason, only P(NP = i) data will be presented. Since the P(EP' = e) data are quite different from the P(EP = e) data, however, both of these distributions will be presented.

The estimation of these probabilities proceeded as follows. Let P_{ij} be the proportion of trials (out of N) in which S reports the digit in the i^{th} position of the digit stream, in the j^{th} position of the response. The P_{ij} form a 8 x 4 matrix which will be discussed below (in section 4). The first 7 columns of the matrix are the first 7 positions in the positive set: the 8^{th} column refers to the 3 positions in the negative set, which are here lumped together. Only the first row of this matrix, P_{i1}, is of interest here. P(NP = i) is estimated directly from P_{i1}. In Recall 1, the equivalent measure is P_i, the proportion of trials in which S reports the digit in the i^{th} position in the response. Thus:

$$P(NP = i) = \begin{cases} P_{i1} & \text{in Recall 4} \\ P_i & \text{in Recall 1.} \end{cases}$$

The equality between P(NP = i) and P_{i1} in Recall 4 means that P_{i1} is the best estimate of P(NP = i). For convenience, the terms P(NP = i) and P_{i1} will be used

interchangeably from here on; the former in situations where the distribution of NP is being used to compute latency; and the latter, when the distribution of NP is being compared with the distribution in other response positions, such as P_{i2}.

Estimation of the EP, and NP', and EP' probabilities proceeds in the same way as for the NP probabilities. Let P_e be the proportion of trials in which e = Min(R), so that $P_e = N(e = Min(R))/N$. Let P'_{il} and P'_e be the proportions after correction for guessing by Model 2. Then, in Recall 4,

$$P(EJ = e) = P_e$$
$$P(NP' = i) = P'_{ij}$$
$$P(EP' = e) = P'_e$$

and in Recall 1,

$$P(NP' = i) = P'_i.$$

The noting response distributions are tabulated as follows. The P(NP = i) distribution is the same as the P_i distribution in Recall 1, and this is given in Table 4. Panel A shows P_i, for i = 1 . . . 7, and Panel B shows P_i cumulated over i = 1 . . . 7. The cumulated proportions are designated as $\underline{P}$, from now on. The P(NP = i) distribution in Recall 4, which is the same as the P_{il} distribution, is given in the first row of each of the matrices

of Table 35. The lower panel on each page of Table 35 shows the P_{ij} in cumulated form, as $\underline{P}_{ij}$. The P(EP = e) distribution is in Table 5.

The noting response distributions are plotted in Figure 12 for Recall 1, and in Figure 13 for Recall 4. In these figures, positions of the positive set are on the abscissa, and proportions are on the ordinate. The Recall 1 curves (in Figure 12) have the S's estimate of NP as a curve parameter. The Recall 4 curves (in Fugure 13) have response position as the curve parameter. It is apparent that all these distributions are unimodel, roughly symmetrical, and approach zero in their tails. The unplotted P(EP = e) distribution in fact has a similar overall shape.

Means and variances for the NP and EP distributions were computed by transforming the position axis (i or e) into a time axis (t_i or t_e) by multiplying by the digit SOA, d. That is,

$$t_i = d(i + i_o), \text{ and } t_e = d(e + ti_o),$$

where i_o is the position of the start of the positive set relative to CC. Thus, $t_i = 0$ if the digit in i was presented simultaneously with the CC. The advantage of this transformation to units of time is that the means and s.d.s of the distributions may be compared in a meaningful way over different conditions of digit SOA. Note however that

a theory that S's perceptions were determined not by the arrival times t_i of the digits, but by the positions i in the digit stream, would be more easily tested by data on the untransformed scale of positions.

Means and s.d.s for the NP and EP distributions are given in Table 11 for Recall 4, and for NP distributions for both Recall 4 and Recall 1 in Table 10. The suplication of the NP Recall 4 data for SOAs of 75 and 109 msec in the two Tables is provided to permit easier comparison.

The relationships between the NP, EP, Recall task, CC and digit SOA are reported next. The method of analysis chosen was the 2-way Model ANOVA (Hays, 1963, p. 357 ff), with the CCs entered as fixed effects and the digit SOAs entered as random effects. Means and s.d.s were obtained from each distribution of NP in each condition of CC and SOA, and the means were entered into the ANOVAs with the pooled s.d.s providing the within-cell error terms. The EP distributions were treated in the same way. The effect of Recall task upon the NP, in the brief SOA conditions, was studied by testing the differences between the NP distributions in the two Recall tasks for each condition of CC and SOA, rather than by using an ANOVA. The computed means and s.d.s were in units of time (msec) in order to facilitate comparisons across different conditions of digit SOA. Thus the analysis was very similar to that undertaken

for the RTs.

d. SOA and CC effects on the noting responses

The CC and SOA effects on the mean noting response are shown in Table 15, which provides a SOA x CC matrix for the NP and EP condition means, for each S in Recall 4. ANOVAs on these means are provided in Tables 12, 13, and 14, for NP in Recall 1, NP in Recall 4, and EP in Recall 4, respectively. The upper level in each of the ANOVA tables gives the marginal NP or EP means, averaged over SOA and over CC.

The main effects of CC and of SOA are significant ineach of the ANOVAs. The main effects of CC are very similar to those of RT. The effects of SOA are rather different: SOA has a much stronger effect on mean t(NP) and mean t(EP) than on mean RT. Both of these points will be considered further below.

The prediction of the Donders' assumptions (assumptions 2 and 3 of the Discussion, section 1b) is that the SOA x CC interaction effect on the mean noting response should be zero. In fact the SOA x CC interaction was significant at .05 for 5 of 9 ANOVAs; but the size of the interaction was very small. That is, the interaction generated an Omega^2 (Hays, 1963, p. 325) of .005 or less (this statistic is a correlation ratio corrected for sample size), and the mean absolute interaction effect was 3 msec

or less, in each of the ANOVAs.* The small interaction may be appreciated visually in Figure 4, where the t(NP) means are plotted with abscissa SOA and curve parameter CC; the curves are roughly parallel to each other. This is also true in Figure 5, where the t(EP) means are plotted in a similar fashion.

The main effects of CC and SOA on all the latency measures may now be considered, on the basis that the interaction effects have all been insubstantial.

The effect of CC upon all the latency measures (RT, NP and EP) is given in Table 27 for both Recall tasks. Panel A shows the main effect for each CC (that is, the mean latency for a CC condition minus the grand mean). Panel B shows the mean of the absolute values of the CC main effects which is a summary statistic for the amount of CC effect shown in panel A. In general, the five measures, of which N(1) and t($\overline{EP}$') have not yet been explained, show very similar effects of CC. Mean latency increases in the order S, C, and U for every S and measure, except for GL, whose latency increases in the order S, U, C for measures N(1), t($\overline{EP}$), and t($\overline{NP}$). The mean CC effect over Ss and measures is -34, 12, and 22 for S, C, and U respectively, and the individual values do not stray far

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*Since each ANOVA is based on 4,800 trials (for AR and GL), small effects may still be significant.

from these means. This can be seen in Figure 8, where the entries in panel A of Table 27 are plotted with CC on the abscissa, CC effect on the ordinate and latency measure as the parameter. However, the amouns of CC effect shown in Panel B is not quite constant over latency measures, but declines in the order N(1) $\rangle$ t($\overline{EP'}$) = t($\overline{NP}$) $\rangle$ $\overline{RT}$ $\rangle$ t($\overline{EP}$), when averaged over Ss. These discrepancies in the estimates of the amount of CC effect will be taken in the Discussion.

The effect of SOA upon the latency measures is given in Table 27, Panel C shows the main effects, and Panel D the mean of the absolute values of the main effects. In general, RT rises slightly with SOA but all the other latency measures drop considerably with SOA. In detail, SOA has somewhat less effect upon N(1) than upon the non-RT latency measures, t($\overline{EP}$) shows a slightly U-shaped effect at 75 msec, and t($\overline{EP'}$) shows a strong U-shape for AK. The overall distinction between RT and the other latency measures remains clear, however, as may be seen in Figure 9.

e. The effect of Recall task on the noting responses

The effect of Recall task was estimated by taking the mean t($\overline{NP}$) in Recall 4, averaged over CC and the relevant SOAs, from the mean t($\overline{NP}$) in Recall 1 over the same conditions. This estimate was 13, 6, and -45 msec for AR, GL and AL respectively. The difference is

comparable to the difference in RTs mentioned earlier for AR and GL, but not for AK. The actual differences in the means for each condition are shown in the last column of Table 10. They show a decrease with SOA, for each CC in each S. However, the effect of CC is unclear. To study these differences further, two statistics for the comparison of entire distributions were used. The 'mean distance' measure is the average absolute distance

$$MD = \frac{1}{8} \sum_{i=1}^{8} | P_i - P_{ii} | .$$

The Kolgomorov-Smirnov D statistic is the maximum D_i, where

$$D_i = \left| \sum_{j=1}^{i} (P_j - P_{ji}) \right| .$$

Values of the MD and D statistics are in Table 16. The D statistic shows a significant difference at .05 in all of AK's comparisons and half of AR and GL's. The MD measure, whose range is from 0 to 2, is greated than an arbitrary small quantity .05 for all of AK's data and for AR at 75 msec. By and large, MD and D both decline with SOA, as did the difference between the means. However, the difference of the effect is reversed between Ss: for AR and GL, t($\overline{NP}$) is later in Recall 1 than in Recall 4, but for AK, it is earlier. (It might be noted that the difference between the distributions reflects not only possible differences in processing load induced by the tasks, but differences in the amount and effect of guessing in the two

tasks; these issues are taken up in the Discussion.)

These results mean that the distribution of P(NP = i) was dependent on the Recall task (in contradiction to Assumption 5 of the Disucssion). For AR and GL, the distributions were nevertheless similar, so that the assumption was violated only weakly. For AK, the violation was considerable. This point is taken up in part 1 of the Discussion, when Assumption 5 is discussed.

f. SOA and CC effects on the variance of the noting responses

The effects of SOA and CC upon s.d.s of the various latency measures are presented in Table 28, Panels A and B. Computation of the s.d. suffers from two potential sources of bias. The first is that S's responses were truncated in the sense that the report of a digit seen before or after the critical group of digits would be miscoded as coming from a position inside the critical group, thus lowering the estimate of s.d.. The second source of bias is due to the often small number of points (digit positions) sampled in the NP and EP distributions. The proportion of trials in which truncation of RTs occurred was very small (Table 1, columns headed RT $<$ .17 and RT $>$ 1.8); but truncation may have been more frequent for the EP and NP measures. If the EP and NP distrubutions are assumed to be unimodel, and if P(NP = 1) = P(EP = 1) = 0, then P(NP $<$ 1) = P(EP $<$ 1) = 0; and similarly, if

$P(NP = 8) = P(EP = 8) = 0$, then $P(NP < 8) = P(EP < 8) = 0$. In neither case can truncation occur. However, in general $P(NP = 1) > 0$, $P(EP = 1) > 0$, and $P(NP = 8) > 0$; so that the possibility of truncation can only be ruled out for the EP distributions on the right (positions later than 7). It does not seem that $P(NP = 1)$, $P(NP = 8)$, and $P(EP = 1)$ vary greatly over SOAs (Table 35 and Table 5), except to be slightly larger at 75 msec; nor do these probabilities vary greatly over CCs: so that it may be that the degree of distortion of the means and variances of the NP and EP distributions induced by truncation is relatively constant over conditions.

The second source of bias, that of a small number of sampled positions, is intrinsic to the method of obtaining the NP and EP distributions. For some conditions, S's responses may fall in a very few positions, so that no matter how many trials are run, a reasonably continuous picture of the distribution is impossible to obtain. Typically there are 7 or 8 points on the NP distribution and between 3 and 7 points on the EP distribution, defining 'points' as digit positions in which the probability of report is greater than zero. Distributions with less than 5 points were obtained for the EP measure for CC = S and SOA = 109 msec in AR, and for all CCs and SOAs of 144 and 214 msec in GL. The N(1) distributions were generated in an attempt to get around both the problems of truncation

and the problem of insufficient data points, by a procedure that will be taken up in the Discussion. The EP and NP means and s.d.s reported are, however, uncorrected for these problems.

The s.d. of the various latency measures were subjected to an ANOVA type of analysis of CC and SOA effects. That is, the pooled s.d.s over SOA are presented in Table 28, Panel A, for each CC; the pooled s.d.s over CC are presented in Table 28, Panel B, for each SOA; and a measure of the CC x SOA interaction effect on the s.d.s is given in Table 28, Panel D. In each case, pooling was done by taking the geometric mean of the s.d.s. From Table 28, Panel A, it can be seen that the s.d.s do not systematically vary between C and U, but tend (in 11 of 15 cases) to be smaller for S. The last column of Panel A gives the average of the absolute differences between the s.d.s and the mean of the s.d.s as a measure of the total amount of CC effect. The CC effect is less for RT than for any other latency measure, (with the one exception of N(1) for GL) by .6, .6 and .3 for AR, GL and AK respectively. The other latency measures do not differ systematically from each other over Ss. From Table 28, Panel B, it may be seen that s.d. increases with SOA when pooled over CC. Excluding RT, the average increase in s.d. for the latency measure is from 88 msec at SOA = 75 to 167 msec at SOA = 214, for AR and GL. The SOA effect, measured again as the average absolute

difference from the mean, is given in the last column of Panel B; it is at least for RT in every S, being .5, .04, and .4 of the average of the other latency measures for AR, GL and AL respectively. Table 28, Panel C gives the same data as Panel B, but each entry is divided by the SOA in order to give s.d. measured in positions instead of msec. In every case, position s.d. declines with SOA. Note that if S responed at random, his NP and EP distributions would be rectangular over the ten digit positions of the critical group, and would have s.d. = 1/12 (10-1) = 2.6. If S were perfect, only reporting the simultaneous digit, his s.d would be zero. The obtained s.d.s must fall between these limits, if the NP and EP distributions are unimodal, and should presumably decline as SOA increases and S becomes more accurate.

The interaction effect of SOA x CC upon the s.d.s of the latency measures was studied by testing interactions agsinst confidence intervals for the hypothesis of no interaction, and by obtaining the average absolute interaction effect (Table 28, Panel D). The 'interaction effect' was defined as follows. Let $V_{c,d}$ be the variance of a distribution obtained with digit SOA = d and CC = c, let V_c be the mean over d, let V_d be the mean over c, and let V be the grand mean; then the interaction effect is $V_{c,d} + V - V_c - V_d$. These interactions were compared with the 95% confidence intervals for $V_{c,d}$, computed by the

procedure of Note 1 (Appendix 3). In 64 of the 165 c,d cells, the $V_{c,d}$ fell outside the confidence intervals for the hypothesis of no interaction, which predicts that $V_{c,d} = V_c + V_d - V$. Note that this procedure does not take into account the problems of truncation or of insufficient data points. These problems bias the variances by unknown amounts. The average absolute interaction effect over the c,d cells, divided by the average variance of the c,d cells, is given in Table 28, Panel D as a measure of the size of the interaction effects (roughly analogous to $Omega^2$ for the size of the interaction effects for the means). This ratio lies between .03 and .33 and averages .15 over Ss and latency measures.

An attempt was made to estimate the effect of insufficient data points upon smapling from a standard normal distribution, using a procedure discussed in Note 2 (Appendix 3). The procedure generated a rough estimate of the condifence interval of the variance for from 4 to 8 data points; Table 28, Panel C gives these revised condifence intervals. The number of $V_{c,d}$ interaction terms outside the revised confidence intervals, given in Table 28, Panel D, column b, is only slightly less than that given in column a. Furthermore, the SS x CC interaction effect on RT is significant, and quite similar in size to that on NP and EP: the RT distribution, of course, does not suffer from the problems of truncation and insufficient

data points. The SS x CC interaction effect on the variances of the latency distributions must therefore be considered genuine.

g. The effect of Recall task on the variances of the noting responses

The effects of Recall task upon t(NP) variances may be seen in Table 10, where the last column shows the s.d. in Recall 4 minus the s.d. in Recall 1. The mean difference over CCs and SOAs is 4, -3, and 26 msec for AR, GL and AK respectively. The differences are small for the former two Ss, but large in AK. This result suggests that the variances are behaving like the means: AR and GL show a small effect of Recall task upon both, but AK does not.

4. Latency Results in the Arrow Experiment

The same set of latency measures were taken in A as in C, U, and S. These measures are the means and s.d.s of RT, t(NP), t(EP), t(EP'), and N(1). The means and s.d.s are presented in Table 29, Panels A to E. Each panel has the same format: the columns show the different measures, the means over those measures, and the means over the measures excluding RT. The actual means are given in Panel A.

The main result is that mean latency in A was a great deal smaller than the latency in the C, U, and S conditions, for every S, SOA, and latency measure. Panel C gives the 'A effect', defines as the latency averaged over

C, U, and S, minus the latency in A. The A effect is considerable, being 211 msec for latency measures other than RT, and 106 msec in RT, when averaged over Ss.

There was also an A effect in the s.d.s. Here, the A effect is defined as the pooled s.d. over C,U, and S, minus the s.d. in A. Somewhat surprisingly, for the latency measures other than RT, pooled s.d. was larger in A than in S, U, and S. The mean difference in favour of A was 23 msec (Table 29, Panel E). For RT, the pooled s.d. was on the other hand smaller in A than in C, U, and S. Here, the means difference in favour of C, U, and S is 12 msec, or 18 msec if the aberrant data for AR at 75 msec is excluded. It is reasonable to assume that the RT difference in s.d.s. shows the true nature of the A effect, which is that both means and variances are smalled in A. The reversal for the measures other than RT may well be because of inefficient selection of the location of the positive set in the A condition (especially for AR and GL at 75 msec, as noted before).

The effects of SOA on the latency measures in the Arrow condition itself will now be considered. (By and large, the SOA effects were similar in the C, U, and S experiment.) The SOA effects are given in Table 29, Panel D. The SOA effect is defined as one-half of the mean latency at 109 msec minus one-half of the mean latency at 75 msec (144 and 109 msec in AK). The main result is that

the SOA effects are small for every measure. This is unsurprising, because only a small range of SOAs was tested. Mean latency at the smaller SOA was larger than mean latency at the longer SOA, by 10, 26, and 61 msec for AR, GL, and AK, for the average of latency measures other than RT. On the other hand, mean RT at the smaller SOA was smaller than mean RT at the longer SOA, by -26, 6, and 7 msec, for AR, GL, and AK. It is typical that RT should show an opposite effect of SOA than the other latency measures. This was confirmed for GL and AK, but not for AR, whose data at 75 msec was aberrant.

If the size of the SOA effect in A is compared with that in C, U, and S, for the 75 and 109 msec conditions only (109 and 144 in AK), the SOA effects are rather similar. Averaging over all the latency measures, the SOA effect was slightly larger in A (by 12 msec).

The SOA effect in the s.d.s of the latency measures was found to be insignificant. This was true, both for the A data given in Panel B of Table 29, and for the C, U, and S data pooled together in Panel B. Neither set of data showed an SOA effect on the s.d.s greater than 2 msec, which is well within the confidence interval for the hypthesis of no effect computed according to Note 1 (Appendix 3).

5. The RT and the Noting Response within Conditions

The relationship between RT and the noting response was studied by conditionalizing RT upon NP and EP. Define $RT(t_i)$ and $RT(t_e)$ to be RTs on trials in which $T_{NP} = t_i$ and $T_{EP} = t_e$. Then let $\overline{RT}(t_i)$ and $\overline{RT}(t_e)$ be the means of $RT(t_i)$ and $RT(t_e)$ respectively. The correlations of $\overline{RT}(t_i)$ with t_i and of $\overline{RT}(t_e)$ are given in Table 44 under column headings r_i and r_e respectively. These correlations are positive but low, declining to near zero for brief SOAs. The regression of $\overline{RT}(t_e)$ on t_e is plotted in Figure 23 in a fashion that needs some explanation. The $\overline{RT}(t_e)$ means were averaged over SOAs, by averaging together all the means whose t_i values fell in the same 75 msec bins. Thus;

$$\overline{\overline{RT}}(t') = \text{Mean } (\overline{RT}(t_e),\ t_e \leqq t' < t_e + 75)$$

This grouping procedure allowed averaging of $RT(t_i)$s over SOAs, even when the digits presented in one condition of digit SOA were not simultaneous with digits presented in a different condition of digit SOA. For all values of $t_e < 575$ msec, the regression line is essentially flat. This finding is represented in Figure 23 by the horizontal straight lines for the different CCs. The flat line is within the (95% confidence interval for every $\overline{RT}(t_e)$ for GL, and every $\overline{RT}(t_e)$ with $t_e < 575$ msec for AR

a $\overline{RT}(t_e)$ for GL, and every $\overline{RT}(t_e)$ with $t_e < 575$ msec for AR$_s$

do not vary systematically with t_e. It is possible to conclude that for $t_e < 575$ msec, $\overline{\overline{RT}}(t_e)$ is unrelated to e. (The same analysis for t_i, which is not plotted, also yields low correlations). For the trials in which $t_e < 575$ msec, a plausible hypothesis is that $\overline{\overline{RT}}(t_e)$ increased directly with t_e, and this hypothesis is represented by the 45° straight line in Figure 23. The hypothesis cannot, however, be tested meaningfully against the small amount of data involved (less than 5%). Note however that all these data consistent with a slight linear increase in $\overline{\overline{RT}}(t_e)$ over all values of t_e (Discission, section 2: and Note 3).

4. Order Information

1. Overview

The purpose of this section of the Results is to describe and present several measures of order information. The case of Recall 1 data, which is the simplest, will be considered first (in section 2). Subsequent sections will consider Reall 4 data. In section 3, and P_{ij} matrices will be analyzed. For example, the mean stimulus position reported in a given response position, $\bar{P}_{ij}$, provides an estimate of order information when compared to the mean stimulus reported in some other response position. If S had accurate order information, then later stimuli would occupy later response positions, on average.

Section 4 discusses 'within-trial' order information which cannot be measured in the P_{ij} matrices. Data from a particular within-trial measure, concordance, is given. More data on this topic will be presented in the Discussion, where it has relevance to particular models for item and order (Discussion, section 3). The main result presented here is that order information is 'poor', in the sense that it is non-veridical, both in Recall 1 and in Recall 4. Order is especially poor in the fast SOA conditions, and it improves in the slow SOA conditions.

2. Order Information in Recall 1

Order information was measured in Recall 1 by testing whether the subject's position estimates were accurate or not. Recall that on every trial, S gave his report of the first digit that he could, the position of which is the NP, and then gave his estimate of where that digit had been in the positive set of positions, PE. S was allowed four position estimates, 1, 2, 3, and 4, where '4' was used to estimate the fourth and subsequent positions of the positive set. The data from Recall 1 form an 8 by 4 stochastic matrix, with the first 7 columns representing the positive set positions, and the 8^{th} column the negative set, and with the four position estimates being represented by the rows. Elements of this matrix are denoted $P_i(j)$, where is is the stimulus position and j the estimate, and $P_i(j) = P(NP = i \mid PE = j)$.

Table 35 gives the $P_i(j)$ data matrices in every condition, abd the same data are plotted in Figure 12 with i on the abscissa and the position estimate j as curve parameter.

If S has no order infromation, he would not be able to estimate the objective position of the noted digit, and $P_i(j)$ would equal P_i for all j. That is, the curves in Figure 12 would overlap exactly. In fact, these curves overlap a great deal at fast SOAs, but begin to separate at slower SOAs, where more order information presumably becomes available. In order to measure the degree of separation of these curves, the mean position $P_{\bar{I}}(j)$ was computed for each value of the PE, where

$$P_{\bar{I}}(j) = \sum_{i=i}^{8} i \cdot P_i(j)$$

(In this computation, negative set responses were included as position 8 so that $P_i(j)$ would form a probability distribution for each j. It is legitimate to find $P_{\bar{I}}(j)$ by averaging only over the 7 positive set positions, but for these data, $P_8(j)$ is so small that the difference between the two computations is negligable).

The value of $P_{\bar{I}}(j) + i_o$ is given for every j in every condition in Panel A of Table 33; notice that these values may be converted directly to time since the occurrence of the CC, by multiplying by the digit SOA. This data is summarized in Panel B, in which the values are averaged over the CC because the effect of the CC was

small. The grand mean has been subtracted from the Panel B entries so that the main effect of the SOA can be seen. This data is plotted in Figure 11, with the SOA as curve parameter and j as the abscissa. The hypothesis of completely inaccurate estimation by the subject (no order information) requires that these curves be horizontal, while the hypothesis of completely accurate estimation requires the curves to have slopes of 1. The actual slopes, by linear regression, are given in Panel B of Table 34 for each CC and SOA. Averaging over CC, these slopes are .14, .21, and .59 for AR, GL and AK, at the faster SOA, and are .05, .30, and .73, at the slower SOA. These values indicate that the position estimates of AR and GL were by and large inaccurate. (Surprisingly, the less well trained subject, AK, was better able to estimate the position of her noted digits, even at the 109 msec shared with the other Ss).

Parenthetically, it should be pointed out that distributions may differ even when their means do not. Therefore, to more rigorously test the separation between the NP distributions conditioned on successive position estimates, the mean absolute distance D(j, j + 1) was found, at each j, where

$$D(j, j+1) = \tfrac{1}{2} \sum_{i} \left(\left| P_i(j) - P_i(j+1) \right| \right).$$

This statistic lies between 0, for totally inaccurate estimation, and 1, for totally accurate. The obtained values are low, hovering around .2 (except for AK's values for D(2,3) and D(3,4), which reach .5), as shown in Panel A of Table 34. This result reinforces the conclusion, based on linear regression of the $P_{\bar{i}}(j)$ means alone, that order information for AR and GL is poor.

3. Order Information in the Recall 4 P_{ij} Matrices

a. Definition of the matrices

The response vectors R=(i,j,k,l) in Recall 4 were used to form an 8 by 4 stochastic matrix $\underline{R}$ for each condition of CC and SOA. The 4 rows of the matrix represent the fours response positions. The first 7 columns represent the 7 digit positions in the positive set; the 8^{th} column represents the 3 digit positions in the negative set. Suppose that on trial n, $\underline{S}$ gave a response R=(i,j,k,l). Then the matrix $\underline{R}_n$ for that trial is produced by placing zeros in all elements of the matrix except r_{11}, r_{j2}, r_{k3}, and r_{14}, where ones are placed. Note that since, the $\underline{R}_n$ matrix is stochastic with column sums either 0 or 1. The matrix $\underline{R}$ is then computed by averaging trials, so that

$$\underline{R} = \frac{1}{\underline{N}} \sum_{n=i}^{\underline{N}} \underline{R}_n$$

The elements P_{ij} or $\underline{R}$ are the proportions of trials in which $\underline{S}$ reports i^{th} stimulus in the j^{th} response position. (By' i^{th} stimulus' is meant the digit that was presented in the i^{th} position of the positive set: this terminology will be used again.) The P_{ij} are calculated independently of any other responses made on a trial, except for the usual restriction that all 4 responses were different from each other. Therefore the $\underline{R}$ matrix gives no information about the 'structure' of the individual responses R. This point is discussed below (in section 4), and it motivates the use of the 'within-trial' order statistics presented in that section.

The eight column means of the $\underline{R}$ matrix are

$$P_i = \tfrac{1}{4} \sum_{j=i}^{4} P_{ij}$$

The P_i are the proportion of trials in which the i^{th} stimulus is reported.

The 'weighted' row mean M_j is the mean stimulus in response j:

$$M_j = \sum_{i=i}^{8} i \cdot P_{ij} \quad , \text{ where } j = 1 \text{ in Recall 1,}$$
$$j = 1,2,3,4 \text{ in Recall 4.}$$

The mean stimulus reported the positive set only is:

$$M^{+}_{j} = \sum_{i=i}^{7} i \cdot P_{ij} \qquad , j \text{ as above.}$$

The convention for P_{8j} is that column 8 represents the entire negative set (this convention is followed throughout).

The matrix grand mean, that is, the mean stimulus reported in an entire matrix, $P_{\bar{i}}$, is

$$P_{\bar{i}} = \tfrac{1}{4} \sum_{j=i}^{4} M_{j} = \sum_{i=i}^{8} i \cdot P_{i}$$

(In the computation of $P_{\bar{i}}$, inclusion or exclusion of the negative set data, that is, use of M_j or $M^{+}j$, is unimportnat because the effect of the negative set responses on the grand mean is small.)

b. <u>The Recall 4 matrix data</u>

The Recall 4 matrices are given in Table 35 and plotted in Figure 13, Table 35 gives each matrix with the positions in the positive set as columns, and response positions as rows. The distribution of the first row, P_{il}, has already been discussed in the section on latency. The subsequent rows have somewhat similar distributions, although there is a tendency in the 3rd and 4th rows for the distributions to become bi-modal. In these cases the

P_{ij} values dip when i is between 3 and 5. The basic reason for this is that on trials in which NP = 3, 4, or 5, the digit in the NP position is 'used up' and cannot be reported again. If, for example, $P_{41} = 1$, then $P_{42} = P_{43} = P_{44} = 0$, by definition. Since NP = 3, 4, or 5 on most trials, other positions in the extremes of the positive set become more likely candidates for the later response positions. This issue is taken up again in the Discussion, in section 4, where a model is presented (Model 3) in which this phenomenon is particularly important.

The mean stimulus position reported from the critical set, $M^+_j + i_o$, is given in Table 7, for each response position j. The M^+_j averaged over the CC are presented in Table 8, the grand mean of the M^+_js, has been subtracted from each entry to assist in comparison across the SOAs. These entries are plotted in Figure 2 against j. Note that a slope of one in this figure implies that the means of the responses are ordered correctly. A zero slope implies that there is no order information in the means. The negative slope for 75 msec for GL is an artifact of the truncation at position 7 of the positive set: the means of the later response positions are underestimated because responses given to the eighth and later stimuli are excluded in this analysis.

The two methods of estimating row means, M^+_j and

M_j, are related as follows: $M^+_j = M_j - (8-M_j)\dfrac{P_{8j}}{(1-P_{8j})}$.

If P_{8j} is close to zero, $M^+_j = M_j$; otherwise, $M^+_j < M_j$. Typically, P_{8j} is zero or close to zero for j = 1, but becomes larger as j increases. The case for j = 1 is of special interest since P_{ij} is used to estimate P(NP = i). In this case, the difference between M_1 and M^+_1, when multiplied by SOA, lies between 0 and 50 msec and averages 9, 25, and 13 msec for AR, GL, and AK respectively. The discrepancy does not vary systematically with either SOA or CC. Given the similarity of the two means for j = i, the NP data analyzed arbitrarily with set responses counted as positive 8. Values of $t(P_{\bar{I}}) = d \cdot (P_{\bar{i}} - i_o)$ measure the onset time of the average reported digit, $P_{\bar{i}}$, in each matrix. Values of $t(P_{\bar{i}})$ are given in Table 9 and plotted in Figure 3, for each SOA and CC. The interaction effect of SOA and CC on $t(P_{\bar{i}})$ was computed as $D_{CC,SOA} = t_{SOA,CC} - (t_{SOA} + t_{CC} - \mu$, where μ is the grand mean, $t_{SOA,CC}$ the table entry, and t_{SOA} and t_{CC} are the marginal entries. The D* value in Table 9 is the average absolute D over all conditions, i.e.

$$D^* = 1/12 \left(\sum_{SOA} \sum_{CC} | D_{CC,SOA} | \right).$$

The values of D* obtained lie between 4 and 6 msec and are small in comparison with the main effects of CC and SOA.

The column means P_i are given in Table 2, and cumulated values $\underline{P}_i$ are given in Table 3, for Recall 4. The P_i distributions in Recall 4 estimate item information without regard to the order of the responses. They will be important in Model 4 of the Discussion (section 3), in which item information measured by P_i is compared with order information measured by Tau_{ij}.

c. The Recall 4 matrix data in the Arrow experiment

The matrixes $\underline{R}$ for the A experiment are given in Table 35. The row means M_j^+ are given in Table 7, and the means less the grand mean $M_j^+ - \mu$ are given in Table 8, Panel B. The increase if M_j^+ with j is of interest as a measure of the degree to which later stimuli are reported in later response positions. The increases were rather similar in A and in the mean of C, U, and S (Table 8, Panel A). The increase $M_4^+ - M_1^+$, for example, was .69 in A and .85 in the mean of C, U, and S, when averaged over Ss over the two lowest SOAs. (An increase of 3 would occur with perfect responses.) For each S, the increase $M_4^+ - M_1^+$ was larger in A than in C, U, and S at 75 msec and smaller in A at 109 msec (109 and 144 msec for AK). That is, order information by this measure increased more with SOA in C, U, and S than in A. (This conclusion was confirmed by the measure of concordance described in the next section.)

A second order measure, that of the mean absolute

effect of response position, $\frac{1}{4} \sum_j (|M_j^+ - \mu|)$, is given in the last column of Table 8. This measure of the average total change from one response to the next was used to compare A with the mean of C, U, and S at 75 and 109 msec (109 and 144 msec for AK). The difference between the mean absolute effects in A and in C, U, and S was .051, .226, and -.043 for AR, GL, and AK respectively. The increase in mean absolute effect was larger in C, U, and S, where it averaged .32 over Ss, than in A, where it is only .06 averaged over Ss. Thus the result for this measure is qualitatively the same as the result for $M_4^+ - M_1^+$, even though M_j^+ is in general curvilinear with j (Figure 2). Both measures show little order information in either experiment, but slightly more in C, U, and S, than in A.

4. Within-Trial Order Information

a. Definitions of measures

The extent to which the objective of the digits was revealed by the S's responses has so far been studied by conditionalizing the mean stimulus reported on the different response positions of Recall 4, and on the different response estimates of Recall 1. Additional information concerning order may be computed for Recall 4 data. The need for finer measures of order in Recall 4 follows from the fact that the averaging procedure used to generate M_j^+ may conceal considerable additional order information. For

example, in both the following sets of response vectors, M^{+}_{j} increases perfectly with j: the set (R =(1,2,3,4), R = (2,3,4,5), R = (3,4,5,6). Yet, only in the former set are the within-response orderings perfect. The number of possible orderings of the Recall 4 responses is 7.6.5.4 = 840. This large number precludes an exhaustive analysis of order. Therefore, order information within eash response was studied by forming three new random variables.

$$R_{i,j} = \begin{cases} 1 & \text{if } \underline{S} \text{ reports stimuli i* and j in R} \\ 0 & \text{otherwise} \end{cases}$$

$$R_{i<j} = \begin{cases} 1 & \text{if } R_{i,j}=1 \text{ and i is reported in an earlier position in R than is j} \\ 0 & \text{otherwise} \end{cases}$$

$$R(i,n) = \begin{cases} 1 & \text{if } \underline{S} \text{ reports a run of n successive stimuli beginning with stimulus i} \\ 0 & \text{otherwise} \end{cases}$$

with probabilities

$$P_{i,j} = P(R_{i,j} = 1)$$

$$P_{i<j} = P(R_{i<j} = 1)$$

$$P(i,n)=P(R(i,n) = 1).$$

to be estimated from the data.

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*Note: as before, 'stimulus i' denotes the digit in the i^{th} position of the positive set.

These basic probabilities are used to compute the following statistics:

$$Cov_{ij} = \begin{cases} P_{i,j} - P_i \cdot P_j & \text{if } i \neq j \\ 0 & \text{if } i = j \end{cases}$$

$$C_{ij} = \begin{cases} P_{i<j} / P_{i,j} & \text{if } i < j \\ P_{j<i} / P_{i,j} & \text{if } j < i \\ .5 & \text{if } i = j \end{cases}$$

$$Tau_{ij} \begin{cases} (P_{i<j} - P_{j<i} / P_{i,j} & \text{if } i \neq j \\ 0 & \text{if } i = j \end{cases}$$

where Cov_{ij} is the covariance of i and j, C_{ij} the concordance of i and j, and Tau_{ij} is Kendal's Tau when $i < j$, ans is -1 times Kendal's Tau if $i > j$.

Note that Cov_{ij} and Tau_{ij} lie between -1 and +1, while C_{ij} lies between 0 and 1. The statistics are as equal to 0 for i = j since $P(R_{i,i}) = 0$, by instruction to S. The statistics may be interpreted as follows. Cov_{ij} increases as the joint probability of report of sitmuli i and j increases above what would be expected on the basis of 'conditional independence'. The condition is that $P_{i,j} = P_i \cdot P_j$, unless i = j, when $P_{i<j} = 0$ rather than $(P_i)^2$ by instruction to S. C_{ij}, the concordance of i & j, increases as the degree of agreement in order between the stimulus and response increases. Tau_{ij} increases as stimulus i tends more and more to be reported before j in the response. The hypothesis of no order information would

imply that $C_{ij} = .5$ and that $Tau_{ij} = 0$, for every i and j. Tau has the following additional properties: it is anti-symmetric, so that $Tau_{ij} = -Tau_{ij}$; it is equal to $2 \cdot P(R_{i<j} \mid i<j) - 1$; and it has variance $n(2n + 5)/ 9n(n-1)$ (Hays 1963, p. 651), where n equals the number of pairs, $\underline{N}(P_{i<j} + P_{j<i})$.

b. The Recall 4 within-trial order information

First, consider the covariances. There are 21 Cov_{ij} terms per condition, that is, $\binom{7}{2}$. The main result is that the Cov_{ij} terms lie between -.15 and +.002 for all Ss and conditions, and do not vary systematically over i or j. (The mean convariance, taken over i and j in the positive set, is given for each S and condition in Table 32. The mean Cov_{ij} terms are small and unrelated to SOA or CC.) Thus, the probability of reporting a digit from position i is essentially independent of the chance of reporting a digit from position j, for all i and j. This important result means that the stimuli were reported independently of each other. (Note that the Cov_{ij} measure is unrelated to the order in which i and j are reported in the response.) Next consider the 21 concordances C_{ij}, which measure the proportion of correct reports of the order of i and j. They displayed a strong dependence upon i and j. The nature of this dependence is disucssed later, in the section dealing with the Tau statistic. Mean concordance, $\overline{C}$, averaged over the C_{ij}, is given for every condition in

Table 31. Panel A of the table shows $\bar{C}$ computed with negative set responses included as position8; Panel B shows $\bar{C}$ with negative set responses excluded. The effect if including the negative set responses is to increase mean concordance by .017, .026, and .045 for AR, GL, and AK respectively. This increase either reflects correct perceptions of the later stimuli of the negative set, or reflects guessing without replacement, which tends to place later digits in later responses (see the Discussion for an analysis of guessing effects). Therefore Panel A data should be accepted if guessing is assumed not to occur, and Panel B data if it is assumed to occur. In both panels, the main results are that $\bar{C}$ increases with SOA, but it is virtually flat over CC, C, U, and A, increasing only with the square. The increase of $\bar{C}$ with SOA is from near chance (.5) at 75 msec to near .8 at the slow SOAs (178 and 124 msec). This result implies that Ss' order information at the fast SOAs is close to zero, using the within-response measure of concordance.

The mean concordance in the A condition may be compared with the mean concordance over CCs given in Table 31. The overall mean difference is .033 over Ss and relevant SOAs. In detail, $\bar{C}$ was slightly higher for A at 75 msec, by .048, and slightly lower for A at 109 and 144 msec, by .074. Thus increasing SOA increased $\bar{C}$ by .166 in C, U, and S, but by only .008 in A, when averaged over Ss. This result replicates the similar result found for the

increase in mean responses M_j^{+-} with j, already described.

Concordance was computed conditional upon EP, the position of the earliest stimulus reported. The mean conditional concordance, $\overline{C}(e)$, was found for each condition and EP, and is given in Table 30, Panel A. These data include the negative set as position 8. Data are given for each EP in which there was more than 10 responses. The last column of Panel A shows the correlation of conditional concordance with EP; starred correlations are significant by a two-tailed t test at 5%. The correlations were large (all above + .75), and in nearly every condition the conditional concordance increased monotonically with EP, except for the highest value of EP. Since the effect of CC upon conditional concordance was small, the mean conditional concordances over CC are given in Table 30, Panel B, and are plotted in Figure 10. By and large increasing EP and increasing SOA have independent effects upon conditional concordance, as may be seen from the near-parallel curves in Figure 10, although no statistical test of this has been performed.

c. Order in Recall 1 and Recall 4 compared

A comparison of some of the possible measures of order in Recall 4 and in Recall 1 is given in Table 37. Order was measured in Recall 4 by mean concordance $\overline{C}$ (Table 31). Two measures of order were used in Recall 1,

both relying on the relationship between NP and the estimate of NP: the first was $M=\bar{P}_i(4)-\bar{P}_i(1)$, the increase in mean NP as the estimated position increased from 1 to 4, and the second was $\bar{D}$, the mean of D(j, j + 1) for j = 1 to 3 from Table 33. M is sensitive to the direction of change in mean NP with the estimate; $\bar{D}$ is sensitive only to the amount of change, not the direction. For all Ss and most measures in Recall 4 (see Table 37), order information increased slightly as CC varied from either C or U to S, and increased somewhat more as SOA increased. (Exceptions to this were the M measure for AR and for GL at 109 msec, where order information decreased in S, and the M measure for AR which dropped as SOA increased; these exceptions are mirrored by similar changes in the slope of the regression line on $\bar{P}_i(j)$ on j given in Table 34, Panel B.) From Figure 11 it may be seen that the $\bar{P}_i(j)$ measure, averaged over CC and subtracted from the grand mean, increases with j for all conditions except AR 109, where it decreases when j = 4. A possible cause of this discrepancy is sampling error, since only .025 of AR's trials at 109 msec had j = 4 (at 75 msec, this proportion was .1). If this is true, a reasonable conclusion is that order increases with easiness of task.

On the other hand, when $\bar{C}$ and $\bar{D}$ or $\bar{C}$ and M are correlated over the 6 observations for each S (2 SOAs x 3 CCs), the correlations are small and

insignificant for both AR and GL by a one-tailed t test of r (Hays, 1963, p. 529) at .05 (Table 37, Panel B). The low correlations may be due to the rather small range of the observed order measures. The amount of order information is small for AR and GL at these SOAs, and a comparison with longer SOAa might have yielded a more consistent increase in the Recall 4 and Recall 1 measures of order information. Thus, the quite reasonable hypothesis that the order measures should behave the same in Recall 1 as in Recall 4, by, for example, showing similar CC and SOA effects, is not supported by the data. That hypothesis is not to be rejected by these data either, however, because of the restricted range of the measures.

The finding that the small amounts of order information obtained in the two tasks did not show quite the same effects of condition should not distract attention from the main result of section b: which is that order information was so small in both tasks. The conclusion that for the short SOAs S's responses were made by and large independently of the presentation order of the digits is inscapable.

d. Item and order information in Recall 4

It is of interest to discover whether 'item' and 'order' information co-varied over conditions of CC and SOA. Item information was measured by P(+), the probability of a response from the positive set. Order was

measured by mean concordance, $\bar{C}$. The correlation between P(+) and $\bar{C}$ is +.94, +.92, and -.87 for AR, GL, and AK. These correlations are based on 12, 12, and 9 data points (conditions of CC and SOA) respectively. The correlation for AK is negative because P(+) decreased with SOA, rather than increasing as in the other Ss. The decrease in P(+) was in artifact of a bad choice of location for the positive set at the longer SOAs. The high positive correlations in AR abd GL reflect the fact that P(+) and $\bar{C}$ both increase as SOA increases, and increase over CCs in the order u, C, S. A more detailed study of the relationship between item and order, using measures that depend on the positive set position (namely, P_i and V(i)), will be given in the Discussion (in the presentation of Model 4). From this study it appears that item and order correlate very highly in all three Ss.

e. Stability in Recall 4 item and order measures

Both $\bar{C}$ and P(+) were conditioned on the position of CC in the latter stream. CC positions were grouped into 4 quadrants, with either 3 or 4 letters in each quadrant. Panel A of Table 39 gives p(+), and Panel B gives $\bar{C}$, for each quadrant. The data here are averaged over the CCs, which themselves had no effect. It can be seen from the table that the quadrant had no important effect on either measure. Thus both item and order information are

independent of the position of the CC in the letter stream, which is support for Assumption 1 (stability).

CHAPTER IV

DISCUSSION

The purpose of the Discussion is, in section 1, to discuss the assumptions of the modified complication method; in section 2, to present two models for latency to account for the results for RT and T; in section 3, to present four models for item and order information that can partially account for the digit responses in Recall 4; and in section 4, to summarize.

The discussion of latency in section 2 is organized so that the basic theory, the two models, the SOA and CC effects on T, and the relationship between latency and visual memory, are discussed in six successive sub-sections. The item and order models in section 3 of the Discussion are presented, after an initial discussion of the basic theory, in sub-sections 2 through 5. Sub-section 6 provides a summary of the four models and a discussion of some additional issues that arises in consideration of the details of the models. Whereas the two latency models are pitted against each other, the four item and order models address somewhat different aspects of the data and are not competitors.

1. Assumptions of the Modified Complication

1. Overview

The purpose of the next few sections is to list and justify sixteen basic assumptions that must be met in the modified complication, in order for this method to be used to estimate detection latency. These assumptions are presented in verbal form. When a formal representation of any of them is required in a model, it will be given as an axiom of the model.

The first three assumptions concern the CC detection latencies. The subsequent assumptions concern first S's perception of the stimuli, and then his memory of the comparison stimuli (the digits).

2. The Assumptions in Detail

a. The latency assumptions

(1) Stability is assumed. In this context, stability refers to the assumption mentioned in section 2d of the Introduction that the presentation time of the CC, T_C, has no effect on latency. That is $P(RT \leq t' \mid t_C=t) = P(RT_C \leq t')$, and $P(NP=i \mid t_C=t) = P(NP=i)$. If true, this assumption allows the averaging of trials with different 'fore-periods' (t_C). Stability was found to obtain in the data, for RT, for T, and also for mean concordance (Results, section 4.4e). (In addition, the usual assumption that different trials may be averaged was also made, with

the effect of session on RT being corrected for in the data of AR and AK when needed (Results, section 3.2) in order to meet this assumption.)

(2) Independence, and (3) Additivity, of the latencies of the detection and post-detection stages of processing are assumed. These two assumptions, necessary for Donder's subtraction method, were explained in section 2 c. of the Introduction. We consider here the results for T_{NP}. Under these assumptions,

$$T_{NP} = L_c + S_d$$

where L_c is the CC detection latency and is independent of the digit SOA d; and S_d is the post-detection latency and depends on d but is independent of CC. This model for T_{NP} (actually, latency model 1 in section 2 of the Discussion) is supported by the finding that mean T_{NP} depends both on the CC and on SOA, but that there is essentially no CCx-SOA interaction effect on mean T_{NP}. The model also predicts that there should be no CCxSOA interaction effect on the variances, and this was not confirmed (Results, section 3.3).

b. The perceptual assumptions

The next four assumptions concern Ss 'perception' of the stimuli in both streams. The first defines the use of the terms 'perception' and 'percept'. The next three concern the mapping of stimuli into percepts, perceptual

latency, and 'independent' perception of the CC and the comparison stimuli.

(4) Discrete percepts are assumed to occur, in the sense that S is assumed to be able to uniquely identify each percept, and thereby identify the stimulus that gave rise to that percept. The use of discrete alphanumerics in this research was designed to make this assumption more plausible. By 'percept' is meant a spatially extended image that is available for report. The term 'percept' will be used to refer to discrete and identifiable percepts only, unless it is modified by the word 'fused' to indicate that two percepts have become fused together, as when, for example, '0' and '1' are fused to form '0'.

Evidence to support Assumption 4 comes from the finding that in most conditions, P(NP=i) was close to zero for at least one value of i. If Ss has often mis-identified their percepts, (reporting an '8' for a '3', for example, because of the similarity of two right-hand sides) then such mis-identified digits would occur in random positions of the critical set, and so increase P(NP=i) above zero for every i.

(5) One-to-one mapping of stimuli into percepts is assumed, with qualifications in Case 1 below. This assumption has two parts: (5a) that the number of stimuli is not greater than the number of percepts; and (5b) that the number of stimuli is not fewer. Both assumptions can be applied to stimuli within and between streams, so that

there are 4 cases to be considered.

Case 1. Assumption 5a, applied within streams. This assumption means that the successive stimuli in a particular stream are all perceived, although not necessarily in the order of presentation. This assumption would fail if successive stimuli masked each other. Such masking would force S to note stimuli for report that were later in time than his attention shift. In this case, T would be over-estimated, and the measurement of detection latency from T could be biased.

Masking could arise either by the 'integration', or fusion, of successive stimuli; or by the 'interruption' of the processing of one stimulus by the processing of the next (Kahneman, 1968). Integration is ruled out by Assumption 4, for which there is some evidence. Interruption could not be ruled out by evidence from this research. The possibility that interruption took place, and thereby violated Assumption 5a, is therefore taken into account in modelling the perception of the digits (Discussion, section 3).

Case 2: Assumption 5b applied within streams. This means that the successive stimuli of a particular stream are assumed not to give rise to 'additional percepts'. Examples of possible additional percepts are: Beta motion, in which stimuli A and B are presented, and S perceives A, B, and motion from A to B; after-images; and percepts created from the combination of features from

successive stimuli, such as if S were presented with 3 and 5, and perceived 3, 5, and 8. The effects of such additional percepts might be either to obscure the percepts of stimuli presented elsewhere in the stream, or to create new percepts that S mistakenly identifies as stimuli; in either case, estimates of L_c based on the distribution of temporal judgements would be biased.

In the experiment, Ss were not aware of the occurrence of any such additional percepts. Perceptible apparent motion, for example, was virtually eliminated by presenting each stimulus for a very brief interval (less than 5 msec), and following it by a longer blank interstimulus interval (ISI). However, the method certainly cannot rule out the existence of additional percepts. (Unless it is assumed that such percepts, if they gave rise to reports, would lead to reports that were distributed randomly with respect to the positions of stimuli in the stream. In this case, it may be possible to remove the influence of such randomly distributed reports. This issue is taken up in section 3 of the Discussion, under Model 2). If the rather simple assumption is made that if such additional percepts did occur, their existence would bias the estimates of L_c equally over the different CCs, then the subtraction method would remove the effect of this source of potential bias.

Cases 3 and 4: Assumptions 5a and 5b applied between streams. This means that the presentation of

stimuli in one stream doesn't change the perception of the number of stimuli in the other stream. Clearly, failure of this assumption would be a disaster for the complication method, since the aim of the method is to use the comparison stimuli to measure detection latencies of the CCs. If the choice of CC were to influence the mapping of comparison stimuli into percepts, then the effect of CC on T would no longer depend only on L_c, but also on the mapping. The presentation method chosen minimized such possible interactions by presenting the two streams at a sufficient distance from each other so that, at the presentation rates chosen, there were no obvious perceptible interactions between the streams. Variations in the rates of presentation of the comparison stimuli were introduced partly in order to test whether the CC effects on T were independent of the presentation rate: this would presumably not be true if cross-stream interactions did in fact exist, and it was true (Results, section 3.3d).

In sum, the assumption of one-to-one mapping of stimuli into responses is qualified by the possibility that the assumption may break down for successive stimuli within the comparison stream, either because of some form of masking, or because of fusion. A correction for the masking case is developed in the Discussion (section 3). It is reasonable to assume that such a breakdown will not influence the estimated latency differences L_c-L_c, although it will influence the actual latencies; and this

assumption may also be tested (Discussion section 3).

Some paranthetical remarks on other tests of Assumption 5

One test of the assumption of one-to-one mapping might be to require S to detect the presence of any specific digit in the digit stream, or to report which of a small number of target digits was present in the stream. Experiments in which S searches through a sequence of 'frames' for target numerals have been conducted by Sperling et al (1971) and by Shiffrin and Schneider (1975). Assuming in the present experiment that S only searches through the digit stream, his operative frame size is 1. Sperling et al (1971) show that search for a target digit amongst letters can be performed perfectly at an SOA of 60 msec at their smallest frame size (2). Shiffrin and Schneider similarly show 95% detection at 80 msec with frame size of 1 (their Fig. 2). In pilot work, AR was able to detect the presence of any particular digit in the stream perfectly at 75 msec with frame size equal to 1. However, in the experiments of Sperling and of Shiffrin and Schneider, the target was searched for amongst stimuli of a different type (letters). When Shiffrin and Schneider asked their Ss to search for a target digit amongst digits, their 'same set distractor' condition, then performance was much worse. Ss were about 80% correct at an SOA of 120 msec, and 95% correct at 200 msec (their Fig. 2). This condition is similar to the pilot work on AR, and yet

the results are not. Perhaps this discrepancy occurred because Shiffrin and Schneider varied frame size (and 'memory set' size) on every trial, or because of different physical parameters of stimulation such as font; it is probably not due to practice effects, since all this data is well-practiced Ss. (Certainly naive Ss find segregation of the successive digits virtually impossible, quite apart from detecting any particular digit, in the conditions of the present experiment.)

Even if Ss are able to discriminate the presence of a particular digit in the digit stream from its absence, the assumption of one-to-one mapping does not necessarily follow. Detection of a particular digit may require processing effort that lessens the probability of detection of succeeding digits, for example. Aarcnson (1968) found that the requirement to recall a digit from a 7-digit sequence, presented auditorily with an SOA of 167 msec, delayed the perceptual processing of that digit as measured by RT for detection of the digit. If either the requirement to detect more than one digit, or the requirement to recall digits, made the perception of any specified digit harder, it would be possible to obtain perfect detection data for one target digit, in conformity with one-to-one mapping, and yet generate perceptual loss of some digits when the additional recall requirements were introduced.

The similarity of the P_{il} data of Recall 4 and the P_i data of Recall 1 in the present research, however,

suggests that at least for AR and GL the requirement to recall 3 additional digits did not change S's performance on the first digit reported (NP). If Model 2 is accepted, the recall task began to overload S for the three digits following the NP, so that g_j, the amount of guessing in the j^{th} response position, increased markedly with j. If Aaronson's (1968) conclusion that recall is in conflict with the detection (in her terms, monitoring) of successive digits, is true in vision as well as in audition, then the decrepancy between the perfect detection of one named target digit in AR's pilot data and the large value of g_j in the Recall 4 task, is accounted for by the burden of recalling 3 extra digits. This means that the results of the Recall 4 task might underestimate the information perceived when S does not have to recall. (Rather than observation of the real world interfering with the real world, memorization of the perceived world interferes with perception!)

(6) Perceptual latency. The assumption is made that the only aspect of S's processing of the stimuli that makes the RT and T depend on the CC, is the time taken to detect the CC, L_c. The ssumption would fall if S could make temporal judgements (and initiate RTs) on the basis of non-temporal cues in the stimulation. Let me clarify this point with two examples. First, suppose that the nature of the comparison stream were to vary reliably with the CC. Then, S could base his responses on the variation

in the comparison stream, rather than on the identification of the CC. Secondly, suppose that a particular CC were reliably associated with a particular comparison stimulus. Then, S could base his noting responses on such an association. In both examples, S's responses would no longer depend only on t_c-t_i.

These possibilities were ruled out by randomizing the stimulus order from trial to trial. Such randomization does not ensure that S never uses non-temporal cues in making his responses; but it does ensure that such cues have no information of relevance to the responses. That is, the use of such cues may inflate the variance of the distribution of noting responses (or of RTs), but it cannot bias the mean.* (Assumption 6 does not rule out the possibility that non-temporal changes in the perception of the comparison stimuli result from the perception of the CC. Indeed, the method of the modified complication requires S to "shift attention" from the CC to the comparison stimuli, and this "attention shift" may strongly influence the perception of the comparison stimuli. The point is that these changes are a result of the response made by S, not a cause of it).

The assumption that changes in RT and in T with CC

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*This is not true if the distributions are truncated. In this case, the mean may be biased as well as the variance. The distributions collected in the following research were truncated, but the area in the truncated tails was probably very small in the case of T and certainly very small in the case of RT.

reflect only changes in the time for processing the CC, and not any other changes, is a basic and untestable assumption of the complication method. The assumption could fail in the following way. Suppose S's perception of the letter stream suffered from order confusions, as did the digit stream at the same rate (214 msec). If the degree of loss of order were to depend upon CC, then an indirect effect of CC upon the measured latency could occur, in violation of Assumption 6. Suppose for example that order were more veridical in S than in C and U, not merely for perception of the digits, but also for perception of the letters. Suppose in addition that the order confusions in C and U tended, on average, to interchange the CC with a letter presented after the CC. Then the perception of the CC would be delayed because of order confusions, more when the CC was a C or a U, than when it was a S. The small size of the CC effect on concordance, and the inherent unlikelihood that the order confusions were directed in time (so that the CC was more likely to be interchanged with a later-presented letter than an earlier presented one), make this source of bias an unlikely one.

(7) Partial independence between the processing of the CC and the processing of the comparison stimuli is assumed to hold. This means that if the processing of the CC influences the processing of the comparison stimuli, the amount of influence is independent of the particular CC presented. This may be contrasted with complete

independence, in which it is assumed that the processing of the two streams is independent in every way, so that, for example, turning off one stream would have no effect on the processing of the other. Complete independence is unlikely to occur empirically, but only partial independence is necessary for detection latencies to be estimated from T and RT. Failure of partial independence implies that the latency estimates would reflect both changes in the CC and changes in the processing of the comparison stimuli that were contingent on the CC change; and such an interaction would violate the Donders' assumptions.

Empirical violations of partial independence occur if it is found that (a) RT and T depend to different extents on changes in comparison stimulus processing; and (b) that the CC effect on $\overline{RT}$ (mean RT), $\overline{RT}_c - \overline{RT}_{c'}$, does not equal the CC effect on $\overline{T}$, $\overline{T}_c - \overline{T}_{c'}$. For example, if critical character c slowed down comparison stimulus processing more than did c', and if T increased with increases in comparison stimulus processing time more than did RT, then $\overline{RT}_c - \overline{RT}_{c'} \leq \overline{T}_c - \overline{T}_{c'}$, in violation of the assumption. Partial independence may also be violated if there exists a measure of comparison stimulus processing that should theoretically be independent of the CC (such as the pairwise order measure explained in the Results, section 4), and that measure is found to empirically depend on the CC, for in this case the change in CC must have differentially influenced comparison stimulus processing.

c. The "attentional" assumptions

The term "attention" commonly covers several related concepts (Moray, 1969). These include "salience", or the 'attention-getting' power of a stimulus; the "direction of attention"; the "intensity of attention", or effort; and "set", or the direction of attention towards expected future stimuli. It is presumed that after long practice, the CCs were very salient to the Ss, so that the results of an experiment in which the CCs were frequently novel might differ from the present results. Assumptions concerning intensity, direction, and set follow.

(8) The intensity of attention is assumed either not to vary at all, or to vary independently of the particular CC presented. That is, while processing capacity may be transferred between the streams of stimuli (attention shifting), the total amount of such processing capacity (intensity of attention) is assumed not to vary with the CC. (If it did, then variations in RT and T with the CC might be due not to variations in L_c, but to variations in the intensity of attention paid to the CC. Similarly, variations in T with the CC might be due to variations in the intensity of attention paid to the digits with the CC, rather than being due to variations in the time of attention shifting produced by variations in L_c). Assumption (8) is reasonable if the total intensity of attention can only vary to a significant degree over a span of time much longer then L_c. It is, however,

untestable.

(9) The "direction of attention" is assumed to be under experimental control, as follows: first S directs his attention to the letters, then he "shifts attention", and then he pays full attention to the digits. Give the assumption of a fixed total processing capacity (Assumption 8), the term attention shift is used to refer to changes in the allocation of that fixed total capacity to one or other of the stimulus streams.

Control over the "direction of attention" is important in the study of latency. Stone (1926) found that "paying attention" to a click could advance its perceived arrival time with respect to a tap, by as much as one quartile of the distribution of the TOJs, for example. Shifts of "attention" may also change the clarity (attensity) and discriminability of visual stimuli, at least in a complex field (Grindley and Townsend, 1968), which might affect L_C. In the present research, control over "attention" was established not just by instruction, but also by presenting the CC in a stream of other letters. S was instructed to maximize his chances of detecting the CC, and, it is assumed, needed to pay "full attention" to the letter stream in order to do so. If Ss tried to "divide their attention" between the letters and the digits, then they found that they could no longer detect the CC on virtually every trial. (As was explained in the Method, letter SOAs were chosen for each S so that

detection accuracy was high only if Ss reported that they "paid full attention" to the letters). Because of this procedure, it may be assumed that the prior-entry effect for the CC was near maximum.

In the Arrow (A) condition, the background letters were turned off. In this condition, S can pay "full attention" to the digits, because detection of the CC is trivially easy. Here, the prior-entry effect for the CC is likely to be at a minimum. However, since "attention" is not well-controlled, as S may devote extra "attention" to the CC without being penalized, the Arrow condition does not really ensure a minimum CC prior entry effect (i.e., continuous maximum "attention" paid to the digits). If it is additionally assumed that the processing of the CC in the absence of noise is 'data limited' rather than 'resource limited' (Norman and Bobrow, 1975), then variations in the "amount of attention" payed to the CC should have no effect on L_C. That is, the prior entry effect should remain at a constant minimum. Given this additional assumption, it is tempting to conclude that the Arrow condition may be used as a second and independent method of measuring L_C, in which prior entry is fixed at a minimum rather than at a maximum. However, there is every reason to expect that the L_C for a CC embedded in the letter stream is greater than the L_C for the same CC in the absence of the letters. Therefore, the change in the conditions of attention in the Arrow experiment is, from this

point of view, confounded with a change in L_c.

The attempt to control "attention" was, as far as it went, reasonably successful. The aim in the C, U, and S conditions was to force S to pay "full attention" to the letter stream until he detected the CC, and only then to "shift attention" to the digit stream. To the extent that Assumption 13 holds, so that lack of attention to a position ensures that the digit in it cannot be perceived, then the finding that $P_i=0$ for $t_i \leq 0$ is evidence that attention did not shift before time 0. The best evidence for this is the low P_i obtained in every condition (Table 2) of C, U and S. In the conditions with a slow digit SOA (144, 178 and 214 msec), P_i was greater than zero for $t_i \leq 0$, and for those conditions the assumption to some extent fails. In the fast digit SOA conditions, $t_1 > 0$ and the assumption that $P_i=0$ for $t_i \leq 0$ is not directly testable. (However, pilot work on AR in the fast SOAs did use a positive set of digits beginning at $t_i=0$, and found virtually no reporting of the simultaneous digit). If it is assumed that digits from the negative set were in fact all guessed, then $P'_1 \equiv 0$.

A violation of Assumption 9 occurs if it is assumed that S did not guess. Then, finding $P(NP=0) > 0$ in the slow digit SOAs is compatible with the assumption that S switched attention earlier than usual in order to take advantage of the easier conditions for these digits; such a strategy would be compatible with the instruction to

'report the first digit seen', but would violate the assumption that attention shifted from the CC according to a probability distribution of times that was independent of digit SOA. On the other hand, since S did not know which CC would be presented, his attention to the letter stream would not vary over CCs: and if it is assumed that the time to perceive the CC was considerably smaller than the time to shift attention, the gain that S might make by shifting earlier in a condition of slow SOA would be small with respect to the total time taken for the shift, and so t(NP) and t(EP) would be relatively unaffected by this violation.

A paranthetical note on the necessity to shift attention

It may seem curious that in the conditions of the present research, Ss were unable to process the two streams in parallel, but had to shift attention between them. Considerable evidence exists that Ss may process several locations in a visual array in parallel (Gardner, 1973; Egeth, Jonides, and Wall, 1972). A reduction in the detectability of one target stimulus may occur when the number of locations in the array is increased, suggesting a sharing of attention or serial scan of locations: but a model in which the confusability of stimuli, rather than the spread of attention, is increased by increasing the number of locations, seems to explain the available data (Gardner, 1973). In an explicit attempt to make shifting between

positions profitable, Shiffrin and Gardner (1972) presented 4 letters either simultaneously, or in successive pairs separated by 500 msec. If S could allocate attention first to one pair and then to the other, he should be able to improve his detection accuracy for a single target letter amongst the 4 in the successive condition over his accuracy in the simultaneous one. He could not.

The attention issue is complex, however. Liss and Reeves found strong evidence for an effect on the detectability of dot targets of shifting attention between locations of a visual display under patterned masking, although there was no attention effect on a briefly presented target without a mask, in unpublished work. Eriksen and Colegate (1971) found that report of the second of 2 letters from an 8 letter display was reduced in accuracy if the second letter were not adjacent to the first, suggesting to them that S serially encoded letters from a decaying icon of the brief display. Independent processing from each location would not explain their results, although a parallel process whose rate depended on the amount of (shared) attention would also explain the results. Taylor, Lindsay, and Forbes (1967) found that $(d')^2$ was reduced to 85% of its original value for detection of a lateral movement of a dot in visual noise, when S had to simultaneously detect its vertical position or to attend to the pitch or intensity of a tone. Posner, Nissen, and Ogden (1975) found that RT was speeded if a

visual target was presented in an attended-to position, as opposed to an unattended position. Norman and Bobrow (1975) suggest that independent processing occurs when performance is 'data limited', and shared processing occurs when performance is 'resource limited'; but it is unclear how to determine the limitations on processing a priori, so that the distinction does little more than summarize the discrepant findings under an admittedly ingenious scheme.

Even if it is accepted that S had to shift attention in the present research, first attending to one stream and then to the other, the data of Sperling et al (1971) in a similar experiment suggests that S could scan both streams if they were presented with a SOA of 60 msec, and still given perfect performance (this research is discussed further below). The aspect of the present experiment that forced S into a serial attention-shifting mode seems to have been not the difficulty of the letter-detection task per se, but the combination of that task with the digit recall task. Parallel processing of both streams would only work if S could prime both letter detection and digit recall processes. Mere passive looking at both streams would probably have sufficed to detect the 'automatic' CC response (Shiffrin and Schneider, 1975) at the slow letter SOA used, but would not have sufficed for the processing of the digits to the level of visual code needed for later recall. Active looking at the

digits, with "full attention," would force "attention" away from the letter stream, and so reduce the probability of detection of the CC by an experimentally unacceptable amount. This interpretation is not consistent with the view of Shiffrin and Schneider, who have evidence that an 'automatic' (high salience) target letter will claim "attention" for itself, even when presented in an un-attended location. (However their data do not exclude the possibility that the effect on subsequent processing of an 'automatic' target would be less in an "un-attended" than in an "attended-to" position, which is the claim being made here). This interpretation is consistent with the idea of Moray and Fitter (1975), that Ss share attention between input channels (streams) until a target is detected in one stream, at which point they shift to that stream. Since in the experiment reported here, Ss knew that they would receive the target CC in the letter stream on every trial, it was worth their while to continuously pay attention to the letter stream, and not divide before the CC was detected. This strategy would have the advantage of speeding the RT to the CC (Woodworth and Schlosberg, 1954, p. 32).

(It may be noted at this point that although the Ss reported here could not process the two streams in parallel at the rates tested, except to a slight extent at the longer digit SOAs, in a demonstration of the experiment one naive observer was able to report the objectively

simultaneous digit on a majority of trials at a digit SOA of 109 msec, a feat not attained by any of the practiced Ss, or any of the other naive Ss).

(10) Set effects are assumed not to occur. Since the CCs were randomized from trial to trial, and since Ss were aware that all the CCs had equal 'value', it can be assumed that the incentive for S to form a set towards one particular CC was minimized. If such a set had occurred then the comparison of latencies over CCs would have been biased. (One particular strategy for S might be to assume that one CC was to be presented on a trial, and react to the presence or absence of that CC. Such a strategy can only be optimal if two CCs can be presented, and three CCs were used in the present research. However, S's introspections suggested that they did in fact form a mild set towards one of the CCs used, the outline square). The method adopted is powerless either to prevent or to measure such set effects, even if it can minimize the incentive for them.

d. Assumptions about memory

The information that S has in memory about the comparison stimuli clearly varies throughout the trial. Four important moments may be listed: the time before the attention shift; the time of the attention shift; the time at which the noting response is made; and the time when the noting

response is reported. Since the stimuli are continuously varying, and since the stimulus re-coding demanded of S is quite complex, any 'running memory' that records new stimuli and new transformations of old stimuli must itself be continuously varying. Two crucial simplifying assmuptions are made, which are: that there is no memory for stimuli before the attention shift (by Assumption 13); and that the memory of the comparison stimuli that S builds up in the moments following the attention shift is 'frozen' until the time of report (by Assumption 14). These assumptions mean that there is only one memory to be concerned about. This single memory is assumed to be visual, rather than verbal (by Assumption 16). The visual memory is assumed to be in the form of a 'buffer', as specified in Assumptions 11 and 12.

The next few assumptions specify the nature and use of the visual 'buffer' memory more precisely. The term 'buffer' is taken from a similar usage by Scarborough and Sternberg (1967).

(11) A visual 'buffer memory' is assumed to exist. The buffer memory contains an unknown number of positions, each of which may be filled by a representation of a stimulus. The buffer is assumed to be initially empty. When it is filled up, new stimulus representations overwrite old ones. The stimulus representations form 'icons', as defined in Assumption 12. The contents of the buffer are strictly ordered in time, but the order of these contents

need not be the same as the order of the actual stimuli (Assumption 14). Which stimuli are given representations in the buffer is specified in Assumption 13.

(12) The contents of the buffer are representations of stimuli which form 'icons.' The term 'icon' refers to spatially extended images of stimuli, or percepts, which are visible to S. and which are the products of 'focal attention' (Neisser, 1967). Such icons must be distinguished from 'rentinally-based' icons* such as postulated by Sakitt (1976), which are also spatially extended and visible to S, but which are assumed to be products of a rentinal 'memory'. The distinction between the two types of icon is forced because of the following consideration. If all 'icons' were retinally based, like after-images, then two things follow. The first is that the concept of a 'buffer' becomes redundant, since the retina may store only one image at a time when successive stimuli are presented to the same location on the retina. The second is that the sequence of seen icons must be in exactly the same order as the sequence of stimuli; retinally-based icons may be lost (through temporal smearing), but they cannot be shuffled in order. These two consequences violate Assumption 14 below, and therefore the contents of the visual buffer memory cannot be retinally-based icons.

One potential qualifications of this argument is

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*or icons based on other similar anatomical substrate in which the temporal order of successive stimulations must be preserved.

that successive stimuli might fuse on the retina, so that the icon was of two combined stimuli. In this case, S could report the two stimuli, if he could disentangle them, but he could not report their presentation order. Such fusion of stimuli, however, violates Assumption 5. (The idea that confusions in report order could be accounted for by such fusions was rejected by Scarborough and Sternberg (1967, footnote 8) in a similar experiment).

In the following discussion, the term 'icon' will be used in Neisser's sense, and will be qualified by 'rentinally-based' where necessary, although neither of these terms is ideal. Assumption 12 requires that the contents of the buffer form icons, rather than are icons. This distinction is made because of the possiblity that the buffer contains partial features, which may be converted to 'icons' by the use of additional information in long-term visual storage. A naive observer cannot discriminate successive stimuli at the rates used in the present research, while an experienced observer sees the successive stimuli clearly, in a form that is visually similar to the experience of a single presentation. It is possible that both observers store equal number of partial features of the successive stimuli, but that the experienced observer has learned how to construct 'correct' icons from the partial features. Other such possibilities exist, and the claim that the buffer contains actual icons prejudges this issue. The contents of the buffer might be

termed 'visual codes', following Posner (1969), if a general term be desired. In this case, the fate of a stimulus to which attention is paid would be as follows: to become, successively, a retinally-based representation; a visual code; and finally an 'icon'. In the normal tachistoscopic presentation, the retinally-based representation might furnish the icon, without the other representations being called into play. To maintain neutrality on this issue, I will call the contents of the buffer 'stimulus representations'.

(13) Item information in the buffer is assumed to be under attentional control. Successive stimuli may overwrite old representations in the buffer, if the buffer fills up, by Assumption 11. However, by Assumption 13, S can control the input to the buffer in order to prevent overwriting. The control of input is determined by the direction of attention; input only occurs if attention is directed towards the stimuli. In the modified complication, this means that no comparison stimuli enter the buffer until attention is shifted from the CC to the comparison stimuli; and that no further comparison stimuli enter the buffer after S has shifted away his attention. If S is assumed to know the size of the buffer, then he may avoid overwriting by shifting attention towards and away appropriately. This assumption is vital to the modified complication. If S could not turn his attention away from the comparison stimuli, then his noting

response, by Assumption 15 below, would be based not on the stimuli near CC, but on stimuli presented at the end of a trial. The noted stimulus would then bear no relation to the CC.

Evidence to support Assumption 13 may be found as follows. Let P_i be the proportion of trials in which S reports the i^{th} comparison stimulus. Then P_i may be used to estimate item information in the buffer, given certain corrections for guessing taken up in the Discussion, section 3. Let i=0 denote the position in the comparison stream of the stimulus that is temporally simultaneous with the CC. Finding that $P_o = 0$ provides evidence for Assumption 13 in two ways, no matter what assumption is made about guessing. First, it shows that comparison stimuli only enter the buffer after the CC is presented, for otherwise P_o would be greater than 0. Second, it shows that stimulus representations in the buffer are not overwritten by stimuli presented after the critical set.

It is implicit in the above discussion of Assumption 13 that Assumption 9 is satisfied. For example, if $P_o > 0$, then either Assumption 13 or Assumption 9 might have failed. This dependence occurs because if the direction of attention is not under control, violating Assumption 9, then there can be no way of testing whether items in the buffer were controlled by attention or not. The assumptions are separated here because in principal there is a distinction between control of the direction of

attention between input streams (as in Assumption 9), and control of which items in a given stream do or do not enter the buffer (Assumption 13).

(14) Order information in the buffer is assumed to exist, such that the contents of the buffer are strictly ordered in time, but not necessarily in the order in which stimuli were presented. Furthermore, it is assumed that presentation conditions exist in which the order of items in the buffer is unrelated to the presentation order.

The assumption that order information exists is necessary because without it, Ss would not be able to perform the task of noting the first comparison stimulus: 'firstness' would be undefined. The assumption that the order in the buffer is not the presentation order is necessary under some conditions, because if S had an accurate memory for the temporal order of the stimuli, then he could reconstruct the 'correct' temporal judgement on the basis of that memory. Such reconstructive judgements might dominate S's responses to the relative exclusion of the temporal judgements that were actually made on the basis of the shift of attention from the CC. Indeed, reconstructive memory might allow S to always report the simultaneous comparison stimulus, so that P_O=1, even when his attention shift was much delayed. Such reconstructions might be based on sequential properties of the stimuli, or on 'time tags' that S could associate to the individual stimuli as they were identified.

If assumption 13 is correct, attention never shifts to the comparison stimuli until the CC is detected. This would mean, by Assumption 15, that the noting responses would accurately measure CC processing latency. S could not reconstruct the comparison stimuli (digits) before the attention shift, because they would not have entered memory. Thus, there is a trade-off between Assumptions 13 and 14, such that the more valid the one, the less important is the validity of the other.

The second part of Assumption 14, that the contents of the visual buffer are not necessarily in presentation order, is supported by the finding that concordance was less than one in all conditions. Indeed, concordance in general lies between .5 and .75 for these conditions. Attribution of the low concordances to verbal memory, or to guessing, rather than to disorder in the visual buffer, is ruled out by Assumption 16 and by the analysis of the possible guessing effects on order in the Discussion, section 3, part 5. The stronger assumption that the visual buffer has contents which are ordered randomly with respect to presentation order may be correct, at least in the faster SOA conditions when concordance is near chance. In order to account for the increase of concordance with SOA, however, total randomness is modelled as a terminal state rather than as an essential attribute of the memory, in the Models presented in section 3 of the Discussion.

Assumption 14 and the measurement of latency by T

The finding of a concordance greater than .5 in the slower SOA conditions means that Ss could, perhaps, bias their digit recalls by a memory search. In particular, the digit reported in the first position of the response, whose position in the stimulus is NP, might not be the digit to which attention was first turned. Rather, it might be the result of a backward search through memory: and a veridically ordered memory could then provide the basis for a forward bias on the NP.

The potential biasing effect of a veridically ordered memory is greatly reduced for the EP measure of attention switching latency, however. Since $t(\overline{EP})$ is found independently of the position of the digit in the response, and since there are 4 response positions, a search through a veridically ordered memory could only bias $t(\overline{EP})$ if the number of digit positions over which digits were normally disordered were greater than 4. If disorder only occurred over 4 or less positions, then the disordered memory would provide S with the same EP as the veridically ordered memory. The time span involved in the 144 msec SOA condition, for example, is 4 x 144 = 576 msec. Evidence that re-orderings over such a time span are in fact infrequent will be given in the discussion of Model 4 (Discussion, section 3). At any event, this argument shows that when S does have some order memory, if he used it to bias his digit recalls, then $t(\overline{NP})$ should

show a larger effect of SOA than t($\overline{EP}$). However, the reverse is the case (Fig. 9), even when EP is corrected for guessing by Model 2 to EP'.

The temporal extent over which Assumption 14 applies

The statement that order information in the buffer can be unrelated, or poorly related, to presentation order, refers to the conditions of the present experiment in which attention is paid to the digits only for a brief time period. If attention to the digits was continuous, as may be the case in the Arrow experiment, then clearly S could tell that, say, the second digit presented was not in the last part of the digit stream. Indeed, it is compatible with the assumptions that order information is only disturbed in the neighborhood of the CC. The act of identifying a CC, or the act of shifting attention, may be responsible for the non-veridical order. When attention is constant and no special act of identification is made, order might well be veridical. The results of the Arrow experiment, in which attention did not need to be shifted are suggestive here: concordance was nearly the same as in the C, U, and S experiment, but the temporal range over which order transpositions occured was considerably less (a result which will be taken up in Model 4, in the Discussion, section 3). (More experimentation is needed to measure the temporal extent of the non-veridical orderings).

(15) The noting response is assumed to be made on the contents of the buffer memory. That is, in making the noting response (i.e. noting the first possible comparison stimulus), S is assumed to report the first such stimulus in the buffer. That the noting response is not based on a different memory, such as a verbal memory or a retinal after-image iconic memory, is ensured by Assumptions 16 and 13 respectively. The assumption that the NPs were not the result of guessing, which is implied by Assumption 15, is supported by the finding that in every condition there is at least one i such that P(NP=i) is close to 0.

(16) Stimulus representations enter verbal memory, if at all, only at the conclusion of a trial, when S must give his report. This assumption means that only visual memory is operative during the trial. This is important for the method, since if the properties of verbal and visual short-term memories differ, the interpretation of the data would be made more complex by the confounding of the two memories. Presentation rates were therefore chosen so that the comparison stimuli (the digits) could not be usefully named (verbalized) when they were presented. Anderson (1976) has found that implicit naming rates for digits vary from 3.5 per sec., to 2.5 per sec if a secondary task as required of S. Ss found that if they tried to name the passing digits, they could name one of them, but then would have spent so much time in naming that the next few digits would be lost. However, the

assumption is on weaker ground for verbal episodic memory. That is, it might be possible for S to set up 'digit-name programs' (as in Sperling, 1963), or it might be that verbal traces in L.T.M. are iso facto activated and entered into episodic memory, during the course of the trial. At the end of the trial, S could then output the digits corresponding to the activated traces or to the programs. The present experiment does not decide between these alternatives and the "visual code" notion. Research in which either unknown, but codeable, characters were used, or in which verbal memory is interfered with in some way, is desireable to settle this point. The best evidence for Assumption 16 at this point is that Ss do in fact claim to report exactly what they saw, not what they might have reconstructed from a verbal trace. This might mean that even if program names or traces are being used, they were in one-to-one relation with the contents of the visual buffer, and were furthermore ordered in the same way.

2. Models of Latency

2. Overview

The purpose of section 2 is to model the motor and attentional RTs in terms of assumed underlying latencies. Part 1a presents the basic variables under consideration (observed and theoretical), and describes the basic additive, Donders' style model for these latency variables. Parts 1b and 1c are somewhat parenthetical; they explain

the relationship between the basic theory and the assumptions about perceptual latency and stages made in section 1 of the Discussion.

The Donders' style model is presented in detail in part 2a, as Model 1, and is disconfirmed in part 2b. A modified Donders' style model, Model 2, is presented in part 3a, in which the objections to Model 1 are removed by decomposing the latency for identifying the CC, L_C, into two independent components. These components are interpreted in part 3b. The assumption made in both models, that the attentional reaction time T is a function of digit SOA, is considered more carefully in Part 4. The dependence of mean T on digit SOA, it is suggested, might have been due to any one of four potentially biasing features of the experimental method. This possibility is rejected in parts 4a through 4g. In part 4h, some interpretations of the SOA effect upon T are considered. During the course of part 4, two new measures of attentional RT were introduced, and the obtained CC effect upon these new latency measures is compared to the CC effect on the old measures in part 5. Finally, the relation between attentional RT and visual memory, touched on in part 1c, is reconsidered in part 6 in more detail, in light of Model 2 and the discussions of the different measures of T in part 4.

1.a. Basic Theory and Variables

The variables under discussion are the latency measures derived from the motor and attentional RTs, and the theoretical latencies assumed to account for them. The variables are subscripted by the conditions of d (digit SOA) and c (CC) that are appropriate. The observed variables are the motor reaction time, $RT_{c,d}$; the attentional reaction time defined by the onset time of EP, which is $T_{EP;c,d}$; and the attentional reaction time defined by the onset time of NP, which is $T_{NP;c,d}$. The attentional reaction time is designated $T_{c,d}$ when the choice of T_{NP} or T_{EP} is indifferent. The theoretical variables are the time to identify CC, L_c; the time to shift attention and to note the first digit, S_d; and the residual motor reaction time R_o.

The three theoretical variables are introduced to model the total latency as the sum of components. The basic theory is that S takes L_c msec to detect the CC. He then initiates a motor response with latency R_o. He also shifts attention to the digit stream and notes the first digit, with latency S_d. Letter detection occurs first; the two other processes are then executed in parallel. That is, the execution of the motor response and the shift of attention are assumed to be independent processes that do not share capacity. Two particular models of this basic theory are presented, of which the first is strongly disproved. The second is also disproved, but it accounts

for a great proportion of the data. Since the basic theory requires the assumption of processing stages, this will be discussed next, before the particular models are given.

b. The Assumption of Two Stages

The latency model for RT depends upon the Donders' subtraction method, which has been reviewed by Sternberg (1969a). As was mentioned briefly in the Introduction, the assumption of 'pure insertion', made by Donders and Wundt, is that the duration of a stage of processing may be estimated from RTs to tasks with and without that stage. This idea suffers in practice from the difficulty of finding cases where a single stage may be inserted without influencing processing rates in other stages. Sternberg's replacement of that assumption by an assumption of 'selective influence' requires that tasks be found in which the duration of only one stage may be selectively influenced, without necessarily eliminating that stage. In Sternberg's research, the duration of the critical stage has been varied by varying the number of items in the memory set (Sternberg, 1969b), the display set (Sternberg, 1975), and the intensity of stimulation (Sternberg, 1973).

Here, the duration of the assumed letter detection stage was varied by varying the letter to be detected (CC). Memory set size was kept constant at 3, except in A (the Arrow condition), where memory set size was 1. Since other features of the stimulation were changed in A (the

'noise' letters were eliminated), the effect of memory set size is impossible to disentangle. The view that letter detection occupied a distinct 'stage' in the present experiment is itself somewhat debateable. To the extent that the idea of a distinct stage receives confirmation when operations that influence only that stage are discovered, the assumption of a letter stage is dependent upon the truth of the assumption of partial independence. To a large extent that assumption held up, but the finding that order information in the digit stream depended upon the CC implies a break-down in the assumption. If the letter detection is tied up with the processing of the digits in some fashion other than the mere time of attention shift, then the letter and digit processing stages are no longer merely successive, but interact in some fashion. Such an interaction may be reason to deny the separation of stages. But because the estimates of the CC effects were so similar across the different measures of latency, including the RT (which itself was independent of digit SOA to a very large degree), and because the effect of CC upon order information was rather small, it does seem reasonable to accept the separation of processing stages implicit in the latency model.

2.a. Latency Model 1

In this model, T and RT each are the sum of two components. Each component latency is modelled by an

independent random variable, that takes one value on each trial of the experiment. The random variables are:

L_c the latency for identifying the CC;

S_d the time to shift attention to the digits and to note a digit;

R_o the residual motor reaction time.

L_c is assumed to be a function of c only; S_d a function of d only; and R_o is assumed to be independent of both. Since c and d are experimentally independent, it follows that L_c and S_d are independent of one another.

The predicted latencies, denoted by the tilda, are

$$\widetilde{RT}_{c,d} = L_c + R_o$$

$$\widetilde{T}_{c,d} = L_c + S_d$$

Test of the model

In order to test the model against the data, the empirical distributions of $RT_{c,d}$ and of $T_{c,d}$ were examined. (The provise is made that since T_{EP} and T_{NP} may differ, the value of S_d for the earliest digit EP may differ from the value of S_d for the noted digit, NP. Since the predictions of interest are indifferent to the choice of T_{NP} or T_{EP}, however, this provise is not of further concern in the discussion of this model).

The model makes the following predictions about the distributions of the predicted latencies. If J_r (X) is the r^{th} cumulant of the distribution of X, then

$$J_r\ (\widehat{RT}_{c,d}) = J_r\ (L_c) + J_r\ (R_o),\ \text{and}$$

$$J_r\ (\widehat{T}_{c,d}) = J_r\ (L_c) + J_r\ (S_d).$$

Two predictions concerning the effects of conditions follow. First, for any cumulant r, variation in CC should product the same effects upon $J_r\ (\widehat{RT}_{c,d})$ as upon $J_r\ (\widehat{T}_{c,d})$. This is because the CC effect upon L_c is the only common source of variation in $\widehat{RT}$ and $\widehat{T}$. Secondly, variation in d should have an effect upon $J_r(\widehat{T}_{c,d})$, but have no effect upon $J_r\ (\widehat{RT}_{c,d})$. This is because d only effects S_d. These two predictions were tested against the first two cumulants, the mean and variance, of the observed latencies (RT, T_{NP}, T_{EP}). These predictions held up quite well, as is clear from Results section 3, except that digit SOA was observed to have a small increasing effect upon mean RT, contradicting the second prediction.

The model assumes that the digit SOA has an effect on $\widehat{T}_{c,d}$ by modifying not L_c, but S_d. Evidence that d does not influence L_c is strong. The effect of CC upon both the mean and the variance of T is similar to the effect upon RT, which is compatible with a model that excludes any main effect of d on L_c. However, although the difference in mean RT between one CC and another is virtually constant over different values of d, and similarly in mean T, this is not true for the differences in variance, where an interaction effect does exist, both for RT and for T (Table 28 Panel D). This interaction contradicts

the independence of L_c and S_d assumed in Model 1. As already pointed out, however, the CC effect upon variance was small, so the finding of a CCxSOA interaction effect of a similar size to the CC effect may mean that this discrepancy with the Model is not critical. (For example, in an experiment with larger CC effects upon variance, a relatively smaller interaction might have been obtained).

Model 1 also predicts a dependence between $T_{c,d}$ and $RT_{c,d}$ for a fixed choice of c and d. This is because, in each experimental conditions, L_c is assumed to vary over trials. On trials in which L_c is long, both RT and T should be long on average; and on trials in which L_c is short, both RT and T should be short on average. Proof of this remark is as follows. Let $E(\widehat{RT}|\widehat{T}=t)$ be the expected $\widehat{RT}$ given that $\widehat{T}=t$. Then, from Model 1,

$$\begin{aligned} R(\widehat{RT}|\widehat{T}=t) &= E(\widehat{T}-S_d + R_o|\widehat{T}=t) \\ &= t - E(S_d|\widehat{T}=t) + E(R_o|\widehat{T}=t) \\ &= t - E(S_d|\widehat{T}=t) + E(R_o). \end{aligned}$$

If the variability of L_c were vanishingly small, so that $L_c = k_c$, a constant, then

$$\begin{aligned} E(\widehat{RT}|\widehat{T}=t) &= t - (t+k_c) + E(R_o) \\ &= E(\widehat{RT}) \end{aligned}$$

and so $E(\widehat{RT}|T=t)$ would be independent of $\widehat{T}$. If on the other hand L_c has appreciable variability, independence does not hold. Thus, let

$$E(\widehat{RT}|\widehat{T}=t) = t' + E(\widehat{RT}),$$

where $t' = t - E(S_d|\widehat{T}=t)$.

Since $E(S_d|\widehat{T}=t)$ and $E(L_c|\widehat{T}=t)$ both must grow with t, and since $\widehat{T} = L_c + S_d$, $E(S_d|\widehat{T}=t)$ must grow less fast than t. Therefore, t' is always positive, and must grow with t (although at a slower rate than t). Therefore $E(\widehat{RT}|\widehat{T}=t)$ must be an increasing function of t, if L_c has variability, no matter how these variables are distributed.

Finally, the model predicts that the CC effect on RT should be equal to the CC effect upon T. That is, for example, if c and c' are two CCs, then $E(\widehat{RT}_c) - E(\widehat{RT}_{c'}) = E(\widehat{T}_c) - E(\widehat{T}_{c'}) = E(L_c) - E(L_{c'})$, at each digit SOA. This equality of efforts should also hold for higher cumulants.

b. Rejection of Model 1

Model 1 may be rejected because mean RT changes with CC to a much lesser extent than does mean T, for every SOA and every S. That is, $E(RT_c) - E(RT_{c'}) < E(T_c) - E(T_{c'})$ for every condition, contra the model. Mean RT increases in the order S, C, U, as does mean T, but only at .55 of the rate for AR, .25 for GL, and .45 for AK (these figures were found by linear regression, and averaged over SOAs).

A second reason for rejecting the model is that $\overline{RT}(t_e)$ was found to be nearly uncorrelated with t_e. This measure is an estimate of $E(RT|T=t)$, although the values of t_e were grouped into 75 msec bins, and although the

correlations are slightly increased if T is defined by NP rather than by EP. It is possible to assume that for $t_e <$ 575 msec, $RT(t_e)$ was unrelated to t_e (Results, section 3.5). If this assumption is made, then the model is only consistent with the data if L_c is assumed to have a variance which is insignificant in comparison with the variances of S_d and of R_o. The size of Var (L_c) can be estimated if Model 1 is accepted, because the variance in RT can only change with CC if the variance in L_c changes (because R_o is assumed independent of CC). Therefore the minimum RT variance over CCs, Min [Var (RT)], is an upper bound on Var (R_o). But an upper bound on Var (R_o) necessarily provides a lower bound on Var (L_c), when Var (RT) is known, because variances add. So the lower bound on Var (L_c) is Max [Var (RT)] - Min [Var (RT)]. The data of Table 44 show cases where the lower bound on Var (L_c) is 4 times larger than the upper bound on Var (R_o). Such cases contradict the assumption that variability in L_c is very small with respect to variability in R_o. Since the latter assumption is necessary in order to satisfy the assumption that $RT(t_e)$ was independent of t_e, the model must be rejected on that assumption (Note 3, p.).

(A possible remedy for this situation is to assume that R_o is influenced by CC. In this case, the model becomes Model 1A:

$$\widehat{RT}_{c,d} = L_c + R_{o;c}$$

$$\hat{T}_{c,d} = L_c + S_d \ ,$$

where $R_{o;c}$ depends upon c. This model clearly predicts that a change in CC should have greater effect upon RT than upon T, since L_c is common to both latencies and $R_{o;c}$ influences only RT. This prediction is disconfirmed by the data (Results section 3), since it was found that the CC had very similar effects upon both the means and the variances of the two latency measures. A version in which R_o is made to depend upon d rather than c has the advantage that the small effect of SOA upon RT can then be accounted for; but the problem of finding a satisfactory estimate of the variance of L_c remains unresolved. In Model 2 the problem is approached by breaking down L_c into two components).

3.a. Latency Model 2

This model is based upon the same idea as Model 1, except that the identification latency L_c is assumed to be the sum of two component latencies. One of the components, v_c, is assumed to depend only upon CC. The variance of v_c is assumed to be very small relative to other components. The second component, v_c, is assumed to depend both on the response, RT or T, and on the CC, but to be independent of SOA, R_o, and S_d. The dependence on response is denoted by priming the V_c term, as V'_c in RT, and V''_c in T. The model is then:

$$\widehat{RT}_{c,d} = v_c + V'_c + R_o$$

$$\widehat{T}_{c,d} = v_c + V''_c + S_d,$$

where all variables to the right of the equals sign are independent random variables. As in Model 1, S_d is assumed to be independent of CC and dependent on d, while R_o is assumed to be independent of both.

Model 2 makes the following predictions about the distributions of the predicted latencies, where J_r is the r^{th} cumulant of the distribution:

$$J_r\ (\widehat{RT}_{c,d}) = J_r\ (v_c) + J_r\ (V'_c) + J_r\ (R_o)$$
$$J_r\ (\widehat{T}_{c,d}) = J_r\ (v_c) + J_r\ (V''_c) + J_r\ (S_d).$$

If it is assumed that v_c is constant, rather than having very small variability, the following simplified predictions can be made. The CC effect is mediated by three terms: v_c, V'_c, and V''_c. If V'_c and V''_c have a common distribution, then the CC effect upon the r^{th} cumulant should be the same for $\widehat{RT}$ and for $\widehat{T}$. This is in fact the case, as has been pointed out for Model 1. The SOA effect is mediated only by S_d, and so only $\widehat{T}$ should show a SOA effect, as in Model 1. The new feature of the model is that since V'_c and V''_c are assumed to be independent of each other, $E(\widehat{RT}|\widehat{T}=t)$ is predicted to be equal to $E(\widehat{RT})$, even when V'_c and V''_c have significant variances. The proof of this follows the similar proof in Model 1. Since $\widehat{RT} = \widehat{T} - V''_c + S_d + V'_c + R_o$, it follows that:

$$E(\widehat{RT}|\widehat{T}=t) = E(\widehat{T} - V''_c + S_d + V'_c + R_o \,|\, \widehat{T}=t)$$

$$= t - E(V''_c|\widehat{T}=t) + E(S_d|\widehat{T}=t) + E(V'_c|\widehat{T}=t) + E(R_o|\widehat{T}=t)$$

$$= t - E(V''|\widehat{T}=t) + E(S_d|\widehat{T}=t) + E(V'_c) + E(R_o)$$

$$= E(T - V''_c + S_d|\widehat{T}=t) + E(V'_c) + E(R_o)$$

$$= E(v_c|\widehat{T}=t) + E(V'_c) + E(R_o)$$

$$= E(\widehat{RT}).$$

If v_c is assumed to have a small variance, then, just as in Model 1 when L_c had variance, $E(\widehat{RT}|\widehat{T}=t)$ should increase (slightly) with t. If on the other hand v_c is assumed constant, as in the above proof, $E(\widehat{RT}|\widehat{T}=t)$ is independent of $\widehat{T}$, and the result that $\overline{RT}(t_e)$ can be assumed to be independent of t_e is consistent with the model. Since there are no limitations on the variances of V'_c and V''_c, the finding that the Max[Var (RT)] - Min[Var (RT)] is large relative to Min[Var (RT)] does not provide a problem for the model, as it did for Model 1.

b. Interpretation of model 2

An interpretation for this model is that v_c is a 'sensory' time necessary for detecting the CC, which varies over CCs sufficiently to generate the mean absolute CC effect of about 20 msec (Table 28). V'_c and V''_c represent later 'decision' times: the time taken to reach the

criteria for generating a RT and a shift of attention respectively. The independence of the two variables might be due to independent fluctuations in the two criteria. (A possible reason for such independent might be that since the RT is unrecoverable but the shift is recoverable, the RT criterion is considerably higher on average than the T criterion, and so responsive to fluctuations at a different and later processing stage. It is however somewhat unnatural to assume that fluctuations in the two decision processes should be unrelated to each other).

Some additional support for the distinction between v_c and V'_c, may be found in a comparison of the S and A conditions in Recall 4 at 75 and 109 msec (109 and 144 msec for AK). Averaging over SOAs, the difference between mean RT for the S and mean RT for the A was considerable, being 62, 70, and 100 msec for AR, GL, and AK respectively. The difference between the pooled standard deviations of the RTs in S and the RTs in A was, however, small; being 2, 1, and 24 msec in AR, GL, and AK. For Ss AR and GL at least, it appears that the effect of turning off the background letters was to decrease mean RT and mean T considerable, but to have no effect upon variance. (This conclusion depends upon the assumption that the RT distribution for the S without background letters would have been the same as the RT distribution for the A).

If this result is genuine, it seems that a large change in the conditions of presentation may strongly

influence v_c, but not influence the V'_c component of L_c. This conclusion is somewhat counter-intuitive, since one might expect that the perceptual effects of, for example, masking by the letters presented just before and just after the CC, would strongly influence the perceptual component of L_c. Since the temporally adjacent letters change from trial to trial, one might then expect that the variability of L_c would be larger in the condition with background letters than in the condition without.

The result demonstrates that an experimental operation may change v_c, the nearly fixed component of L_c, but not V'_c, the varied component. This is evidence in favor of the distinction between v_c and V'_c, and thus is evidence for Model 2.

4.a. Further Analysis of the SOA Effect Upon T

The use of $T_{c,d}$, defined as either $T_{NP:C,D}$ or as $T_{EP;c,d}$, to measure the latency to detect the CC is justified by the finding that mean T varies with CC in the same way that mean RT does. It might be hoped that in addition, T would show no effect of digit SOA. This would be the case if T, like RT, were a 'pure' measure of CC detection latency. For the estimates of T that have been so far discussed, T_{NP} and T_{EP}, the data show that T does indeed depend upon SOA. This was reflected in the latency models by making S_d, a component of T, depend on d. However, it could be that various aspects of the experimental

method bias T_{NP} and T_{EP}, so that they show an effect of SOA even when the underlying switch latency is not influenced by SOA. That is, the truth might be better expressed in Model 2A , as follows:

$$\hat{T}_{c,d} = L_c + S_o,$$

where S_o is independent of d.

The features of the experimental method that might bias T_{EP} and T_{NP} are fourfold. The first feature is that the positive set of digit positions is truncated in length, so that digits seen from outside the positive set may be mis-coded. The second is that the distribution of T is assumed to be continuous while the digit stream is necessarily temporally punctate. This means that the continuous distribution of T must be assumed to be 'sampled' by the small set of digit positions. The distributions of T_{EP} and T_{NP} are discrete, and therefore may not correctly estimate the distribution of T. This fundamental problem of sampling digit positions has been ignored up to now. The third feature of the method is that S may guess digits to fill up his response if he sees less than 4 digits in Recall 4, so that T_{EP} may be biased by guessing. This is unlikely to occur for T_{NP}; since S may be assumed to nearly always see at least one digit, which he will give as his first response in both Recall tasks. The fourth feature is that at the digit rates chosen, S may not be able to identify every digit that is presented. In this

case, he may shift attention and then have to wait until a digit can be identified. Since each one of these experimental features may vary with digit SOA, the amount of bias introduced by each may vary with SOA. Thus, the finding that T_{EP} and T_{NP} also vary withSOA, does not have to imply that T varies with SOA.

The purpose of the next section is to present new measures, N(1) and EP', that correct NP and EP respectively for some of these features of the method. The main point at issue is whether these corrected measures also show an effect of SOA. Since the question of which is the 'better' measure of latency is unclear, the fact that N(1) and EP' also show the expected CC and CCxSOA effects will also be documented in the following section (section 5).

b. The SOA effect on T_{NP}

In this and the next section a model for NP is developed which account accounts for the effects of truncation and of sampling by the digits. Guessing is assumed to occur in the first response position only very rarely (Results, section 3.3.b), so NP does not need to be corrected for guessing. (The question of detection probability is deferred for the moment).

A sampling theory for NP assumes that:

$$NP=i, \text{ if } d.i \leq T < d.(i+1).$$

This assumption means that S notes the digit that has just been presented, when he shifts attention to the digits. This requires the assumption that S has a (icon-like) memory of the digit that has just been presented, which lasts until the next digit is presented, and is independent of attention. The shift of attention allows S to 'read' this icon-like memory for the last presented digit. (This assumption does not mean that S has no memory for digits presented prior to NP: only, that such digits are no longer in this type of memory, and may enter the response in Recall 4 in any other response position than the first. A detailed discussion of the relationship of latency and visual memory is postponed until a later section).

An alternative to this sampling theory will be presented below in section f.

c. The normal model for attention shifting

The Normal model makes the basic assumption that the latency of the attention-shift, T, is a normally-distributed random variable $N(\overline{T}, Var(T))$. The probably that S notes a digit in position i of the digit stream is assumed to be equal to $P(i \cdot d \leq T < i \cdot (d+)$, the area under the normal $N(\overline{T}, Var(T))$ between $d \cdot i$ and $d \cdot (i+1)$. (This follows from the assumption already made that NP=i, if $i \cdot d \leq T < i(d+1)$.) A subsiduary assumption is made to deal with the effects of truncation of the critical set. Since the Normal distribution extends to infinity, there is a

chance that T will fall on positions before and after the critical set. If this occurs, then it is assumed that S notes a digit that is placed at random with respect to the digits in the critical set. Therefore the probability N(i) that S notes a digit that was placed in position i is the sum of the probability that T falls between i and i+1, and one-tenth of the probability that T falls outside the critical set (there are ten digits). That is,

$$N(i) = \int_{d.i}^{d.(i+1)} N(\bar{T}, Var(T))$$

$$+ \frac{1}{10}\left[\int_{-\infty}^{d.i_o} N(\bar{T}, Var(T)) + \int_{(i_o+10).d}^{+\infty} N(\bar{T}, Var(T))\right]$$

In this model, T and Var(T) are unknown. The best estimate for N(i) is P(NP=i), the observed proportion. A computer program performed a grid search for best-fitting values of T and Var(T) that would minimize the differences between N(i) and P(NP=i); for i = i_o+1 to i_o+10 (the three negative set positions were grouped together in fitting). A separate search was undertaken in each experimental condition. The statistic minimized was the Kolgomorov-Smirnov D statistic for the difference between the distribution (Siegel, 1956, p. 47). The minimum values of D were within the 5% confidence intervals for 51 of the 58 conditions of S, Recall task, CC, and SOA tested. The

associated root-mean square (RMS)* values were quite low; for example, all but 5 values were less than .1. Thus although the Normal prediction was theoretically unjustifiable, because T must in fact be bounded, the general shape of the obtained P(SJ=i) distributions was quite well described by the model.

The assumption of Model 2A that the distribution of attentional shifts is independent of digit SOA may now be tested against the best-fitting parameters of the Normal fit. If Model 2A is correct, then $\overline{T}$ and Var(T) should show no effect of digit SOA. (It is theoretically possible for N(i) to depend on SOA, even when $\overline{T}$ and Var (T) do not, in the normal model, because the SOA influences the points on the time axis where the normal distribution is sampled).

d. Analysis of the best-fitting parameters of the normal model

The parameters of the model, $\overline{T}$ and Var(T), that had been estimated by the best-fit procedure, were subjected to an analysis of variance. The entire set of 58 pairs of parameters were used, whether or not the obtained fit was within the 5% confidence interval. The ANOVAs exactly paralled the ANOVAs used on the other latency measures (RT, EP, and NP) that were presented in the Results section. That is, a 2-way ANOVA of CC and SOA was used, for every S and both recall tasks. The within-cell error was set equal to the pooled Var(T)s over conditions of SOA and CC. The 6 ANOVAs (3 Ss and 2 Recall tasks) are given in Table

26. The main effects (condition means $\overline{T}_{c,d}$ minus the grand mean) are summarized in Table 25 and graphed in Fig. 6.

The prediction of the latency model that $\overline{T}$ should depend upon CC was confirmed by the finding of a significant CC effect in every one of the ANOVAs. The amount and direction of the CC effect is similar to that for mean RT, except for GL's letter C condition in Recall 4. The effect of SOA on $\overline{T}$ was significant for every S, but was small for AR and large for GL and AK. The large decline in $\overline{T}$ with SOA for GL and AK (Fig. 6) is evidence that the attention shift did depend upon SOA, in support of latency Model 2.

An incidental finding was that Recall task had a small effect on $\overline{T}$ for AR and GL, which is consistent with the results for mean RT. This was not the case for AK, for whom Recall task had a considerable effect on T (of 58 msec on average), but a small effect on mean RT. (AK's delayed $\overline{T}$ in Recall 4 was presumably not due to a delayed coding of the CC, which would have increased RT, but to some response interference induced by the additional recall load).

e. A problem in interpreting the SOA effect on the mean attention shift ($\overline{T}$) in the normal model

The SOA effect in $\overline{T}$ might possibly be accounted for by the assumption of the normal model that S noted the digit that had just been presented, when he shifted his attention to the digits. It might in fact be the case the S could only note the next occurring digit, after he had

shifted attention. In this case:

$$NP = i \text{ , if } d\cdot(i-1) \leqslant T < i\cdot d$$

This assumption leaves the estimates of Var (T) in the Normal model unchanged, but reduces $\overline{T}$ by one digit SOA in each condition. In fact, however, subtracting d from each value of $\overline{T}$ increases, rather than decreases, the estimated SOA effect. Therefore this alternative assumption does not change the conclusion that the attention shift depends on the digit SOA.

f. Estimation of the Attention shift from T_{EP}, in Recall 4

The assumption of the sampling theory that S notes the digit that has just been presented, when he shifts attention, might be queried in a different fashion. Suppose that S has perceptually ordered the digits in an order different from their presentation order (Assumption 14). In this case, he may report a later-occuring digit in the first response position, and an earlier-occurring digit in one of the later response positions. On such trials, EP < NP. In order not to over-estimate the time of attention shifting by confounding the measure of T with the observer's perceived order, it might be preferable to estimate the attentional shift latency T from the distribution of T_{EP}, rather than from T_{NP}. (A qualification to this argument will be discussed in Model 1 of section 3, below). The alternative sampling theory for T is therefore

assumed:

$$EP = e, \text{ if } d\cdot(e-1) < T < e\cdot d$$

The result of immediate importance is that mean T_{EP} shows an effect of SOA that is similar in size to the SOA effect on mean T_{NP} (Results, section 3d). It therefore seems necessary to conclude that the attentional shift latencies did depend on the digit SOA, in violation of Model 2A (and support of the original model, Model 2). Before reaching this conclusion, however, the effects of the various biasing features of the experimental method, which were listed in section 4.a above, must be examined.

Truncation of the EP distributions probably did not occur, since both P(EP=1) and P(EP=8) were found to be very small in every condition. The feature of the experimental method that may well have biased T_{EP}, however, is the requirement that S report 4 digits. If S in fact saw* less than 4, he would have to guess from the remaining digits in order to make up his response. Study of the P_{ij} distributions in Recall 4 (Table 35) shows that the effect of more guessing would be to bias mean T_{EP} downwards in some cases. Although guessing virtually never occurs in the first response position, the finding that the P_{i3} and P_{i4} distributions are usually bimodal suggests that S might

*Note: 'Saw' is used here in the sense of Assumption 4: that S has a sufficient perceptual representation that he can identify the digit.

be filling up these later response positions with digits that were guessed from the pool of unseen digits. Guessing would create such bimodal distributions because S would be less likely to guess digits that had been presented in positions in the middle of the positive set, where the probability of perception is high. Digits guessed from late stimulus positions would have no effect on EP, but digits guessed from early stimulus positions would give rise to spurious EPs on some trials. The effect of such spurious EPs on $\overline{T}_{EP}$ would depend both on their number and on their mean distance from the centre of the 'true' EP distribution in msec. This means that even though one might expect that there would be less guessing in slower SOA conditions, and so spurious EPs, nevertheless these fewer spurious EPs would be weighted by a larger value of SOA in the computation of $\overline{T}_{EP}$. Therefore $\overline{T}_{EP}$ might be biased downwards in slower SOA conditions by guessing, as suggested by the data. Clearly the exact effect of guessing on T_{EP} cannot be estimated without a model for guessing, that predicts both the number and the location of the spurious EPs in a given condition.

g. A guessing model for EP

An estimate of P(EP'=e), where EP' is an unguessed earliest response, may be obtained from Order Model 2.1. This model is presented in section 3 of the Discussion. The model is due to Sperling and Melchner (1976). It makes the

assumption that S sees four or fewer digits on each trial (in an all-or-none fashion), and makes up his response by guessing from the remaining digits when he sees less than four. The derivation of P(EP'=e) from this model will be explained when the model is presented.

The distribution of P(EP'=e) was obtained by the Sperling and Melchner (1976) method, in each condition of CC and digit SOA. The distributions were unimodal, with their largest probabilities in the third or fourth position of the positive set, and probabilities less than .15 in the tails (positions 1, 6 and 7 of the positive set) (Table 20). The means and s.d.s were converted to msec by multiplying by the digit SOA, and are given in Table 23. The means are plotted in Fig. 7, and can be seen to decrease with condition in the order U,C,S and in the order 75,109, 144, and 214 msec in all cases (except that letter C and U were reversed for GL at the fast SOAs). These CC and SOA effects upon the means were found to be significant by an ANOVA that was performed by the same method as for the other latency means (Results, section 3): the 3 ANOVAs, one for each S in Recall 4, are given in Table 23.

The finding of a strong effect of digit SOA on $t(\overline{EP'})$ (i.e. mean P(EP'=e) expressed in msec), is evidence that the effect of guessing was not responsible for the SOA effect upon $\overline{T}$ that had been found for the other measures of T. Indeed, it may be seen in Fig 9, which compares latency measures, that the SOA effect upon $t(\overline{EP'})$ was very similar

to that on $t(\overline{EP})$, the 'uncorrected' measure.

Thus, T was found to depend on SOA, even when 3 features of the experimental method that might have biased the estimates of mean T are controlled for; that is, the features of truncation, of small number of sampling points, and of the possibility that the requirement to recall 4 digits in Recall 4 may have introduced guessing.

h. Interpretation of the dependence of the attention shift (T) on SOA

From latency Model 2, we have

$$T_{c,d} = L_c + S_d,$$

and the dependence of T on SOA that this model predicts has been verified for several different possible measures of T in the previous section. Since S_d is defined as the time taken to shift attention and to identify the first digit, it is reasonable to ask whether the effect of SOA is on the attention shift itself, or whether it is on the time taken to identify the first digit. Both answers seem possible; the first, because S may shift attention faster if he expects an 'easier' (slower) SOA; and the second, because at fast SOAs S may take longer to identify the first digit. He might, for example, not be able to identify the first digit that he pays attention to; and the chances of this happening may be greater when the SOA is shorter and the time available to process the digits is correspondingly less.

The second of the above answers may be formalized by the following expression for S_d. Let S_o be the latency for shifting attention, and let L_d be the latency for identifying the first digit. It is assumed that S_o and L_d are independent random variables; that S_o is independent of the SOA; and that L_d depends on the SOA. Then

$$S_d = S_o + L_d$$

A model of this type (Model 1 of section 3 of the Discussion) will be considered later, when S's perception of the digits also modelled. It will be shown that there are models for digit perception that assume attention shifting to be independent of SOA, and can predict the data. Therefore the data cannot in itself be used to establish whether or not attention switching is a measure of L_c alone, or of both L_c and the digit processing. What has been established, however, is that even if T does depend on digit SOA, its dependence does not interact with the CC effect (by and large). Therefore even if T depends on SOA, the subtraction method may still be applied, on the assumptions of Model 2. Thus, letting c and c' be two different CCs, then $T_{c,d} = L_c + S_d$ and $T_{c',d} = L_c + S_d$ by definition, so that $E(T_{c,d}) - E(T_{c',d}) = L_c - L_{c'}$ for all possible values of d.

5. Further Analysis of the CC Effect on T

The question arises whether the various measures of

T are consistent with one another, and with the RT, in the amount of CC effect on their mean and variance. Main effects of CC, defined by condition mean minus grand mean μ, are summarized in panel A of Table 27 and shown in Fig. 8 for each latency measure. The mean absolute CC effect, defined as

$$\frac{1}{3} \sum_{i=1}^{3} | CC_i - \mu | ;$$

is given in Table 27; panel B, for each latency measure. It is apparent that the measures are qualitatively, but not quantitatively, consistent with each other, given that the confidence intervals for these means are of the order of 6 to 8 msec. Rather, the average CC effect obtained is greatest for the N(1) measure, next for t($\overline{EP'}$), next for $\overline{RT}$, and least for t($\overline{EP}$).

An interpretation of these differences is as follows. If RT were dependent only on the recognition time for each critical character, and if shift time were independent of CC, then all T measures would show the same CC effects as RT. On the other hand, to the extent that the EP measure is contaminated by guessing, some of the trials on which the EP measure is based have an earliest response that is independent of shift time and therefore of CC. So the effect of random guessing is to reduce the obtained CC effect. This is consistent with the result that t($\overline{EP}$) showed 5 msec less average CC effect than $\overline{RT}$. Given a successful method

for eliminating guessing from EP, then $\overline{RT}$ should look the same as $\overline{EP}$. This is true for two Ss, AR and GL, whose $\overline{RT}$ and T($\overline{EP'}$) effects differ by one standard error or less, but is not true for AK. However, AK's $\overline{RT}$ effect is even less than t($\overline{EP}$), suggesting that for AK either shift time did interact with CC, or that the $\overline{RT}$ effect was fortuitously underestimated. (While the other Ss showed similar CC effects on $\overline{RT}$ over SOAs, AK had a CC effect on 144 msec that was half the size of the CC effects on the other SOAs. If this aberration had not occurred, her $\overline{RT}$ effect would have closer to the t($\overline{EP'}$) effect). So, it seems reasonable to conclude that $\overline{RT}$ and t($\overline{EP'}$) are consistent with each other in CC effect.

Consistency with $\overline{RT}$ does not seem to be the case for $\overline{T}$ (the N(1) mean), however. Since guessing in the first response is rare, some other interpretation of the difference between the CC effects on $\overline{RT}$ and $\overline{T}$ must be made. Investigation shows that the size of the CC effect on $\overline{T}$ decreases slightly with SOA; this is not true for the effect on $\overline{RT}$. Thus, while the CC effect at 214 msec is almost the same by both measures, it is 1.5 times as much at 75 msec for AR and GL, and 2.4 times as much at 109 msec for AK. It is not clear why this slight divergence should occur.

6. The Fate of Un-Attended Visual Stimuli

The latency models so far considered have all assumed that Ss do not report digits that were presented before they shifted attention, in line with Assumption 13 of the Introduction. Clearly, if Ss were able to report digits presented before the attention shift, then it would not be possible to estimate attention shift latencies from the digit reports directly. It might be, for example, that S sometimes gives his noting response on the basis of the first digit attended to, and sometimes gives it on the basis of a memory for the previously presented but un-attended digits. Such a mixture of responses might partly explain why T decreases with digit SOA; as digit SOA is lengthened, for some reason it might become easier for S to recall un-attended digits from early in the digit stream.

The results of the present research are not quite conclusive on this point. At long SOAs, P(EP=0) is greater than zero, which suggests that S can report digits presented before he shifted his attention at such SOAs. However, if the guessing correction model of Sperling and Melchner (1976) is applied to the data (as is done in Model 2 of section 3 of the Discussion), then it is the case that $P(EP'=0) \equiv 0$. (The few responses at simultaneity (position 0) are attributed in this model to S's guesses).

Although the fate of unattended auditory stimuli has been extensively investigated following the work on attention to one of the auditory messages (Moray & Fitter, 1973;

Moray 1969 reviews the earlier work), I have not found any comparable work in vision. The result in audition is that in situations where S has a complex task to perform (such as shadowing), information on the unattended 'channel' is mostly lost, with the exception of highly meaningful stimuli such as the S's own name, and more sensory information such as the pitch of the message. This is consistent with the assumption that in the present research, S cannot identify which digits are being presented before the CC, but would be aware if the digits were turned off. When S is paying full attention, he may continue to process the information in an icon, after the icon has been replaced, in either a verbally or a visually coded form (Sperling, 1963; Turvey, 1973; Coltheart, 1972); and when S is paying very little attention, but is not burdened by any additional tasks, he may process auditorily presented information to the point of being recallable later on (Moray & Fitter, 1973); but the case of little attention with a subsiduary visual task, such as detection of a target letter, has not been investigated outside the present research so far as I know. Indeed, the present data is compatible with the claim that attention is shared between the digit and letter streams, until the target CC is detected, at which point the need to execute a response would cause S to shift attention (Moray & Fitter, 1973), first to the CC and subsequently to the digits. This would predict that digits seen well before the CC, under 50% of attention, would

sometimes be sufficiently coded to enter S's response. However, if this occurred it did so infrequently, since such digits would contribute uniformly to P_i and so must have probability less than the minimum P_i.

3. Models for Order and Item Information in Recall 4

The purpose of section 3 is to present models for S's perception and report of the digit stream in Recall 4. The purpose of the first part (3.1 a) is to review the relationships between the various statistics computed in the Results section,and the measurement of 'item' and 'order' information. The next part (3.1 b) shows how item and other information relate to the question of attention switching discussed in section 2 of the Discussion. A general theory for order, item and latency is presented in part 1c, where latency is represented by a single variable T and is not decomposed (as it was in the previous section).

Four particular models are presented in parts 2 through 5. For each model, the discussion is ordered in the following way. First, the parameters and axioms of the particular model are given. Next, any restrictions on the model are given if appropriate, and the restricted model is tested. The parameters of the best-fit for the restricted model are then analyzed in terms of their dependence upon CC and on SOA. Finally, various miscellaneous matters are discussed, which include the relationship of the restricted

model to the question of the measurement of 'item' and 'order' information.

The reason that 4 different models are presented, rather than one, is that the models are based on some rather different assumptions, which the data (and general theory) are not strong enough to disprove. The assumptions that are common to each model are presented in part 1c in verbal form. The assumptions that differ are presented in part 1d. The models also differ in the aspects of the data that they predict, and these differences will be summarized in part 6. (The summary in part 6, belongs logically with part 1c, but is easier to explicate after presentation of the details of the models).

Models are ordered by decreasing specificity. Model 1 predicts the individual response probabilities, P(R=(i,j,k,l)). Model 2 predicts the unordered response probabilities, P(R=[i,j,k,l]). Model 3 predicts the item and order statistics P_{ij} and Tau_{ij}. Model 4 predicts only Tau_{ij}. The number of parameters decreases with model number.

1a. 'Item' and 'Order' Measures

The measures of item and order information under consideration are all probabilities, except Tau_{ij}, which is a transformed probability. The measures given in the Results section may be grouped into three categories; those that reflect item information alone, those that effect order information alone, and those that

reflect both. The only measure to reflect item information alone is $P_i = P(i \in R)$, the probability of report of a digit from position i. The measures of order information alone are C_{ij} and Tau_{ij}, of which only Tau_{ij} will be considered in this section.

The measures that reflect both item and order information are P(R=r), P(i,n), P_{ij}, and $P_{\bar{i}j}$. These are, respectively, the probabilities of a. each individual response; b. responses with runs of length n (i.e., R = (i,i+1,i+2,.,.,i+n)); c. reporting the i^{th} stimulus in the j^{th} response position, and d. 'serial position'. Of these measures, only P(R=r) and P_{ij} will be of further interest. The last measure, $P_{\bar{i}j}$, is a measure of serial position because it is the mean stimulus position reported in response position j. Despite its similarity with traditional serial position measures, it is not further discussed. Since the $P_{\bar{i}j}$s are coarse averages, they were deemed unsuitable for detailed model testing. The measure of runs, P(i,n), was only used in testing a refinement of model 1. (Although this measure is closest to the idea of 'correctness' of order, and should therefore be of value for testing the models, the data under consideration were in general not ordered correctly. That is, P(i,n) was in general small for all i and all n, $1 \leqslant i \leqslant 7-n$ and $2 < n < 4$. Models 1, 3, and 4 ensured that P(i,n) was small by ensuring that response order was usually unrelated to stimulus order, and made no further prediction about the

exact size of P(i,n), while Model 2 did not make an order prediction.)

b. Item, order, and latency

The following models concern item information, order information, and the latency for shifting attention. Although these three are conceptually distinct, they cannot be independently estimated in the present experiment. For example, if it is known which digits were perceived (item information), and how they were ordered, then the attention shifting latency (T_{NP} or T_{EP}) can be determined In the following models, item information is derived from attention shifting and order information in Model 1, latency of the attention shift is derived in Model 2, and order information is derived in Models 3 and 4. This point will be returned to in part 6 of the present section, once the models have been presented in detail. The next sub-section outlines a theory of processing stages in preparation for the detailed models.

c. A general theory of 'stages' of processing in Recall 4

The background theory for the processing of the digits in the different models is that S's digit responses are determined by a 3-stage process, using the term 'stage' rather loosely. (The 3-stage idea is not necessarily true for only of the models to be true, since it involves causation and the models do not. The term 'background

theory' refers to this causative idea).

The stage theory assumes that item information is determined by the first stage, order by the second, and response processes by the third. Stage 1 determines which digits will be perceived on a trial, but not the order in which they will be perceived. The operation of stage 1 is assumed to be controlled by attention.

Stage 2 determines the order of the digits. In Model 1.1, the ordering is assumed to be either random or the same as the input order. In Model 3, the ordering is assumed to be determine by random sampling with replacement of the perceived digits. In model 4, ordering is determined indirectly by attention. (Model 2 makes no commitment to ordering.) Finally, the function of stage 3 is to ensure that S reports the first 4 digits in the percept in the order in which he saw them; if the percept has less than 4 digits in it, then S is assumed to guess at random from the remaining digits.

A paranthetical note about the effects of guessing

Before describing the four models in detail, it must be pointed out that ideally each would attribute the same role to guessing and so be based upon the same estimate of item information. But this is not so. The essential problem concerns whether S does or does not detect 4 or more digits. If he does, then he must select from the perceived digits in order to respond. If he does not, then he must guess

from the remaining digits to complete his response. But these two processes are quite different. In the first, lack of order information can occur only if S's actual percept is ordered differently from the stimulus sequence; while in the second, lack of order may be due mostly or solely to random guessing.

It would be desirable to distinguish the two cases. This is easy if the stimulus sequence is much longer than the percept.* In this situation, random guessing will ensure that all P_i are greater than zero; and indeed; the exact amount of guessing will be measureable by the P_i at the end of the sequence where S never detects. For example, absence of guessing will entail that $P_i=0$ for position i at the end of the sequence. Unfortunately the sequence of ten digits used in the present research was not long enough for this method to be applicable. All digit positions were reported from; but whether this was due to guessing or to genuine detections is impossible to say. The four models place very different exmphasis on the role of guessing; Model 2 places the most, and Model 1 the least. The amount of item and order information attributed to S is thus more of a matter for the model to decide than would have been the case if a more appropriate stimulus sequence had been chosen for the research.

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*As percept is defined in Assumption 4.

d. Basic theory and variables

The theory assumes that the S's response is determined by a perceptual process, in stages 1 and 3, and a response process in stage 3. In this section a formal version of this theory is presented, which is common to the four detailed models which follow. The theory models the perceptual process by assuming three 'primitives'; detection, attention, and permutation. The probability of detection of an attended-to digit is assumed greater than 0, but for an unattended digit, it is assumed equal to zero. Attention and detection together determine the 'item information' available; i.e., which digits are "perceived" that is, enter the buffer.* The order information is determined by the permutation that is chosen. The nul permutation leaves the objective order of the digits unchanged, while any other permutation ensures that the digits are perceived in other than their true order.

The response process outputs the first four digits perceived, in the order in which they were perceived. If less than 4 digits were perceived, then the response is completed by randomly chosen digits from the set of unperceived digits.

The following random variables represent these ideas. Let:

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*Note: perception is modelled by the buffer of Assumption 11. In this theory, the buffer is represented by the vector W.

$T = t$ if attention is shifted to the digits at time t

$T_o = t$ if attention is shifted away from the digits at time t

$A = a$ if digits in position $a = (a_1, a_2, \ldots a_m)$ are detected

$X = x$ if permutation $x = [x(1), x(2), \ldots x(m)]$ of the intergers (1,2,..m) is choosen

$W = w_{a,x}$ if the sequence of digits perceived* comes from positions $w_{a,x} = [w_{a,x}(1), \ldots \ldots, w_{a,x}(m)]$

$R = r$ if digits from positions r = (i,j,k,l) are reported.

$G(R,W) = G(r, w_{a,x})$ if the guessing processing G generates r from $w_{a,x}$.

Then, models of the process must connect these variables in the following way:

1. $T, T_o \rightarrow A$ (Stage 1 of processing)
2. $A, X \rightarrow W$ (Stage 2 of processing)
3. $W, G(R,W) \rightarrow R$ (Stage 3 of processing)

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*Note: perception is modelled by the buffer of Assumption 11. In this theory, the buffer is represented by the vector W.

where (1.) determines the item information, (2.) determines the order information, and (3.) determines the response from the item and order information, and from the guessing rule.

In general, the times T and T_o are unconstrained. In order to ensure that the perceived digits are all different (that is, all members of the critical set), the following restriction must be placed upon T and T_o:

$$0 \leqslant T \leqslant T_o \leqslant 10.d$$

where d is the digit SOA. The other variables are unconstrained, except in so far as (1.), (2.), and (3.) above are specified.

Development of the models may be faciliated by defining the following:

#k is the projection of rank k of a vector, so that if $Y = (y_1, y_2, \ldots . y_n)$, then $\#_k(Y) = (y_1, y_2, \ldots y_k)$, for $k \leqslant n$.

* is an operator that generates a set of elements from a vector, so that $Y^* = (y_1, y_2, \ldots . y_k)$

$\oplus$ generates the direct sum of two vectors, so that if $Y = (y_1, y_2 .. y_n)$ and $Z = (z_1, z_2, z_3 \ldots . z_k)$, then $Y \oplus Z = (y_1, y_2 \ldots y_n, z_1, z_2 \ldots \ldots z_k)$

The 3 stages are handled in different ways in the four models. The essential differences are as follows.

The first model (Model 1) assumes that detection of the attended-to digits is perfect, and that attention is paid to a fixed number m of consecutive positions. The vector A is thus determined by T (the onset of attention) and by m. The model places various constraints on G and on X in order to generate predictions concerning R. The second model (Model 2) assumes that not all the attended-to digits are detected. Rather, four or fewer digits are detected on each trial, between positions n and n+m, which are fixed. The model makes no commitment to X, but does specify G, in order to predict the unordered response probabilities P(R*=r*) rather than the ordered responses P(R=r). The guessing rule G in Model 2 is taken from a model of Sperling and Melchner (1976). (The results of the model are used to generate item information 'after correction for guessing', P'_i, as previously mentioned).

The third model predicts item and order information, as does Model 1, but does not specify T or T_o. Rather, the model takes the probabilities of digits being perceived (P''_{ij}) as parameters, and generates item and order information from a specified permutation rule motivated by the idea of 'random sampling without replacement'. The fourth model (Model 4) is that of a 'strength' or 'precedence' process, where the procedence of a digit determines both item and order information, and is itself determined both by digit onset time and by the amount of attention payed to the position in which the digit was presented. In this

model, attention is assumed to vary continuously, rather than being switched on at time T and off at time T_o.

2. Model 1

a. Model parameters and their interpretation

The model parameters are:

m	The number of digit positions to which attention is paid.
d	The digit SOA.

Model random variables (r.v.s) are as defined on page 154:

$T = t$	if attention is shifted to the digits at time t
$X = x$	if permutation x = [x(1),....x(m)] of the integers (1,2.....m) is choosen
$W = w_{n,x}$	if the sequence of perceived digits comes from positions $w_{n,x}$ = [n+x(1), n+x(2), ..., n+x(m)]
$R = r$	if digits from positions r = (i,j,k,l) are reported.

These variables have the following interpretation. T is the moment of shift from the letters to the digits. Associated with T is a position n+1, the greatest integers less than or equal to t/d. The digit in position n+1 is

the first to be payed attention (because parallel processing of both streams is assumed not to occur). Having shifted attention, attention is paid to the next m digit positions (where m is a parameter, not a r.v.), and perceives those digits in some permuted order, x. The perceived order is represented by a particular vector $w_{n,x}$. Note that $w_{n,x}$ is determined solely by the first digit seen (n) and by the particular permutation x of the m! possible permutations. Finally, the response R is a 4-tuple (in which the actual digits reported by S have been replaced by their digit positions). Because of the experimental design, the stimulus and response have no repeated elements.

The purpose of the general model is to connect R,W,X and T together. The idea is that T and X together determine W, which in turn determines R. The assumption is made that W, like R, has no repeated elements, so that all the digits that S perceives are different. The r.v.s are then connected by the following axioms:

b. Model 1 axioms

1. $P_d(R=r \mid W=w_{n,x}, X=x', T=t) = G(r, w_{n,x})$

2. $P_d(W = w_{n,x} \mid X=x', T=t) = \begin{cases} 1 & \text{if } x=x' \text{ and } d(n+1) \leq t < d(n+2) \\ 0 & \text{otherwise} \end{cases}$

2. $P_d(X=x \mid T=t) = H_d(x)$

Axiom 1. means that X and T only influence R through their joint effect on W. Some function G, to be specified in sub-

models, determines the effect of W on the response R. Axiom 2. means that the W perceived depends only on X and T. T has its effect by specifying the earliest digit position, n+1, in W. The digit in n+1 is the first to be perceived if attention is switched between d(n+1) and d(n+2), but not otherwise. By Axiom 3, the choice of permutation X is independent of the time at which attention is shifted.

It follows from probability theory that

$$P_d(R=r) = \sum_{n,x} \sum_{x'} \int_t P(R=r \mid W=w_{n,x},\ X=x',\ T=t)\ P(W=w_{n,x} \mid X=x',\ T=t)\ P(X=x' \mid T=t)\,dp\ (T \leq t)$$

$$= \sum_{n,x} \sum_{x'} \int_t G_d(r,w_{n,x})\ P(W=w_{n,x} \mid X=x',\ T=t)\ H_d(x')\ dP(T \leq t), \quad \text{, Axiom 1}$$

$$= \sum_{n,x} \int_{t=d(n+1)}^{d(n+2)} G\ (r,w_{n,x})\ H_d(x)\ dP(T \leq t) \quad \text{, Axiom 2}$$

$$= \sum_{n,x} G_d(r,w_{n,x})\ H_d(x)\ [F(d(n+2))-F(d(n+1))]$$

where F(t) is the distribution function of T. That is, the general version of Model 1 predicts that

$$P_d(R=r) = \sum_{n} \sum_{x} (G_d(r,w_{n,x})H(x)f_{n+1}) \ ,$$

where $f_{n+1} = F(d(n+2))-F(d(n+1))$.

c. A restriction on G

The following rather stong restriction on guessing is made: that the guessing function be independent both of the digit SOA, and of thelocation of the attended-to set (the time of attention switch). That is, where g_m is a new guessing function that is dependent on m but is independent of d, n, and x:

$$G\ (r,w_{n,x}) = \begin{cases} g_m & \text{if } n \in N \text{ and } x \in X' \\ 0 & \text{otherwise.} \end{cases}$$

where N and X' are special sets of positions and permutations respectively, and are as follows:

Case 1. $m \geq 4$

$n \in N$ iff $Max(r^*)-m \leq n < Min(r^*)$

$x \in X'$ iff $r = \#_4(w_{n,x})$

Case 2. $1 \leq m < 4$

$n \in N$ iff $n = Min(\#_m(r)^*)-1$

$x \in X'$ iff $\#_m(r) = w_{n,x}$

Case 3. $m = 0$

$n \in N \ \& \ x \in X'$ for all n and x.

The motivation for the restriction on the $G_d(r,w_{n,x})$ is as follows. The restriction means that percept $w_{n,x}$ will lead to a response r = (i,j,k,l) with some probability g_m dependent only on m, as long as n and x are correctly choosen. Since $w_{n,x}$ has smallest element n+1 and largest

elements n+m, the members of the response must not exceed these bounds for $m \geqslant 4$. That is, the minimum of R* must be greater than n, and the maximum of R* must be less than or equal to n+m. In the case that $1 \leqslant m \leqslant 4$, this must be modified so the first m elements of R* include n+1; that is, n+1 is the minimum of $\#_m(R)^*$. Now, consider x; this is the single permutation that places i,j,k and l in the first 4 positions of W, given a particular value of n and given $m \geqslant 4$. If $1 \leqslant m \leqslant 4$, then x is the single permutation that places $\#_m(R)$ in the first m positions of W; the remaining 4-m digits of R are unrelated to W and must be specified by g_m in sub-models. Finally, consider m=0. In this case, the value of m and x are irrelevant, and g_m must specify the response probability entirely.

d. <u>The derivation of the unordered response probabilities</u>

$P(R^*=r^*)$, the probability of a response independent of the order of its elements, is equal to the sum of the probabilities of all the responses which contain the same (ordered) elements. That is:

$$P(R^*=r^*) = \sum_{r'} P(R^*=r^* \mid R=r')\ P(R'=r'),$$

$$\text{where } P(R^*=r^* \mid R=r') = \begin{cases} 1, & \text{if } R^*=r'^* \\ 0, & \text{otherwise.} \end{cases}$$

$$= \sum_{r'^*=r^*} \sum_{n \in N} \sum_{x \in X'} (g_m \cdot H(x) \cdot f_{n+1})$$

e. Model 1.1

In this model, W is accurately reported. If W contains less than four digits, the 4-m remaining responses are completed by guessing at random from the 10-m remaining digits. This further restricts G to

$$G_d(r,w_{n,x}) = \begin{cases} 1 & \text{,if } r = \#_4(w_{n,x}) \text{ and } m \geq 4 \\ \frac{6!}{(10-m)!} & \text{,if } \#_m(r) = w_{n,x} \text{ and } m < 4 \\ 0 & \text{,otherwise.} \end{cases}$$

In addition, W is not permuted with probability q. With probability 1-q, W is permuted at random. Permuting at random generates the identity permutation x_o with probability 1/m!. Thus,

$$H_d(x) = \begin{cases} q + \frac{1-q}{m!} & \text{,if } x=x_o \\ \frac{(1-q)(m!-1)}{m!\,m!} & \text{,if } x\neq x_o \end{cases}$$

Thus, from the general model,

$$P_d(R=r) = \sum_{n,x} G_d(r,w_{n,x}) \cdot H_d(x) \cdot f_{n+1}$$

$$= Q \cdot \text{Min}\left(1, \frac{6!}{(10-m)!}\right)$$

$$\text{where } Q = \begin{cases} \left(q + \frac{1-q}{m!}\right) f_i & \text{,if } x=x_o \\ \frac{(1-q)(m!-1)}{m!\,m!} \sum_{n=r-m+1}^{n=r} f_n & \text{,if } x\neq x_o \end{cases}$$

and where $$\underline{r} = \begin{cases} \text{Min } (r^*) & \text{, if } m \geq 4 \\ \text{Min } \#_m(r^*), & \text{if } m < 4 \end{cases}$$

$$\overline{r} = \begin{cases} \text{Max } (r^*) & \text{. if } m \geq 4 \\ \text{Max } \#_m(r^*), & \text{if } m < 4. \end{cases}$$

The guessing rule in Model 1.1

The motivation for the further restriction upon the guessing rule $G_d(r,w_{n,x})$ in Model 1.1 is as follows. If $m \geq 4$, guesses do not occur, so that $g_m=1$. Otherwise, guesses occur completely at random from 10-m digits, to make up the missing 4-m elements of the response. Since the 4-m digits must be guessed in the correct order to obtain the given response, correct guessing occurs on 1 choice of (10-m)! / (10-m-(4-m))! possible choices; that is, with probability 6! / (10-m)!. The motivation for the permutation rule is much less strong. The assumption that the model either does not permute, or permutes at random, leads to easy calculations and provides a mechanism for the effect of digit SOA, which is to increase the probability of not permuting. (The assumption of random permutation is compatible with the finding that mean concordance is close to chance for the fast SOAs).

(These two restrictions on Model 1 make Model 1.1 easily testable. The less restricted version, Model 1, should ideally be tested without the restrictions of Model 1.1. For example, the assumption that the permutation employed was independent of the time of attention shift,

which is Axiom 3, should be tested without restrictions on the possible set of permutations. However, I was unable to find a way of doing this).

Model 1.1 was conclusively rejected. The next few sections, which give the details of the computation and testing of this model, explain why, and suggest improvements which might generate better fits to the data. However, I have not implemented these suggestions, principally because the model changes character at the point $m \geqslant 4$, and a direct test of $m \geqslant 4$ in a new experiment seems desirable.

f. The fit of Model 1.1

There are nine parameters for Model 1.1 for each condition. The parameters are the buffer size, m; the probability of not permuting, q; and the seven probabilities f_e, $1 \leqslant e \leqslant 7$. For notational convenience, and following the terminology used in the models for latency, let $f_e = P(EP' = e)$, where EP' is the position of the digit first payed attention. That is:

$$f_e = P(EP'=e) = P[d\cdot(e) \leqslant T < (e+1)\cdot d)]$$

When EP'=e, $W=w_{e-1,x}$ by Axiom 2.

Model 1.1 was fit with the assumption that $m \geqslant 4$. Under this assumption, f_e may be estimated directly from the data. The estimation proceeds as follows. If permutation does not occur on a trial, the P(EP=i) estimates f_e, because the digit reported first (EP) is the digit to

which attention was first turned (EP'). If permutation does occur, then there is a chance that EP ≠ EP', because the digit presented in position EP' was subsequently permuted out of the first four positions of $w_{e-1,x}$, and was therefore not reported. The chance of this occurring is $(1-q)(m-4)/4$.

We have that:

$$P(EP=e) = \sum_{k} P(EP=e \mid EP'=k).P(EP'=k) \quad \text{, by probability theory.}$$

$$= P(EP=e \mid EP'=e).P(EP'=e) + \sum_{k\neq e} P(EP=e \mid EP'=k).P(EP'=k)$$

But, $P(EP=e \mid EP'=e) = 1 - (1-q)(m-4)/4 = q+(1-q)4/m$

And, $P(EP=e \mid EP'=k\neq e) = [(1-q)(m-4)/m) \; . \; [P(e= \text{Min}(R^*) \; , \; e\neq k)]$

$$= [(1-q)(m-4)/4) \; . \; [P(EP'=e-1) + P(EP'=e-2)$$

$$(m-5)/m + P(EP'=e-3)(m-6)(m-5)/m^2 + ...]$$

If the terms involving P(EP'=e-x) for $x > 2$ are ignored, because they are small, and if the following substitutions are made for typographic ease,

$$Q = (1-q)(m-4)/m, \text{ and } P_e = P(EP=e),$$

then:

$$P_e = f_e - Q\,(f_e - f_{e-1} - f_{e-2}\,(m-5)/m)$$

Since $f_e = 0$ if $e < 1$ by assumption, it follows that for

e=1,

$$f_1 = P_1 + Q(f_1)$$
$$= P_1/(1-Q)$$

Using this value for f_1, the value of f_2 may be found:

$$f_2 = P_2 + Q(f_2-f_1)$$
$$= (P_2 - Qf_1) / (1-Q)$$

Similarly,

$$f_3 = (P_3 - Q(f_2-f_1(m-5)/m))/(1-Q)$$
$$f_4 = (P_4 - Q(f_3-f_2(m-5)/m))/(1-Q)$$

and so forth.

Rather tnan estimating f_5, f_6 etc, it was assumed from inspection of the data that f_6 etc would all be zero; so f_5 was defined as

$$f_5 = 1 - (f_1+f_2+f_3+f_4).$$

The computer searched through the parameter space for $4 \leq m < 7$ and $0 \leq q \leq 1$. For each pair of m and q values, the 5 f_i values were computed, and the model predictions $P(\hat{R}=r)$ were generated. The RMS (root mean square) error was then found as RMS = $\sum_r p.(p-q)^2$, where $p = P(\hat{R}=r)$ and $q = P(R=r)$. The computer found the best fitting values of m and q by selecting those values that minimized RMS.

The RMS values for Model 1.1 are given in the penultimate column of Table 65. The RMS values have been

multiplied by 100 in the Table for typographic convenience. The absolute size of the RMS values is not particularly meaningful. If the data had probability 1.0 for R=r and the theory predicted probability 1.0 for R=r'≠r, and all other Rs had 0 probability, then RMS=1.0. The obtained RMS's are certainly small with respect to this value. If, on the other hand, the theory predicted a flat probability distribution over all 7x6x5x4 possible responses, each having probability 1/ 7x6x5x4 = .00119, and if the data had all its probability at just one response, which is the worst case for this prediction, then RMS = .035. This RMS value is close to the worser fits obtained. In fact the model predictions were of unequal probabilities over responses, and so the maximum possible RMS was certainly larger than .035. The RMS values in the ultimate column of Table 65 are values for a fit in which q=0, and m was free to vary in order to minimize RMS. (The f_i and m values in this case are not tabulated). The similarity of the RMS values when q was allowed to float to the values in which q=0, is evidence that the model prediction does not gain very much from the q parameter. That is, the proportion of trials in which S did not permute (and therefore was predicted to report digits from 4 consecutive positions) was low, and so taking account of these cases did not improve the fit very greatly. Nevertheless, the increase of q with digit SOA is consistent with the finding of greater order information at the longer SOAs found

in the Concordance measure already discussed. In fact, at 214 msec the large values of q obtained (averaging .29 in AR and .47 in GL) did produce a considerable effect on RMS in comparison with the case of no order (q=0).

The predicted response distribution P(R=r) was reduced to a predicted item matrix P_{ij} and a predicted order matrix Tau_{ij}, in the same way that the P(R=r) obtained in the data were reduced to P_{ij} and to Tau_{ij} matrices (Results sections 4.3 and 4.4). The predicted item and order matrices were very discrepant with the data matrices. The errors in prediction were systematic, and lead to a rejection of Model 1.1. The principle cause of failure is that when q is near zero, the model predicts that Tau_{ij} should be close to zero for all values and i and j, and the model also predicts that P_{ij} should be close to P_i for all values of j. Inspection of the data matrices (Tables 35 and 62) shows that neither of these predictions are anything like correct. In some conditions, values of q were somewhat larger than zero; but in none of these cases was enough order predicted to increase the absolute values of the Tau_{ij}, or to shift the P_{ij} distributions so that M_j would increase with j, as in the data.

Despite the failure of Model 1.1, an analysis of the best-fit parameters is still of interest, since possible future improvements of the model are thereby suggested. Sections g, h, and i have this purpose. They are, however, parenthetical, and should be missed on first reading.

g. An analysis of the best-fitting parameters of Model 1.1

The parameter values for the best fits of Model 1.1 are given in Table 65, and the values of q and of the mean f_i are given in Table 66. The values of m are either 4 or 5 for all conditions, with a tendency to decrease with SOA in AR and in GL. The values of q (Table 66) show a small effect of CC, in which C and U have equal effects but S has a variable effect over Ss, and a larger effect of SOA, in which q increased strongly when SOA increased to 214 msec. The SOA effect upon q suggests that the probability of a 'quadruple' response, in which R = (n,n+1,n+2,n+3), increased with SOA in a different way from the probability of a correctly ordered pair, as given by Kendal's measure of concordance, C_{ij}. C_{ij} increased sharply as SOA increased sharply as SOA increased from 75 to 109 msec, but then rather levelled off (Table 31). The empirical probability of a quadruple response is given in the column marked n,n+3 in Table 64, Panel A, where it may be seen that the marked increase at 214 msec suggested by the model fit for q did in fact occur. The implication that pairwise order information did not increase as rapidly as quadruple order information for the longer SOAs is somewhat strange. It is clear that as the probabilities of the pairs (n,n+1), (n+1,n+2), and (n+2,n+3) increase, so does the probability of the quadruple (n,..,n+3), even if S were increasing his pairwise order information only (and was reporting randomly

selected pairs of pairs). Such as effect could not be large enough to account for the large increase in quadruple order information at 214 msec, however, because the pairwise order information does not increase enough in that condition. It therefore seems not that the proportion of pairs increased in general in the longer SOAs, but that the proportion of pairs that become linked together systematically to form quadruples increased.

The values of f_i given in Table 66 are very similar to the P(EP=e) if m = 5, and identical if m = 4. The mean f_i, or $f_{\bar{i}}$, is given in the Table in msec as $d(f_{\bar{i}} - i_o)$. These means are similar to the $t(\overline{EP})$ means shown in Fig. 5, and the mean absolute effects of $f_{\bar{i}}$ given below Table 66 are virtually identical to the mean absolute effects of CC and SOA upon $t(\overline{EP})$, discussed in section 2.

h. A further test of Model 1.1 by Runs

Model 1.1 predicts that $P(R=r \mid x=x_o) = (q + \frac{1-q}{m!}), f_i$, if $m \geqslant 4$. This means, approximately, that $P(R = (i,i+1,i+2,i+3) = q.f_i$, since 1/m! is rather small. The obtained probability that R = (i,i+1,i+2,i+3), and the expected probability $q.f_i$ are given in Table 67 under the column heads O and E respectively. The values in this table are averaged over C,U, and S, in order to increase the number of trials (to 1200 for AR and GL, and to 900 for AK), and make the estimates of these rather small probabilities somewhat more reliable. The predicted values are slightly

too high for R=(1,2,3,4) and R=(2,3,4,5), and are slightly too low when R=(4,5,6,7). This means that q, the probability of permutation, is dependent upon T and is not constant, contradicting Model 1. Ss are slightly more likely to permute when they shift early than when they shift later, it seems. This conclusion, however, is strongly dependent upon the exact values of f_i and q found by the fitting procedure, and is susceptible to the problem of small numbers of observations. Therefore this data does not provide a strong reason for rejecting either the assumption of Model 1.1, that permutation is random or nul, or the basic Axiom 3 that H(x) is independent of T.

The data in Table 64 allows a more subtle test of Model 1.1. There are 7 possible types of run, where a run of length j occurs if R = (,.,.,n,n +1,., n + j-1,..): these runs are R=(n,n+1,.,.), R=(.,n,n+1,.), R=(.,.,n,n+1), R=(n,n+1, n+2,.), R=(.,n,n+1,n+2,n+3), R=(n,n+1,n+i,n+i+1), and R=(n,n+1,n+2,n+3). The probabilities for these 7 classes were found averaged over C, U, and S for each SOA. The probabilities of the 'quadruple' responses, R=(n,n+1,n+2,n+3), and of the response pattern R=(n,n+1,n+2,.) where found to increase with SOA, but the probabilities of the other classes were roughly stable over SOA. Model 1.1 predicts the increase in the 'quadruple' response probabilities with SOA because q increases with SOA; however, the model does not predict the increase in the probability of R=(n,n+1,n+2,.). A refinement of the model would take such cases into

account by paramaterizing the probability of permutations such as $W_{n,x}$ = (n, n+1, n+2, x(n+3), x(n+4).....). I have not tested such a model because further refinements seem inappropriate to data in which the estimates are generated from only 400 trials per condition. Taking into account only those responses of greater than 5% probability, Table 64 Panel B shows the probability of all such responses and of all such quadruple responses under the headings P(R) and P(R=(n..n+3)). Both sets of probabilities increase with SOA, as S's orderings become less random and more concentrated upon certain permutations, but the ratio between them remains generally in favor of the quadruple responses. This supports the model distinction between no permutation and random permutation, in the sense that it implies that other 'favored' permutations amongst the higher probability responses are still not as favored as the no permutation or quadruple response.

i. Item and Order in Model 1.1

Order information in this model is determined only by the probability of permutation, q. Item information, on the other hand, is determined by q, by m, and by T, in some cases. If m=4, then q is irrelevant and item information is determined only by T. Thus if T were fixed, then P_i=1 for $i = \left[\frac{T}{d}\right] + k$, k=0,1,2,3, and P_i=0 for i elsewhere. If T varied over two positions, k and k+1, then P_i = .5 if i=k or i=k+4; P_i=1 if i = k+1, k+2, or k+3; and P_i=0 for i

elsewhere. In a fit to P_i by a program that varied the distribution of T over positions in order to find a best fit, P_i distributions were well fit if T was allowed to vary over at least 3 successive positions (and P'_i from Model 2.1 was fit if T varied over 2 positions, as discussed in part 3 of this section).

In the more complex case when $m > 4$, q is also important in determining item information. If q=1, S never permutes and the value of m is irrelevant as long as $m > 4$. However, if q is small, then S reports the first 4 of the m digits only on a small proportion of trials. Almost equally often, he reports some other set of 4 of the m digits. The effect of reducing q is therefore to bias the item information distribution to the right, and increase its variance, for a fixed distribution of T and a fixed $m > 4$.

For the best fits obtained here, m was either 4 or 5 and q was small. This means that item information, and by a similar argument P(EP=e) and P(NP=i), tends to overestimate the mean and variance of the attention shift, when m=5. As already noted, however, the distribution of f_i in fact was similar to that of P(EP=e). This would have been increasingly less the case as m grew larger than 4; the largest value of m obtained by the fit, m=5, did not introduce enough bias to radically alter the 'attention shifting' distribution estimates.

3. Model 2

a. Model parameters and their interpretations

T, T_o — The times at which attention is turned on and off. Define $b = \left[\frac{T_o - T}{d}\right]$ as the number of positions attended to.

d — The SOA of the digits.

Model random variables (r.v.s) are

$R^* = r^*$ — If the response $r^* = (i,j,k,l)$

$W^* = w^*$ — If digits in positions $w^* = (n+1,\ldots,n+m)$ are perceived.

These r.v.s have the same interpretation as in Model 1. The model does not predict R, but R*; and since $m \leq 4$ by assumption, every perceived digit is reported no matter what permutation is chosen, and so the choice of permutation can be ignored. This means that Model 2 can give predictions about item information, but not about order.

b. Model axioms

For notational convenience, let b^* be the (fixed) set of positions payed attention, so that $b^* = \left\{ \left[\frac{T}{d}\right]+1, \left[\frac{T}{d}\right]+2, \ldots, \left[\frac{T}{d}\right] + b \right\}$. Then:

Axiom 1

$P(R'^* = r'^* \mid W^* = w^*) = G(R^*, r'^*, w^*)$;

where $R'^* = r^* \cap b^*$.

It follows from probability theory that

$$P(R'^*=r'^*) = \sum_{w^*} G(r^*,r'^*,w^*)P(W^*=w^*).$$

c. Restrictions on G

Model 2 may be developed by using the guessing correction procedure of Sperling and Melchner (1976), who developed a model for a slightly different situation. In their situation, S is presented with a set of b randomly chosen stimuli (without replacement) taken from an alphabet of more than b potential stimuli. Their situation is adapted to the present one by taking the alphabet as the set of 10 critical digits and taking the stimulus set to be the b digits payed attention. The theory (Disscussion: Assumption 13) is the S's turning on and off attention is gating the sequence of digits so that the unattended digits may be regarded as not stimulating the S at all. The guessing rule of Axiom 1 may now be specified (from Sperling and Melchner, Equation 10) as

$$G(r^*,r'^*,w^*) = \frac{\binom{10-b}{4-u}}{\binom{10-m}{4-m}}$$

where u is the number of elements of r'*.

This guessing rule is justified as follows. S perceives $m \leqslant 4$ digits and must guess 4-m digits to make up his response; he has 10-m digits to guess from, and may do so in $\binom{10-m}{4-m}$ ways (without replacement). Of these guesses,

u-b may be placed in just one way to generate r* from r'*. The remaining 4-u guesses must be selected from the 10-b digits in the complement of b* to be indifferent to the digits in r'* and this may be done in $\binom{10-b}{4-u}$ different ways.

d. Model 2.1

It follows from Axiom 1 and the guessing rule that

$$P(R'^* = r'^*) = \sum_{w^*} \left(P(W^*=w^*) \cdot \binom{10-b}{4-u} \div \binom{10-m}{4-m} \right) ,$$

where u is the number of elements of r'*.

This model may be developed in one of two ways: either the P(W*=w*) must be determined by the model and P(R'*=r'*) may then be predicted; or estimates of the P(R'*=r'*) may be obtained from the data, and the model solved for the P(W*=w*). In the absence of a model for determining the P(W*=w*), the second method was used. Since there are the same number of different W*s as there are R'*s, the only free parameter of the model is b, the number of positions payed attention. For a given value of b, the solution of the model for the P(W*=w*) may be obtained by the method and computer program given in Sperling and Melchner (1976).

Define P'_i and P'_e as follows:

$$P'_i = P(i \in w^*) = \sum_{w^*} P(i \in W^* \mid W^*=w^*)\, P(W^*=w^*)$$

$$\text{where } P(i \in W^* \mid W^*=w^*) = \begin{cases} 1 & \text{if } i \in w^* \\ 0 & \text{otherwise} \end{cases}$$

$$P'_e = P(e=\text{Min}(w^*)) = \sum_{w^*} P(EJ'=e \mid W^*=w^*)\, P(W^*=w^*)$$

$$\text{where } P(EJ'=e \mid W^*=w^*) = \begin{cases} 1 & \text{if } e = \text{Min}(w^*) \\ 0 & \text{otherwise} \end{cases}$$

P'_i is the probability of reporting the digit in position i anywhere in the response, P_i, after correction for guessing by Model 2.1. Similarly, P'_e is the probability that EP=e after correction for the EPs that were guessed. As before, $P'_e = P(EP'=e)$, and $P_e = P(EP=e)$.

Define g_i as the estimated amount of guessing at position i, so that $g_i = P_i - P'_i$. Thus $\sum_i (g_i + P'_i) = \sum_i (P_i) = 4$.

e. Fit of Model 2.1

Let the total probability of guessing be g, where $g = \frac{1}{4} \cdot \sum_i g_i = 1 - \frac{1}{4} \cdot \sum_i P'_i$. Model 2.1 was fit with a value of b that would minimize g, subject to the constrains that $b \leqslant 7$ and that the estimated P'_i should all be positive. The constraint that $b \leqslant 7$ was adopted in order to ensure that only positions in the positive set could be in b*. The constraints that P'_i should be positive arose because for some values of b, the size of b* may be underestimated and so g is overestimated. If g is overestimated, g_i in some positions where P_i is small may be overestimated, so that $P'_i = P_i - g_i$ may be negative. Note that this constraint only provides a lower bound on b: it is possible that the P'_is are underestimated even when all of them are positive.

The positions of the critical set that were used

when Model 2.1 was fit with b subjected to the above constraints, are given in Table 42. The distributions of P'_i and P'_e are given in Tables 17 and 20 respectively, for each condition of digit SOA and CC. The estimated total amount of guessing, g, is given in Panel A on Table 18. The ratio of detections to detections and guesses, that is, P'_i/P_i, is given in Table 19 for each condition. The distributions of P'_i and P'_e are all unimodal, and all have zero probability for positions outside b* by definition, so that the problem of truncation does not arise, as it did for the corresponding uncorrected distributions P_i and P_e. The means and s.d.s of the P_e distributions, expressed in msec, are entered in Table 21. The CC and SOA effects upon mean $t(P'_e)$ are given in Table 22, and an ANOVA upon these means is given in Table 23. The $t(P'_e)$ means and s.d.s are compared with the other measures of latency in Tables 27 and 28 and in Fig 8.

f. Analysis of the best-fit parameters for Model 2.1

The principle result for the latency measure is that the distributions of P'_e are similar to those of P_e. The CC and SOA effects upon mean $t(P'_e)$ mirror the effects upon mean $t(P_e)$, so that the possible assumption that those effects were indirectly caused by guessing must be abandoned. Indeed, since Model 2.1 tends to overestimate the amount of guessing by limiting the size of b*, while the $t(P_e)$ measure of latency is based upon the assumption of no

guesses, it seems very likely that any other guessing model that fell between these extremes would also find a similar effect of digit SOA and CC upon latency.

In so far as P'_e and P_e differ, the CC and SOA effects upon $t(P'_e)$ are slightly greater, both in mean and in variances. This is consistent with assumption that the effect of random guessing wou'd tend to shift all means towards the same point (the mean of the critical set), and tend to "smudge out" any differential CC or SOA effects upon variance. The smudging out would occur because guesses would increase the variance of $t(P_e)$ by an amount that would be relatively insensitive to condition. It is the case that for a few conditions, variance in $t(P_e)$ was less than variance in $t(P'_e)$, however, in contradiction with the expected smudging out effect (Table 28 Panel A).

g. Generalization of Model 2.1 to find a corrected P_{ij} matrix, P'_{ij}

Model 2.1 may be generalized by considering the number of responses, r, to be variable from 1 to 4. In this case, the guessing rule $G(r^*,r'^*,w^*) = \binom{10-b}{r-u} / \binom{10-m}{r-m}$ (Sperling and Melchner, 1976). For each value of r, the first r positions of S's responses are included, and all other positions excluded, in the analysis. Define $P'_i(r)$ to be the perceived item information obtained in the same way as P'_i, but conditioned on the inclusion of only response positions $j = (1,2,.,.,r)$. Then,

$$P'_{i1} = P'_i(1)$$

$$P'_{i2} = P'_i(2) - P'_i(1)$$

and, in general, for $j > 1$

$$P'_{ij} = P'_i(j) - P'_i(j-1).$$

The P'_{ij} distributions represent the additional information gained from each position i to be found in each response position j, because the $P'_i(j)$ distributions represent the cumulated probability of the digit in position i being reported in any response position from the 1^{st} to the j^{th}. The P'_{ij} distributions, i = (1,2...7), are defective, since the probability of guessing in the j^{th} position, g_j, where $g_j = \sum_{i=1}^{7} P'_{ij}$, is greater than zero.

The P'_{ij} matrixes are given in Table 37 and plotted in the usual way in Fig. 14. If the assumptions of Model 2.1 are valid, then the P'_{ij} matrices are the P_{ij} matrices corrected for guessing. The large increase in g_j with j is evidence that the 4 responses used (in some of AK's conditions, the first 3 responses used) contained the great majority of the information available to S in the task. That is, had there been a 5^{th} response position, it seems from the small values of P'_{i4} that P'_{i5} would have been essentially zero. (It is worth repeating that, had a larger stimulus set been used, evidence that S was not guessing might have been obtained, so that Model 2 would be

disproved; and conversely, had the S's responses been found to extend over a very long temporal interval, the assumption that responses from the later positions were in fact guesses could be made more plausible). For the present data, the finding that 4 responses were sufficient to capture nearly all of the information available to S must be regarded as highly model dependent. Note that for the slow SOAs, g_4 is considerably less than 1, and in these conditions there is every reason to believe that S could have reported more than 4 digits on most trials if asked, so that the methodology may underestimated S's total information.

Since the focus of the research is on the latency measures, the possibility that S might have been able to give more information from the later stimulus positions is not harmful. However, because of the loss of order information, it might well be that a 5th response might have included some information about early stimulus positions, and so influenced the estimates of T. This effect should not have biased the present data very much if Model 2.1 is accepted, because at fast SOAs P'_{i4} was small for all i's and at slow SOAs the probability of permutation was reduced, so that the proportion of trials in which the EP' would be the hypothetical 5^{th} response position would be small. If, on the other hand, a model is accepted in which S is assumed to see $m > 4$ digits on each trial, then the greater m is than 4, the more biased estimates of latency (and of EP') will be. From this point of view it is perhaps

comforting that the best-fitting values for m in Model 1.1 were 4 or 5, so that the mean of f_i was not far from the mean of t(EP'). This means that the estimates of Latency were similar, no matter whether S was assumed to see 4 or more digits and permute them, or less than 4 and guess.

h. A Model for T based on Model 2.1 best-fit parameters

The P'_i distribution was converted to a defective stochastic distribution by dividing each P'_i by the number of responses, 4, so that $\frac{1}{4}\left(\sum_i P'_i\right) + g = 1$. Define $\underline{P}'_i = \text{Cum}\ (\frac{1}{4}P'_i) = \sum_{j=0}^{i} P'_j$. The $\underline{P}'_i$ are given in Fig. 15 for each SOA, where CC is the curve parameter, and in Fig. 16 for each CC, where SOA is the curve parameter. These cumulative distributions represent the increase in item information with time, where the item information is corrected for guessing and is estimated independently of the response position. It is noticeable that these c.d.f.s increase at a reasonably linear rate, up to some asymptotic value. A simple model for this was formulated as follows: S turned attention on at some fixed time T after the CC, turned it off at some fixed later time T_o, and detects the digit in each attended-to position with probability h. If T occurred at a time that was not an integer multiple of the digit SOA, then the probability of detection of the first digit EP' attended to was assumed to be $\left(h \cdot (T-t_e)/d\right)$, where e=EP' and d= digit SOA. Consistent with the

assumptions of Model 2.1, $\underline{S}$ was assumed to detect from 4 positions or less, so that the probability of his detecting more than 4 digits was zero. The model was fit with the simplifying assumption that $\underline{S}$ always payed attention to 4 positions, so that $T_o = T + 4d$. In this model, $\underline{P'}_i$, the predicted cumulated item probability to position i, is

$$\underline{P'}_i = \sum_{j=0}^{i} (\tfrac{1}{4} P'_j) = \begin{cases} 0 & \text{,if } t_i < T-d \\ h(t_i - T) & \text{,if } T-d \leq t_i \leq T+3d \\ h4d & \text{,if } t_i > T+3d \end{cases}$$

$$= h.\ \text{Min}\ [\text{Max}(0,\ t_i - T)\ ,\ 4d]\ .$$

As usual, it is assumed that $EP' = e$ if $t_e \leq T < t_{e+1}$ (section 2).

i. Fit of the model for T

This model was fit by minimizing the Kolgomorov-Smirnov D statistic over the space of parameter values of T and h investigated by the program, where D = Max $(|\underline{P'}_i - \underline{P'}_i|)$, i=1,2,..,7 , and where $\underline{P'}_i$ and $\underline{P'}_i$ are the predicted and obtained cumulative probabilities respectively. The best fit values for T and d/h are given in Table 68, and for these values none of the predicted distributions of $\underline{P'_i}$ can be rejected at the .1 level of D. The third column of the table for each $\underline{S}$ gives 1 - MSE, where MSE = $\sum_i (\underline{P'}_i - \underline{P'}_i)^2 \ / \ \sum_i (\underline{P'}_i)^2$ is the ratio of the total squared errors of prediction to the total squared $\underline{P'}_i$

values. The closeness of MSE to 0, and thus of 1-MSE to 1, is evidence of a close fit by a least-squares criterion. The values of T and of d/h are summarized in Table 68 . Since the slope of $\underline{P'}_i$ is measured in digits per msec, the inverse of the slope, or d/h, is the number of msec needed for each [illegible]it to be perceived, according to the m[illegible]

j. An interpre[illegible] parameters

The val[illegible]fects of CC and of SOA upon latenc[illegible]effects are 28 msec, 21 msec, and 17 [illegible] respectively; and the mean absolute S[illegible]msec, 87 msec, and 61 msec respectively. These effects are very similar in magnitude to the CC and SOA effects upon t($\overline{EP'}$) given in Table 27. This means that although t($\overline{EP'}$) and T are shifted with respect to one another, the discussion of the latency effects of CC and of SOA upon t($\overline{EP'}$) applies to T. The values of d/h show virtually no effect of CC but a strong effect of SOA. The effect of SOA is to increase the time taken to perceive each additional digit, or d/h, which seems somewhat paradoxical. However, if digit SOA is increased while detection is kept constant, then d/h must increase with d. At fast SOAs, an increase in SOA should have a large effect upon h, so that d/h might decrease with d; but at slow SOAs where h was high and could not increase very much, d/h would increase with d. In Norman and Bobrow's

(1975) terms, the output measure d/h would be 'resource limited' at fast SOAs and 'data limited' at slow SOAs. inspection of the data in Table 68 suggests that, rather approximately, d/h = d + k, where k is some constant for each S, at least for Ss AR and GL. This implies that h = d/(d+k). When the model was re-run with this const placed upoh h, fits were obtained that could not be rej at the .05 level of the Kolgomorov-Smirnov D statistic, for all conditions of AR but C and U at 75 msec, for all conditions of GL but S at 214 msec, and for all conditi of AK except those at 178 msec. The form h = d/(d+k) m h approaches 1.0 as SOA becomes long and 0 as SOA becom short, which is correct. Putting together this result the latency model for T,

$$\underline{P}'_i \triangleq \left(\frac{d}{d+k}\right) \cdot \text{Min [Max } (0,\ t_i - L_c - S_d),\ 4d].$$

In Norman's terms, this constraint upon h means that d/ is data limited by d when d is large, and resource limi by k when d is small. In order to approach pure resour limitation, a range of values of d would need to be for for which d/h decreased with d: with the present experimental methodology, this would require SOAs faster than msec (but slower than 40 msec, where the digits appear become visually inseparable). The confirmation of a c stant value for k at these rates would support the idea that k represents a fixed limitation for each S.

values. The closeness of MSE to 0, and thus of 1-MSE to 1, is evidence of a close fit by a least-squares criterion. The values of T and of d/h are summarized in Table 68 . Since the slope of $\underline{P'}_i$ is measured in digits per msec, the inverse of the slope, or d/h, is the number of msec needed for each extra digit to be perceived, according to the model.

j. An interpretation of the best-fitting parameters

The values of T show the usual effects of CC and of SOA upon latency. The mean absolute CC effects are 28 msec, 21 msec, and 17 msec, for AR, GL and AK respectively; and the mean absolute SOA effects are 42 msec, 87 msec, and 61 msec respectively. These effects are very similar in magnitude to the CC and SOA effects upon $t(\overline{EP'})$ given in Table 27. This means that although $t(\overline{EP'})$ and T are shifted with respect to one another, the discussion of the latency effects of CC and of SOA upon $t(\overline{EP'})$ applies to T. The values of d/h show virtually no effect of CC but a strong effect of SOA. The effect of SOA is to increase the time taken to perceive each additional digit, or d/h, which seems somewhat paradoxical. However, if digit SOA is increased while detection is kept constant, then d/h must increase with d. At fast SOAs, an increase in SOA should have a large effect upon h, so that d/h might decrease with d; but at slow SOAs where h was high and could not increase very much, d/h would increase with d. In Norman and Bobrow's

(1975) terms, the output measure d/h would be 'resource limited' at fast SOAs and 'data limited' at slow SOAs. An inspection of the data in Table 68 suggests that, rather approximately, d/h = d + k, where k is some constant for each S, at least for Ss AR and GL. This implies that h = d/(d+k). When the model was re-run with this constraint placed upoh h, fits were obtained that could not be rejected at the .05 level of the Kolgomorov-Smirnov D statistic, for all conditions of AR but C and U at 75 msec, for all conditions of GL but S at 214 msec, and for all conditions of AK except those at 178 msec. The form h = d/(d+k) means h approaches 1.0 as SOA becomes long and 0 as SOA becomes short, which is correct. Putting together this result with the latency model for T,

$$\underline{P}'_i \triangleq \left(\frac{d}{d+k}\right) \cdot \text{Min } [\text{Max } (0,\ t_i - L_c - S_d),\ 4d].$$

In Norman's terms, this constraint upon h means that d/h is data limited by d when d is large, and resource limited by k when d is small. In order to approach pure resource limitation, a range of values of d would need to be found for which d/h decreased with d: with the present experimental methodology, this would require SOAs faster than 75 msec (but slower than 40 msec, where the digits appear to become visually inseparable). The confirmation of a constant value for k at these rates would support the idea that k represents a fixed limitation for each S.

k. A random-sampling model for order, given Model 2.1

Define $\hat{P}'_1 = 4.\ (\underline{P}_{i+1)} - \underline{\hat{P}}'_i)$, so that $\hat{P}'_i$ is the uncumulated probability of perceiving the digit in position i, predicted by the model. If S were to have no order information, then on each trial he would perceive digits in accordance with the distribution $\hat{P}'_i$. He would then randomly select 4 of these digits, guessing at random from the remaining digits if he perceived less than four digits, for report. A computer was programmed to select 4 responses according to the defective probability distribution $\hat{P}'_i$, repeatedly sampling until 4 different responses were selected. Selection of a 'guess' occurred with probability equal to $1 - \sum_i \hat{P}'_i$. On the occurrence of a 'guess', the program selected at random from the as-yet unselected digits, with probability 1/(10-u), where u is the number of digits already selected. (This sampling model simulates the case when q=0 and $m \leq 4$ in Model 1, except the number of digits assumed seen on each trial, m, is constant in Model 1 but a r.v. in Model 2.) By sampling on each trial, the computer generates a response R = (i,j,k,l), $i \neq j \neq k \neq l$. The program was run to 3,000 trials in order to ensure 3rd decimal place accuracy in the matrices R computed on the responses. Note that the sampling model includes guessing, so that the R matrix may be compared directly with the R matrix obtained from the data.

The fits failed badly, for the following reason.

If the distribution $P(\hat{R}_{i1})$ is symmetric around its mean, then repeated sampling from that distribution will produce symmetrical distributions $P(R_{ij})$ for $j > 1$, even given the $i \neq j \neq k \neq l$ rule. If the $P(\hat{R}_{i1})$ is skewed, then successive samples will be more likely to be chosen from the longer tail, thus moving the mean of $P(\hat{R}_{ij})$ towards the longer tail as j increases. Thus the amount of order information in the $\underline{\hat{R}}$ matrices depends upon the summetry of the first response distribution $P(\hat{R}_{i1})$. For the obtained data, the first response is reasonably symmetrical (Table 35): indeed, it has been seen to be symmetrical enough to be fit by a Normal distribution N(1). The finding that successive means $M_j = P_{ij}$ increase with j (Fig. 2) for all conditions with digit SOA greater than 75 msec, thus disproves the sampling model. Indeed, this problem is severe enought eliminate the possibility of the sampling model with <u>any</u> distribution of $\hat{P}'_i$: when the computer was programmed to find a best-fitting set of P'_is, the best-fit probabilities still could not successfully generate the $\underline{R}$ matrices.

One possible generalization of the sampling model is that $\underline{S}$ generated his response $\hat{R}=(i,j,k,l)$ by sampling i from R'_{i1}, j from R'_{i2}, k from R'_{i3}, and l from R'_{i4}, subject to the usual rule that $i \neq j \neq k \neq l$. This generalized model will be discussed in the next section, on Model 3, in section 4e. The model was fit by a Monte-Carlo procedure explained in section 4d. When the predicted $\hat{Tau}_{ij}$ values

were matched against the data, it was found that the sampling 'without replacement' model did quite well at the short SOAs, but not so well at the longer SOAs. This point is further discussed in the context of a two-stage sampling model in the next section.

1. The structure of the W* obtained from Model 2.1

The structure of the $P(W^*=w^*)$ distribution estimated by Model 2.1 was studied in each condition of Recall 4. Each W* is assumed to consist of the set of digit positions that contained perceived digits; the W* contain no information about the order of the digits in the response, as has been noted, but do contain information about the nature of the percept. In the "successive detection" model, assumed in Model 1, the W* contain the successive digits from the onset to the offset of attention. In the "independent detection" model, S detects digits in the attended-to position with probability $P'_i < 1$, with detection at position i independent of detection at position k, but subject to the constraint that no more than 4 digits are detected. Thus,

$$P(i \in W^* \ \& \ k \in W^*) = P(i \in W^*).P(k \in W^*) - c,$$

where c is a correction factor to remove those trials in which more than 4 digits would be seen according to pure independence. If the total amount of guessing, g, is large, then the probability of seeing more than 4 under pure independence would be small, so that c would be

negligable. In conditions where g was large, digit SOA was small, and, setting c=0, the independent detection model was found to generate predictions that were close to the observed P(W*=W*)s. The successive model failed, because W*s with non-successive digit positions were frequent: for example, P(W*=(i, i+2)) = .16 in AR letter C at 75 msec. In the condition where g was small, digit SOA was large, and c was not negligable. Here, the two models both predict that the next 4 digits following T have very high probabilities of report, so the data cannot discriminate between them.

Thus the data seemed compatible with an assumption of two successive stages of independent sampling, since independent detection of the stimuli, and independent selection of the detected stimuli for the response, provided reasonable fits to the P(W*=w*) and to Tau_{ij} respectively, at least when the SOA was fast. In the first stage, the digit stream is sampled for digits, chosen at random according to the P'_i distribution with the constraint that no more than 4 digits may be detected on a trial. In the second stage, the detected digits are sampled in a random order for the response. If less than 4 digits are detected, additional digits are then selected from the remaining digits in order to complete the response (so that g_j increases with j). This 'response' would be the set of digits actually seen by S, according to the introspection

that Ss reported just what they saw. (If this two stage model be accepted, the entire fitting procedure of Model 2.1 may be inverted. It would be possible, for a given set of P'_is, to predict the actual item and order data using the 2 stages of sampling. This process would be analogous to the use of m, f_e, and q to determine item and order information in Model 1.1, except that for this model detections would be independent up to 4, rather than linked together by the size of m and the value of T.) Because there is some order information over and above that which could be generated by independent sampling without replacement at the slower SOAs, the two stage version of Model 2 would fail at the slower SOAs.

The problem with such a two-stage model is in the second stage. In order to fit the data it is necessary to assume that S makes successive samples from successive distributions, P'_{i1}, P'_{i2}, etc. rather than repeatedly sampling the same distribution P'_i. The evidence for this was given in the preceeding section. Thus the two-stage model would have to be elaborated to include a mechanism that 'shifted' the P'_i distribution to the right as the successive samples were being made. This mechanism would itself provide some order information, in that it would induce a stronger correlation between M_j and j. It does not seem worthwhile to introduce the rather strong

assumption of no order information (random sampling), only to modify that assumption through a new mechanism. Therefore the two-stage random sampling notion was rejected.

4. Model 3.

a. Model parameters and their interpretation

P''_{ij} Model parameters are the elements P''_{ij} of a stochastic matrix P", where index i corresponds to positive set positions (i=8 for the negative set), and index j correspond to the 4 response positions. There are 4 x (8-1) = 28 free parameters in each condition.

The model random variables are

$A = a$ if digits in positions $a = (a_1, a_2 \ldots a_m)$ are detected.

$W = w_a$ if digits in positions $w_a = (w_a(1), \ldots w_a(b))$ are seen.

$R = r$ if digits in positions $r = (i,j,k,l)$ are reported.

Random variables W and R are the same as before (Model 1). However, A has a different character. In Model 3 it is assumed that the same digit may be detected more than once, so that the elements of A need not all be different. Further, the elements of A need not be in the order of presentation. (Unlike previous models, this model does not specify the permutation X that is applied to A). It is assumed that m is not fixed, except that m must be less

than or equal to 10, so that digits from outside the critical set are not allowed to enter A.

The set of detected digits, A, is generated by a process involving independent detections of the digits, as follows:

b. Axioms

(1) $P(R=r \mid W=w_a, A=a') = G(r,w_a)$

(2) $P(W=w_a \mid A=a') = \begin{cases} 1 & \text{if } w_a = \hat{\#}_m(a') \\ 0 & \text{otherwise} \end{cases}$

(3) $P(A=a) = P(a_1=i).P(a_2=j)...P(a_m=1)$

$$= \prod_{j=1}^{m} (P''_{ij}) \quad , \text{ where } P''_{ij}=P(a_j = i).$$

While Axiom 1 is the same as in Model 1, Axiom 2 is changed because of the new character of A. The symbol $\hat{\#}_m(x)$ means the vector obtained by deleting identical elements in the first m positions of vector x. For example, $\hat{\#}_5(1,1,3,2,5) = (1,3,2,5)$.

From the axioms, it follows that:

$$P(R=r) = \sum_{w_a} \sum_{a'} P(R=r \mid W=w_a, A=a').P(W=w_a \mid A=a').P(A=a')$$

$$= \sum_{w_a} \sum_{a' \in B} G(r,w_a).P(A=a') \text{ , by Axioms 1 and 2,}$$

where $a' \in B$, if $w_a=\#_m(a')$

Restrictions on G

The model is developed only for the case in which the number of different elements in A, which is u (so that m-u is the number of repeated elements), is greater than or equal to 4. In this case, no guessing is assumed to occur. Then:

$$G(r,w_a) = \begin{cases} 1 & \text{if } r = \#_4(w_a) \text{ and } u \geq 4 \\ 0 & \text{otherwise} \end{cases}$$

It follows from this and the above derivation of P(R=r) that

$$P(R=r) = \sum_{w_a \in X} \sum_{a' \in B} P(A=a')$$

where $w_a \in X$ if $r = \#_4(w_a)$ and $u \geq 4$.

From Axiom 3 and the definition of P''_{ij}, this in turn means that

$$P(R=r) = \sum_{w_a \in X} \sum_{a' \in B} \left[\prod_{j=1}^{m} P''_{ij} \right]$$

P(R=r) can be computed from this equation, from the following considerations. To satisfy $a' \in B$, it must be the case that $w_a = (i,j,k,l,m...)$ if $a=(i,x,j,y,k,z,l,w...)$, where x,y,x,w are the sets of elements that are removed by the application of $\#_m$. That is, x is either null, or all its elements are equal to i. Similarly, y is either null, or all its elements are equal to i or j; z is null or equals i,j, or k; and w is null or equals i,j,k, or l. The remainder of W, which is $W-\#_m(W)$, is irrelevant, because of the condition that $w_a \in X$.

It follows from independent detections (Axiom 3) and the above, that

$$P(w_a(1)= i) = P''_{i1}$$

$$P(w_a(2)= j \mid w_a(1)=i) = P''_{j2} \;/(1-P''_{i2})$$

$$P(w_a(3)=k \mid w_a(2)=j,\ w_a(1)= 1) =$$

$$P''_{k3} \;/(1 - P''_{i3}-P''_{j3}-P''_{k3})$$

and so forth.

Since $r = \#_4(w_a)$ on the assumption that $u \geq 4$,

$$\begin{aligned} P(R=r) &= P(W=w_a \mid \#_4(w_a)=r) \\ &= P(w_a(1)=i,\ w_a(2)=j,\ w_a(3)=k,\ w_a(4)=1) \\ &= P(W_a(1)=i)\cdot P(w_a(2)=j \mid w_a(1)=i)\cdot P(w_a(3)=k \mid w_a(2)=j, w_a(1)=i)\cdot \\ &\qquad P(w_a(4)=1 \mid w_a(3)=k,\ w_a(2)=j,\ w_a(1)=i) \\ &= \frac{P''_{i1} \cdot P''_{j2} \cdot P''_{k3} \cdot P''_{14}}{(1-P''_{i2}) \cdot (1-P''_{i3}-P''_{j3}) \cdot (1 - P''_{i4}-P''_{j4}-P''_{k4})} \end{aligned}$$

The numerator of this ratio expresses the multiplicative independence property, while the denominator expresses the correction necessary to make every response element different (so that r=(i,j,k,l), where i≠j≠k≠l).

Model 3 was developed in order to derive predictions for $\hat{P}_{ij}$, the predicted value of P_{ij}. From the condition that i≠j≠k≠l, we have

$$\hat{P}_{i1} = P''_{i1}$$

$$\hat{P}_{i2} = \sum_{j\neq 1} (P''_{ji} \;\&\; i2)$$

$$\hat{P}_{i3} = \sum_{k\neq j\neq 1} (P''_{i3} \;\&\; J2 \;\&\; k1)$$

$$\hat{P}_{i4} = \sum_{k\neq j\neq 1\neq i} (P''_{i4} \;\&\; j3 \;\&\; k2 \;\&\; 11).$$

From the assumption of independent selection of successive samples,

$$P''_{ji} \;\&\; i2 = \begin{cases} P''_{i2} \cdot P''_{ji} & \text{, if } i\neq j \\ 0 & \text{otherwise.} \end{cases}$$

Therefore,

$$\hat{P}_{i2} = \sum_{j\neq i} (P''_{i2} \cdot P''_{ji}) = \left(\sum_{i\neq j} P''_{ji}\right) \cdot P''_{i2}$$

and similarly for P_{i3} and P_{i4}.

That is,

$$\hat{P}_{i1} = P''_{i1}$$

$$\hat{P}_{i2} = P''_{i2} \cdot \sum_{j\neq 1} (P''_{j1}) = P''_{i2} \cdot \sum_{j\neq i} (\hat{P}_{j1})$$

$$\hat{P}_{i3} = P''_{i3} \cdot \sum_{k\neq j\neq i} (P''_{k2}) \cdot \sum_{j\neq i} (P''_{ji}) = P''_{i3} \cdot \sum_{k\neq i} (\hat{P}_{k2})$$

$$P_{i4} = P''_{i4} \cdot \sum_{k\neq j\neq 1\neq i} (P''_{k3}) \cdot \sum_{j\neq 1\neq i} (P''_{j2}) \cdot \sum_{1\neq i} (P''_{11}) = P''_{i4} \cdot \sum_{1\neq i} (\hat{P}_{13})$$

and thus in general

$$\hat{P}_{ij} = P''_{ij} \cdot \sum_{k\neq i} (\hat{P}_{k,j-1}).$$

c. Fit of Model 3

A straightforward fit to the P(R=r) could be obtained from Axiom 1 for a given P" matrix. Since the P''_{ij} s are unknown, however, a search for the best-fitting set of predicted P(R=r)s would be computationally difficult. Whereas in Model 1.1 only 2 free parameters needed to be estimated to predict the P(R=r)s, in this model there are 28 such free parameters. To avoid this labour, advantage was taken of the derivation of the P_{ij}s from the the P''_{ij} s. If it is assumed that the P_{ij} s provide the best estimates of the P_{ij} s, then the P''_{ij} s may be found by inverting the above expressions for P_{ij}. The inversion method was not analytic, but rather was done by a Monte-Carlo procedure, described in the next section. The method used ensured 2nd decimal place accuracy in computing the P_{ij} s,

for the range of P_{ij} s that were being fit (between .005 and .995).

d. The Monte-Carlo procedure

The P_{ij} were derived from an arbitrary matrix P" as follows. On each 'trial', 4 values X_1 through X_4 of a rectangularly distributed random variable X were obtained, where $0 \leq X \leq 1$. Let $\hat{R}_{ij} = 1$ mean that the digit in the i^{th} position was sampled for response position j. Then, in a predicted response $\hat{R} = (i,j,k,l)$,

$$\hat{R}_{ij} = \begin{cases} 1 & , \text{ if } \sum_{k=1}^{i} P''_{kj} \leq X_j < \sum_{k=1}^{i-1} P''_{kj} \text{ , and if} \\ & \\ & i \in \#_{j-1}(R^*) \\ & \\ 0 & , \text{ otherwise.} \end{cases}$$

If i was rejected because it was already chosen in $\hat{R}^*$, then a new value of X_j was sampled. Thus, by the end of each trial, the Monte-Carlo procedure generated a response $\hat{R}$, with elements all unequal to each other.

A complete set of predicted responses was obtained for a large number of computer-generated trials. From this set, the probabilities $P(\hat{R}=r)$ were obtained. In fitting Model 1.1, the $P(\hat{R}=r)$ were tested directly against the $P(R=r)$. For the reason given above (section c), in fitting Model 3 the $P(\hat{R}=r)$s were first reduced to the

small set of $\hat{P}_{ij}$s. This reduction was done in the same way as P(R=r) was reduced to P_{ij} in the data (Results, section 4). The predicted $\hat{P}_{ij}$s were then matched against the data P_{ij}s by finding $\epsilon = \text{Max} \mid \hat{P}_{ij} - P_{ij} \mid$. The computer performed a grid search, varying the P''_{ij} distributions until the minimum value of ϵ was found. The values of P''_{ij} at that minimum were assumed to be the best predictors of the data. The values of ϵ at minimum were generally very small, so that 2nd decimal place accuracy was ensured in prediciting the P_{ij}s. The number of trials run in each pass of the Monte-Carlo, 3000, was enough to ensure 3rd decimal place accuracy in obtaining the $\hat{P}_{ij}$s from the P''_{ij}s.

It is not clear whether success in obtaining a nearly exact prediction of the P_{ij}s is evidence for the model or not. Although there may be P_{ij} matrices for which an inversion is impossible, the use of a Monte-Carlo method, rather than an analytic problem in order make this apparent. (I have not solved the analytic problem in order to discover whether such matrices exist. If they do not, then success in finding an inversion is inevitable, and the model cannot be disconfirmed at this level.) The model was therefore tested in the following way. Using the P''_{ij} distributions for which the error in prediction of P_{ij} was minimum, the entire set of 3,000 Monte-Carlo trials was re-computed. This set of trials was reduced to the set of $\hat{Tau}_{ij}$ values, in the same way that the data was reduced to the Tau_{ij} values in the Results (section 4). Thus, the 28 P''_{ij}

parameters of the model were used to predict both the 28 P_{ij} s and the 7x7=49 Tau_{ij} s, in each condition of the experiment.

The measure of fit to Tau_{ij} by the Model in Table 69 is one-half the mean absolute deviation, which is $\frac{1}{2}.\left(\frac{1}{42}\sum_i\sum_j |\hat{Tau}_{ij} - Tau_{ij}|\right)$, as there are 6x7 non-zero Tau_{ij} cells which enter the average. (Since Tau_{ij} must lie between -1 and +1, the mean absolute deviation must lie between 0 and 2. Thus the deviations are halved to ensure that they lie between 0 and 1.) The deviations, entered under the heading "Model 3" in Table 69, show a small dependence on CC and a larger dependence on SOA, but are by and large small in value. (By visual inspection, the $\hat{Tau}_{ij}$ curves showed the same laminar U-shape forms as the Tau_{ij} curves. The small errors in predicting Tau_{ij} that did occur, seem to have been unsystematic over i and j.)

e. <u>An application of the Monte-Carlo in Model 2.1</u>

The same Monte-Carlo procedure was applied to the P'_{ij} distributions generated by Model 2.1. In the application, the P'_{ij} matrices took the same role as the P''_{ij} had done. To make the matrices stochastic, P'_{8j} was defined as $1-\sum_{i=1}^{7} P'_{ij}$.

The $\hat{Tau}_{ij}$ values, predicted by Model 2.1 and the assumption of sampling at random without replacement emboided in the Monte-Carlo procedure, were tested against

Tau_{ij} by finding one-half the mean absolute deviation, just as with the Model 3 predictions. These deviations are entereted under Model 2.1 in Table 69. The deviations show a small effect of CC, and a considerably larger effect of SOA. Visual inspection of the predicted $\hat{Tau}_{ij}$ values showed that Model 2.1 tends to predict values for the extreme positions (i and j = 1,2,6,or 7) which are too close to zero. The reason for these systematic deviations seems to be as follows. Model 2.1 over estimates the amount of guessing in the extreme positions. Random guesses do not contain order information, except by default (guessing is without replacement), so guessing tends to bias $\hat{Tau}$ towards zero. This problem is particularly severe in the long SOA conditions, when a larger proportion of extreme responses were from detections rather than from guesses. Thus the discrepancy tends to increase with SOA.

f. Analysis of the best-fitting parameters of Model 3

The parameters of interest are the set of 28 P''_{ij} values in each condition. These values are graphed for each condition in Panel B of Fig. 13, pages 1 through 39. Investigations of these figures shows that P''_{ij}s are like P_{ijs} , except that when j = 3 or 4, the P''_{ij} distributions are more peaked. This peaking means that $P''_{3,4} > P_{3,4}$, while $P''_{1,4} < P_{1,4}$, for example. The reason for this peaking in intuitive terms is that $P''_{3,4}$ is depleted in its

effect when stimulus 3 has already been chosen, say for the first or second response. The likelihood that this stimulus has already been chosen is approximately $P"_{3,1} + P"_{3,2} - (P"_{3,1} \times P"_{3,2})$. This likelihood increases if either $P"_{3,1}$ or $P"_{3,2}$ is increased. Therefore the stimuli with high probability of already being chosen will tend to be depleted more. In order to ensure a value of $P_{3,4}$ which is sufficiently avove zero, $P"_{3,4}$ must be considerably above zero. For conditions in which P_{ij} is generally low, such as the 75 msec SOA conditions, the depletion effect will be small and so $P"_{ij}$ will generally be quite similar to P_{ij}; and this is the case (for example, Fig. 13 page 1). Where P_{i1} is quite large for some i, the depletion effect will occur and P_{i3} and P_{i4} will therefore differ from $P"_{i3}$ and $P"_{i4}$ (for example, Fig. 13 page 5).

The fact of peaking when j=3 and j=4 (and even, to a lesser extent, when j=2) means that the $P"_{ij}$ distributions are more similar to each other than the P_{ij} distributions, within each condition. Ideally, all 4 $P"_{ij}$ distributions would be the same. This would occur if S were taking 4 successive samples, without replacement, from some single distribution Q_i. This was not the case: not only do the $P"_{ij}$ distributions differ from each other visually, but an attempt to find a single Q_i distribution from which the data could be generated by sampling without replacement failed rather badly. An attempt was therefore made to

describe the P''_{ij} distributions by finding some function $Q_i(t)$, with the property that $Q_i(t)$ should be negatively skewed for small t, symmetrical and unimodal for medium t, and eventually flat at $Q_i(t) = .1$ for $t = \infty$. This dependence on t means that as S successively sampled from $Q_i(t)$, the shape of $Q_i(t)$ would change as time went by, so that $Q_i(t)$ would be initially peaked around the time of attention shift, and would finally be flat when all perceptual information had decayed and S could only guess. Ideally, such a function $Q_i(t)$ could be computed from a single function of time, q(t), such that $Q_i(t) = \int_{d.1}^{d.(i+1)} q(t)$. The function q(t) would be assumed to be constant over digit SOAs, and would reflect the influence of attention upon the perceptibility of successive digit positions. I am fairly confident that such a function does not exist. The principle reason is that the P''_{ij} values must be fairly exact in order to ensure reasonable fits to P_{ij} and Tau_{ij}. Distributions that might be candidates for $Q_i(t)$, such as the Gamma, are unlikely to predict exactly the values of P''_{ij} that were obtained by the Monte Carlo simulation. Thus even finding $Q_i(t)$, let alone q(t), proved to be impossible for me. Unless some particular can be obtained, the best estimate for the $Q_i(t)$ distribution is P''_{ij}, for the four time values indexed (somehow) by j. The failure to find a candidate for Q or q considerably limits the usefulness of Model 3.

g. The relation of the Model 3 fits to Item and Order Information

As noted in the preceeding sections, if a function q(t) could be found, then item information would be determined without replacement from q(t). Since such a function was not found, item and order information are determined in a somewhat more complex way by sampling from the 4 P''_{ij} distributions. Item information, as measured by P_{ij}, is the result of successive sampling from the P''_{ij}; the fact that the sampling is without replacement influences item information as well as order, since it is the sampling rule that converts P''_{ij} into P_{ij}. Order information, as measured by Tau_{ij}, is also the result of successive sampling from P''_{ij}. Because the P''_{ij} distributions are peaked, some orders (such as those beginning R=(4,5..)) are more likely than others (such as R=(2,4...)).

In the terms of Model 1, this means that the H(x) are all different. The assumption of Model 1.1 that permutations either do not occur (with probability q) or occur at random with equal probability, is therefore at variance with Model 3. Rather, the particular values for H(x) in terms of Model 1 are related in a complex way to the values of P''_{ij} and the assumption of random sampling without replacement in Model 3, even though the ideas of 'random sampling' and 'random permutations' seem rather rather similar. I have not obtained the rule that transforms H(x)s into sets of P''_{ij} (for a fixed window in Model 1,

such a rule must exist). However, as an illustration, consider the case of 'perfect' order information. In Model 1, this means that $H(x_o)=1$. In Model 3, this means that the P''_{ij} distributions are highly peaked around successive stimulus positions, so that for example $P''_{3,1} = 1$, $P''_{4,2} = 1$ $P''_{5,3} = 1$, and $P''_{6,4} = 1$. In the case of no order information, $H(x_o)$ is at chance level, and the P''_{ij} distributions are, for example, all identical and all placed in the critical set with mean at i=5.

h. An interpretation for Model 3

One interpretation for Model 3 is for perception of the digits to be undertaken by J successive 'servers' that monitor the digit stream. The effect of the shift of attention would be to turn on each server in succession. The j^{th} server removes the digit in the i^{th} position of the sequence according to the probability distribution P''_{ij} for report in the j^{th} response position: once a digit is removed, it cannot be perceived again by any servers operating at a later time. Because of variability in the process, server j sometimes operates before the earlier serves such as server k, $k < j$, even though the mean digit position served by j is later than that served by k, There need be no 'unified' percept W in this model, since the J servers may operate independently of each other (except that the digit stream is sampled without replacement). Finding J=4, at all SOAs, would be fortuitous, since one would not

such a rule must exist). However, as an illustration, consider the case of 'perfect' order information. In Model 1, this means that $H(x_o)=1$. In Model 3, this means that the P''_{ij} distributions are highly peaked around successive stimulus positions, so that for example $P''_{3,1} = 1$, $P''_{4,2} = 1$ $P''_{5,3} = 1$, and $P''_{6,4} = 1$. In the case of no order information, $H(x_o)$ is at chance level, and the P''_{ij} distributions are, for examp[illegible] and all placed in the critical set with[illegible]

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expect that the perceptual system could operate just as many processes as required by the response.

Visual inspection of the P''_{ij} distributions (Fig. 13, Panel B), suggests that there may be only 2 different servers at 75 msec, with the first response being fed by 1 server, and the 2nd, 3rd and 4th responses being fed by 3 server, with identical distributions. At 109 msec, there appear to be 3 different servers, with the 3rd and 4th responses having two identical servers; and at later SOAs, there appear to be 4 (or more) servers. A possible interpretation of this observation is to assume that there is a new type of server in every new psychological 'moment' (Stroud, 1955). At fast SOAs, successive digits begin to share the same server because they fall into the same moment. Thus, $P''_{ij} = P''_{ik}$ if j and k are having to operate in the same distribution of moments. To quantify this idea, let D_{jk} be the horizontal shift that translates P''_{ij} into P''_{ik}, so that if $\sum_{i=o}^{I} P''_{ij} = \sum_{i'=o}^{I'} P''_{ik}$, then $D_{jk} = I'-I$.

D_{jk} should be constant over all I if the servers are assumed to have districutions with the same variances (but different means), and if I values are interpolated where necessary. If the time axis is quantized in the same way over SOAs, then there should be some quantal size at which the D_{jk}s have the observed size for all SOA conditions.

That is, if all the cumulated $P"_{ij}$ curves for one CC are plotted by t_i, then a) they should all appear to be translations of the same curve; and b), they should fall on top of one another in a small number (J) of distinct locations upon the time axis, regularly placed at intervals of one quantum.

An attempt was made to force the obtained $\underline{P}"_{ij}$ distributions to meet these two constraints by forming average $\underline{P}"_{ij}$ distributions in temporal locations where the observed distributions tended to cluster, at the optimum fixed interval. The optimum was found by minimizing the absolute deviation of the obtained and constrained $\underline{P}"_{ij}$. Having found the optimum $\underline{P}"_{ij}$, the predicted $P"_{ij}$ were found by de-cumulating, and were entered into the Monte-Carlo simulation routine in order to predict the observed P_{ij} and Tau_{ij}. The fits were in general rather poor in comparison to the unconstrained fits,for two reasons: the $\underline{P}"_{ij}$ were not all parallel, and the averaging process into quantal units required rather gross shifts of mean for some of the $P"_{ij}$. (It was found in the fitting process that movements of $P"_{i3}$ and $P"_{i4}$ were relatively harmless in comparison to movements of $P"_{i1}$ and $P"_{i2}$, because the effect of incorrectly estimating $P"_{ij}$ when j is large is somewhat smoothed over by the larger proportion of random guessing predicted for large j.) The failure of these constraintes leaves the distributions of the $P"_{ij}$ unexplained.

5. Model 4

a. Model parameters and their interpretation

The parameters of the model are a set of seven 'position precedences', V(i), $1 \leq i \leq 7$. A digit that was presented in a position with a high precedence, it is assumed, is more likely to be reported before a digit from a position with low precedence. To formalize this assumption, define H(x) as a monotonically increasing anti-symmetric function. That is, $x < y$ implies $H(x) < H(y)$, and $H(x) = -H(-x)$. The order information available to S about positions i and j is assumed to be measured by Tau_{ij} (as defined in the Results, section 4). The fundamental axiom of Model 4 is as follows.

b. Axiom

There exists a function V(i), and a monotonic and anti-symmetric function H(x), such that

$$Tau_{ij} = H(V(i)-V(j))$$

From this axiom and the definition of H, it follows that $Tau_{ij} = -Tau_{ji}$, as is required by the definition of Tau_{ij} (Results, section 4).

The axiom implies, and is implied by, 'double concellation'. This property is as follows:

$$Tau_{ij} < Tau_{kl} \quad \text{implies} \quad Tau_{ik} < Tau_{jl}$$

Proof that double cancellation follows from the axiom is as follows. Because H is monotonic, $H^{-1}(Tau_{ij}) < H^{-1}(Tau_{kl})$ implies $V(i)-V(j) < V(k)-V(l)$; but this implies that $V(i)-V(k) < V(j)-V(l)$ by re-arrangement of terms, and this in turn implies that $H^{-1}(Tau_{ik}) < H^{-1}(Tau_{jl})$. This implies the right-hand side of double cancellation because H is monotonic.

c. Tests for this axiom

The axiom was tested by finding whether double cancellation did hold in the observed Tau_{ij}s. There are $\binom{7}{4}$ possible 'quads', or sets of quadruples (i,j,k,l) such that $i \neq j \neq k \neq l$. Double cancellation should hold for all of these 210 quads per condition. However, since the observed Tau_{ij}s are subject to statistical fluctuation, it is necessary to construct a test of the hypothesis that there are no violations of double concellation. This was done by finding 95% confidence intervals, using the estimate of the variance of Tau given in the Results Isection 4). Let e_{ijkl} by the 95% confidence interval around the difference $Tau_{ij} - Tau_{kl}$. Then,

$$e_{ijkl} = (1.96) \quad (Var(Tau_{ij}) + Var(Tau_{kl}))^{\frac{1}{2}}$$

In order to test for violations of double cancellation, only quads in which $Tau_{ij} - Tau_{kl}$ was less than $-e_{ijkl}$ were considered. The number of such quads is given in column 1 of Table 52 for every condition. Of these quads, the number of violations of double cancellation are of interest. A

violation was scored only if $Tau_{ij} - Tau_{kl} < -e_{ijkl}$, and $Tau_{ik} - Tau_{jl} > +e_{ikjl}$. The number of such violations is given in column 2 of the same Table, and in column 3 the proportion of violations to the number of tests in column 1 is given. The hypothesis that there were no violations can be rejected at the 5% significance level if the proportions in column 3 are larger than 5%. There are ten conditions in which the hypothesis can be rejected (these are starred in the Table), out of 39 conditions tested. The final column of this table shows that the mean absolute size of the violations tend to be small (the largest possible size is 2).

The number of violations in the quad tests is summarized in Table 54. Panel A shows the violations summarized for each S, and Panel B for each SOA. Clearly, the proportion of violations is similar over Ss, but increases with SOA. Only at SOAs of 178 and 214 msec are there a significant number of violations. These violations in fact reports from positions with large numbers of observations (positions 3,4,5, and 6 of the positive set), as well as positions with few observations (1,2, and 7), although this data is not tabulated. It is certain, then, that the model fails at long SOAs. Nevertheless, the size and number of violations is small, and the axiom of Model 4 holds up very well overall.

The same type of test of double cancellations was made for a different set of positions. If, in the rule

for double cancellation, l is set equal to k, then $Tau_{ll} = 0$ (by anti-symmetry), and

$$Tau_{ij} < 0 \quad \text{implies} \quad Tau_{il} < Tau_{jl}$$

This 'triple' condition was tested by the method of forming confidence intervals in the same way, except that now $Var(Tau_{ll}) = 0$. The number of tests, number of violations, and proportion of violations to tests is given in Table 53. Violations were significant in 5 of the 39 conditions tested (they are starred in Table 53). The triple tests are summarized in Table 54, in which the number and proportion of violations is given for each S in Panel A and for each SOA in Panel B. As with the quad tests, the number of violations increased somewhat with SOA, although in these tests they did not reach 5% when averaged over Ss and CCs.

d. A restriction on H

Solution of Model 4 requires that H and V be specified. In this section H will be specified. The purpose of H is to capture the difference V(i)-V(j) as far as possible, ensure anti-symmetry and monotonicity, and not allow Tau to be larger than +1 or smaller than -1. A possible form for H that will accomplish this purpose is:

$$H(x) = \begin{cases} 1 & , \text{ if } x > 1 \\ x & , \text{ if } -1 \leq x \leq 1 \\ -1 & , \text{ if } x < -1 \end{cases}$$

This form, although arbitrary and not smooth, has the advantage of computational simplicity.

Given this form for H, $-1 < Tau_{ij} < +1$

$$Tau_{ij} = V(i) - V(j) \qquad \text{(Equation 1)}$$

Averaging both sides of this equation yields

$$\frac{1}{n} \sum_{j=1}^{n} Tau_{ij} = \frac{1}{n} \sum_{j=1}^{n} (V(i) - V(j))$$

$$= V(i) - \frac{1}{n} \sum_{j=1}^{n} V(j)$$

$$= V(i)$$

Since the average of V(j) over j equals zero, from anti-symmetry*. Therefore, under this form of H, V(i) is merely the average value of Tau_{ij} found over j, as long as Tau_{ij} does not reach values of +1 or of -1. For convenience in later work, mean Tau_{ij} over j, or $\frac{1}{n} \sum_{j=1}^{n} Tau_{ij}$, will be denoted $Tau_{i\bar{j}}$.

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*Note: this follows because $\frac{1}{n} \sum_{j=1}^{n} V(j) = \frac{1}{n^2} \sum_{j=1}^{n} \sum_{i=1}^{n} Tau_{ij} = 0$

The graphical effect of this restriction on H is that the Tau_{ij} curves, plotted against i with j as the curve parameter, must be all parallel to one another, unless Tau_{ij} reaches +1 or -1. This is because of the prediction that $Tau_{ij} = V(i)-V(j)$. The set of graphs of Tau_{ij} against i, with j as curve parameter, that are shown in Fig 20 do show this expected parallelism; and this is also true of the conditions not graphed. Inspection of these graphs will show cases where Tau_{ij} curves cross each other, thus potentially violating the axiom, or are not parallel to one another, thus potentially violating the assumed form of H(x). However, these cases are by and large within the confidence interval, as already shown; for example, they typically occur when P_i is small and so the number of observations is small (as, for example, when i=1).

e. A Test of Model 4 with the restriction on H

The form $Tau_{ij} = V(i)-V(j)$, that is, Equation 1, where V(i) are found as the averages of Tau_{ij} over j, may be tested by computing the average and then forming a predicted Tau_{ij} from the V(i),V(j) thus obtained. This procedure is the same as testing for a lack of interaction in a two-way analysis of variance, since the predicted cell value is a linear combination of the marginal values of the array with no interaction term. The error in prediction, $Tau_{ij} - Tau_{ij}$, may then be compared to the confidence

interval for the difference. Of 42 (7 x 6) comparisons per condition, the error was greater than the 5% confidence interval, when averaged over subjects and critical characters, in 0,1.5, 2.2, and 5.3 comparisons, for 75,109, 144, and 178/214 msec respectively. This number of errors is significant at 5% for 144 (.052) and 178/214 (.127), particularly the latter condition where the size of the average error becomes appreciable (.22 as opposed to .14 for the smaller SOAs) (Table 57). This is the condition in which the assumption of no saturation used to derive V(i) is most likely to be false. The actual values of V(i), estimated as the Mean Tau_{ij} over j (and tabulated as $Tau_{i\cdot}$) are given in Table 58, and are plotted in Fig. 19. In Table 62 the Tau_{ij} matrices are given, with positions i in the positive set as columns, and positions j as rows. The last row of each Tau_{ij} matrix (the 8^{th} row) is the mean Tau_{ij} over the column above. These are the values given in Table 58 for V(i). These tables may be used to find the error in prediction $Tau_{ij} - V(j) + V(i)$ for each i,j cell. In fact these discrepancies are small, especially for values of i and j between 2 and 6 where there is considerably more date to estimate each Tau_{ij} value.

f. Model 4.1 : a model for V(i).

The preceeding section justifies the assumption that corresponding to every position i is a 'precedence' measure V(i), such that the relative ordering of i and j

depend upon the difference V(i)-V(j) in their precedences. It seems reasonable to suppose that the precedence of a position is related to both its onset time t_i in the digit stream, and to the probability of report from that position, P_i. One simple model for such a relation is that V(i) is an increasing function F of P_i, and a decreasing function G of t_i, so that more probable and earlier positions gain in precedence, and less probable or later positions lose in precedence. If the effects of F and G are additive, then the following axiom for Model 4.1 holds.

g. Axiom for Model 4.1

$$V(i) = F(P_i) - G(t_i).$$

When $-1 < Tau_{ij} < +1$, for all i,j, we have by Equation 1

$$\begin{aligned} Tau_{ij} &= V(i) - V(j) \\ &= F(P_i) - F(P_j) - (G(t_i) - G(t_j)). \end{aligned}$$

As a special case, consider a linear difference model such that

$$F(x-y) = F(x) - F(y), \text{ and } G(x-y) = G(x) - G(y).$$

Then,

$$Tau_{ij} = F(P_i - P_j) - G(t_i - t_j) \qquad \text{(Equation 2)}$$

h. Tests for Model 4.1

Tests may be made by choosing subsets of the

Tau_{ij}, P_i, P_j, t_i and t_j values such that

Case 1. $G(t_i - t_j)$ is constant

Case 2. $F(P_i - P_j)$ is constant

For Case 1 data, Tau_{ij} should depend only on the difference in probabilities, while for case 2, Tau_{ij} will depend only on the difference in times. But Case 1 occurs when $t_i - t_j$ is fixed, and case 2 occurs when $P_i - P_j$ is fixed, no matter what the exact forms of F and G. Thus tests of the two parts of the difference equation may be made seperately, by considering the observable t_is and P_is. Since the t_i are determined by SOA, there are 13 possible values of $(t_i - t_j)$ for each SOA, giving 13 categories to test in Case 1. Since the probabilities are continuous, however, some categorizing scheme must be imposed upon the $P_i - P_j$ differences. To obtain a reasonable number of observations per category, ten classes were formed. Let e be the lower bound of a class. Then, the ten classes of (i,j) pairs with $e \leqslant P_i - P_j < e + .2$ in each class, were formed by running e from -1 to +.8 in .2 steps.

Case 1 was tested by testing the implication

$$t_i - t_j = t_k - t_l \;\&\; P_i - P_j < P_k - P_l \Rightarrow Tau_{ij} < Tau_{kl}$$

Of trials in which the left side of the implication was true, the right side was true on 83% of trials averaged

over Ss and SOAs (Column P2 of Table 55). The ratio of the average probability difference ($|(P_i - P_j) - (P_k - P_l)|$) given the truth of the implication to the average probability difference given the truth of the left side was .92 (over Ss; Column P1 of Table 55). The latter measure is the proportion of successes weighted by their size. Both measures decrease as SOA increased but show little effect of CC (critical character); the unweighted proportion (P1) declining from .86 at 75 msec to .78 at 178/214 msec (averaged over Ss), and the weighted (P2) from .96 to .87. More than 95% of the failures occur with Tau differences within the combined confidence intervals, except for 178 and 214 msec, where some genuine violations occurred.

Case 2 was tested by the implication

$$t_i - t_j < t_k - t_l \;\&\; e \leq (P_i - P_j) < e+\delta \Rightarrow Tau_{ij} < Tau_{kl}$$

for e = (-1.0), (-1.0 +), (-1.0 + 2), ... ,(+1.0) .

This implication is strict only if e is very small, but in order to obtain a reasonable number of observations, e was larger than 0.

For the special case where e=0, various values of δ were tried, and Table 56 shows the number of violations of the monotonicity implication when $\delta e \leq .24$. Ss show an average of 5.1 violations out of 21 possible comparisons

(column N of Table 56), which reduces to .19/21 when Tau differences inside the confidence interval are excluded (Column V, averaged over Ss), a proportion less than 5%. The δ values listed in column e secured a similar number of observations in each condition. For the general case of e varying, δ was set at .2 and ten classes of data were formed: $e = \{(-1.0), (-8), \ldots .(+.8), (1.0)\}$. Data were graphed and the monotonicity implication checked by determining whether Tau_{ij} values decreased as $t_i - t_j$ increased, for a given e. However, for a fixed e and $t_i - t_j$, Tau_{ij} values were found to vary widely enough to ensure numerous violations of monotonicity. By computing the average Tau_{ij} for e and $t_i - t_j$ fixed, the prediction that mean $Tau_{ij} = F(e) - G(t_i - t_j)$, with F and G monotonically increasing, could be checked. For ranges of $t_i - t_j$ from 75 msec x 1 to 214 x 6 = 1284 msec, and fixed e, Tau_{ij} showed a negatively accelerated decrease of about .2. For a given $t_i - t_j$, increasing e produced an accelerating increase in Tau_{ij}.

Linear F and G functions must therefore be rejected, both because of the lack of monotonicity shown in the individual Tau_{ij}s and because the average Tau_{ij}s do not vary linearly, with e and $t_i - t_j$. Nevertheless, given the intrinsic variability of the data (and given the unknown effects of guessing), the linear approximation seems the best available simple model for this data. An

effort to understand the possible effects of guessing was made by requiring that $(P'_i/P_i) \cdot (P'_j/P_j)$ should be greater than ½, for 'mostly correct' data, and less than ½ for 'mostly guessed' data, where P'_i is the estimated probability of seeing in position i from Model 2. The data described above was the'mostly correct' data. The 'mostly guessed' data showed a similar effect of F(e) and virtually no effect of $t_i - t_i$, as would be expected if guessed items gave no temporal order information.

i. Linear estimation of Model 4.1 parameters

For the range of SOAs tested, than a linear approximation to the small effect of t_i seemed reasonable. On the assumption of a linear form for F and G, it follows that

$$V(i) = \underline{a}.(P_i - P_o) - \underline{b}.(t_i - t_o)$$

and so

$$Tau_{ij} = \underline{a}.(P_i - P_j) - \underline{b}.(t_i - t_j).$$

The values of P_o and t_o may be determined from the consideration that the sum of V(i) over i must be zero, by antisymmetry, and for this to be true for any possible values of $\underline{a}$ and $\underline{b}$, then P_o must be the mean probability report and t_o must be the mean time of presentation. For the 7 positions tested, then, i=4 is the mean position,

and so

$$V(i) = \underline{a}.(P_i - \frac{1}{7} \sum_{i} P_i) - \underline{b}.\ d \cdot (i-4) \qquad \text{(Equation 3)}$$

As derived from Equation 1, V(i) equals the mean value of Tau_{ij} over j, denoted $\overline{Tau_{ij}}$ for convenience. Using $\overline{Tau_{ij}}$ to estimate V(i), the equation can be tested by linear regression, from which values for $\underline{a}$ and $\underline{b}$ may also be obtained. (As long as $\underline{b}$ ís small, so that the time effect is not large, the linear approximation for $G(t_i)$ will be reasonable.) The partial correlation of $\overline{Tau_{ij}}$ with P_i, given i, averages .91 over Ss and conditions (Table 59), reflecting the reasonableness of a linear approximation to F. The high correlations of $\overline{Tau_{ij}}$ with P_i in the same table reflect the smallness of the effect of t_i.

The regression was computed step-wise. First, $\underline{a}$ in Equation 3 was determined form the regression of $\overline{Tau_{ij}}$ on P_i. Then $\underline{b}$ was determined from the regression of e_i on t_i, where e_i = $\overline{Tau_{ij}}$ minus the value of $\overline{Tau_{ij}}$ predicted from the P_i alone. That is,

$$\overline{Tau_{ij}} = \underline{a}(P_i - P_o) - \underline{b}(t_i - t_o)$$

$$= r_{\overline{Tau_{ij}},P} \left[\frac{\sigma_{P_i}}{\sigma_{Tau_{ij}}} \right] (P_i - P_o) - r_{e_{i,i}} \left[\frac{\sigma_i}{\sigma_{e_i}} \right] (t_i - t_o).$$

The regression coefficients $\underline{a}$ and $\underline{b}$ are given in

Table 60, and the average absolute error in prediction $\overline{Tau_{ij}}$ from the above regression is given in Table 61: note that the absolute error must lie between 0 and 2. The term P_o is determined by the P_i distribution, and the mean time t_o = d (mean position) = 4d, so these terms are not tabulated. The errors in prediction are small in magnitude and show no effect of CC, but they do increase slightly with SOA, which is to be expected since saturation begins to occur with the longer SOAs and in that case the linear model must break down.

For the form of Eqation 5 to be correct, b should be constant over conditions. This was not found to be the case. As SOA increased, b first increased and then decreased for each S. The ratios of the largest values of b to the smallest, when averaged over CC, were 2.5, 10.0 and 3.5 for AR, GL, and AK respectively: these values seem to be too far from 1.0 to be accountable for by statistical variation, although it is the case that b is a rather shallow parameter in the regions tested. Table 60 gives the values of b.d, which multiply the position difference (i=4) rather than the time difference (t_i - 4d). The position parameter b.d increases monotonically with d. with the exception of 109 msec in AR, levelling off as d becomes longer. This suggests a more ocmplex effect of SOA upon $\overline{Tau_{ij}}$ than that represented in Equation 5. On the other hand, the contribution of t_i to the prediction

of Tau_{ij}^{-} is small at the best, and it may be that the choice of a step-wise regression model was not the most appropriate, so the finding that the regression model requires that b be a function of d is not very compelling. (As an exercise, the best-fitting function was found, with a as above and b equal to $\frac{1}{d}(k - e^{-qd})$, with k and q parameters for each S. The finding that this form did almost as well as the linear b is more evidence that b is shallow, than evidence in favour of the exponential per se, however).

j. Analysis of the best-fit parameters of Model 4.1

Table 60 shows that as SOA increases, the importance of P_i (parameter a) decreases and the importance of position (parameter bd) increased, a result which is compatible with the increase in q, or order information, with SOA in Model 1.1. (The montonicity of a and bd with SOA is however violated in the 109 msec condition for AR.)

The effect of CC upon both a and b is small. However, if processing in the two streams obeyed 'partial independence' (Assumption 7 of Introduction), then the effect of CC should be to change the latency T but not the nature of the processing of the digits. Measures of digit processing such as Tau_{ij}^{-} should therefore be independent of CC, and the effect of CC upon a and b shows this not to be the case. The CC effect is small, but since the effect of CC upon T is also small, it is not possible to

say whether the CC effect upon a and b would remain small if CCs of very different latency were used when the background 'noise' letters were on. To the extent that the A condition meets the Assumption of partial independence, then, the values for a and b.d may be meaningfully compared in A and in C, U, and S for the relevant SOAs (75 and 109 msec in AR and GL, 109 and 144 msec in AK). The differences between the average of C, U, and S, and mean A, are .144 and .027 for a and bd respectively. The mean absolute differences are .471 and .022 for the same comparisons. For each S, A has a smaller effect of position(bd), and a smaller effect of P_i (a), on Tau_{ij}, than does either S or the mean of C, U, S (with the exception of AR for parameter a, where the opposite result occurs). The A effects are somewhat inconsistent across Ss and SOAs, but since they are quite large in comparison to the variations of a and bd over the other CCs, it appears that the A data provides some evidence against the assumption of partial independence.

k. An interpretaion for Model 4.1

One interpretation is that each digit position receives two distinct 'measures' on each trial. The first measure is one of strength, and is determined only by the amount of attention payed to that position. The second measure is of 'arrival time', which is equal to the objective arrival time plus some constant. If S were to

respons only on the basis of arrival time, he would respond with perfect order. The 'precedence' V(i) of position i is then a weighted linear sum of the strength and the arrival time. Probability of report, P_i, is assumed to be a monotonic function of the strength at the i^{th} position, so that V(i) is a weighted sum of function of P_i and a function of t_i. Equation 5 is an example of such a weighted sum. The model thus assigns two distinct measures to each position, and re-combines the two measures to form the position measure V(i). Digits are then reported in order of decreasing V(i). As SOA becomes becomes longer, the contribution of t_i becomes larger and V(i) becomes monotonic with t_i. As SOA becomes shorter, the effect of attention (strength) becomes larger, and if attention varies rather considerably as it does in this experiment, V(i) becomes monotonic with attention and virtually independent of t_i. This predicts the result obtained that order information declines with SOA, and also suggests that Tau_{ij}^{-} should become highly correlated with P_i in just those conditions in which overall order information is poor, and this is in fact the case.

6. Summary of the 4 Models

a. Item and Order information

The four models all distinguish between item and order information. Thus, in Model 1, item information is determined by T and m, while order information is determined by H(x), or by q in Model 1.1. (Although the permutation does have an effect upon the item information in the response (rather than in W) if m is larger than the number of response positions (4).) In Model 2, the item information alone is computed by the guessing rule; and the success or lack of it in the prediction of order from a second stage of random selection of the detected digits, is independent of the assumptions made in Model 2 about detection. In Model 3, the unguessed item information is assumed to be P''_{ij}, and again the order information is predicted upon the basis of random sampling from the detected items. In Model 4, item information depends on 'strength', and order depends upon some combination of arrival time and 'strength'. In summary, item and order are determined by distinct factors in each model.

The item/order destinction has thus been used, but not in itself justified. An ideal justification would be a theoretical proof of the 'relative independence' of the two measures of information, followed by an experimental demonstration of, for example, conditions with the same item

information and very different order information. By 'relative independence' of item and order is meant that once certain items are detected, their order is free to vary independently of their probability of detection (item information). In this work I have simply made this assumption, and tested models embodying it, without independent proof. I have suggested that experimental evidence for variation in order information with item information constant might be obtained in this paradigm through control of the "fluctuations of attention", although the evidence for this in the comparison of the A and the C, U, and S conditions is rather weak.

b. Stages in the Models

All four models require two successive stages for the perception of the digits, the first stage to generate item information and the second to generate order information. They are all compatible with the idea that attention shifting is the mechanism responsible for controlling stage 1. Models 1,2, and 3 are compatible with the idea that the second stage operates by a mostly random permutation (or selection) of the digits by a weighted sum of strength and arrival time, where the strength is determined by attention and is itself a determinant of item information. To the extent that in Model 4 the affect of arrival time was found to be small, the need for a second stage is lessened.

The need for two stages might be questioned: and indeed, if the prior entry idea were to be fully used, it

would be possible to invent a rather more complex single stage process that could deliver both item and order information. Such a single stage would identify digits at a rate dependent both upon the input rate and upon the amount of attention paid, and both order and item information would then depend upon digit identification latencies. The assumption of two stages should be regarded as a convenience rather than as a proven necessity. Any guessing stage, of course, would be regarded as a response process and thus as a third stage following the other two (or as a second stage following the single one, if a single stage model were used).

c. The "direction of causation"

Having distinguished item and order information, the four models relate tham rather differently. On the assumption of Model 2, that S sees 4 or less digits on each trial, the further assumption that item and order information are independent of each other may be tested, as in the two-stage sampling assumption applied to Model 2. On the assumption of Model 1 that S sees every digit from T until attention is turned off m digits later, then when $m \geqslant 4$, P_i is merely the probability that a digit in position i is seen amongst the first four digits. That is, 'item' information in the response is determined by T and by the order information as expressed by H(x). Model 3, like Model 2, assumes that item and order were independent, but Model 4 assumes au contraire that order information is determined

by item information P_i (and to a much lesser extent by arrival time t_i). Thus the four models make every possible assumption about item and order information; that they are independent, that item causes order, and that order causes item.

The question of direction of causation may be considered in terms of the distinction between 'strength' and 'arrival time'. In models based upon strength, such as Model 4, variation in attention varies the strangth of the digit being perceived. Digits from positions with high strength are most likely to be reported, so that P_i is monotonic with strength. The model assumes that digits are reported in order of precedence, and precedence was found to predominantly derive from strength (P_i). Thus, 'strength' is the determining factor in Model 4. In models based upon arrival time, such as Model 1, on the other hand, digits are reported in the order of perceived arrival time. The effect of attention is to vary detection latency, and thus vary the order of the perceived digits from the true order, through the 'prior entry' mechanism. Item information is in this case derived from order, which itself is determined by the objective arrival time and by attention. Clearly in both models variations in attention change some single attribute 'X' of the positions in the digit stream, and the choice of strength or time as the embodiment of X is to some extent according to tast, although all models require some temporal variable to account for the latency data (RT and T).

d. Prior entry

The results of the present research may be considered in terms of the Law of Prior Entry (Titchener, 1908). In the letter monitoring task, S pays close attention to the letters, and so he may be assumed to perceive the CC before he perceives the first digit. This produces a prior entry effect in favour of the CC of $T = d(EP+i_o)$ msec. In the digit detection task, attentional variations may be responsible for the order errors in the following way. Suppose that S reports digits in the order of their perceived arrival time t'_i when the real arrival time of the i^{th} digit is t_i. Then, suppose that $t'_i = t_i + L_i$, where the detection latency for the i^{th} digit, L_i, is a decreasing function of the attention paid at time t_i, $A(t_i)$. An example of such a function is $L_i = k\ (\frac{1-A(t_i)}{A(t_i)})$. Thus, as attention varies from 0 to 1, latency varies from infinity (and i is effectively never seen) to 0 (and i is seen immediately). If $L_{i+1} < L_i + d$, then $t'_i > t'_{i+1}$ and the digits presented in position i and i+1 would be seen in reverse order.

Thus fluctuations in attention may re-order the series of digits in perception; and if some limitations are placed upon $A(t_i)$, and thus upon L_i, only certain permutations of the stimulus order would be possible. Empirically, in the conditions of fast SOA, the order of positions from largest to smallest Tau_i is as follows: j, j+1, j-1, j+2, j-2,..., where j is the 4^{th} or 5^{th} position of the positive

set depending upon the condition. Such an ordering is compatible with a symmetric, inverted U-shaped function of $t'_{i'}$. If the effect of t_i is rather small in such conditions, as suggested by the low values of $\underline{b}$ in Model 4, then the main cause of this result would be a symmetric, U-shaped function of L_i against t_i, itself caused by a symmetric, inverted U-shaped function of $A(t_i)$ against t_i.

As a speculative mechanism for this sort of prior entry effect on the digit stream, imagine that there are ten 'servers', each uniquely dedicated to a particular digit. Upon detection of a digit, the server outputs a temporal marker. Detection occurs when the information available about that particular digit, which is accumulating over time, reaches some threshold value. The effect of shifting attention would be to speed the processing of an attended-to digit, and so speed up the rate of accumulation of information. Thus 'detection' of digit i+k, at time t'_{i+k}, could occur earlier than detection of digit i, at time t'_i, if digit i+k were paid more attention than digit i. The problem of 'overtake' of the digits, which arises from the basic finding that earlier-presented digits may be perceived after later-presented digits, is then solved by the assumption that information about the digits is transmitted by ten parallel independently-operating detectors. Synthesis of the outputs of these detectors would generate a percept. The synthetic process would

order the digits in the percept by the temporal order in which the corresponding detectors reached their threshold values.

e. Serial and parallel 'servers'

The experimental task requires S to serially input, and then serially output, a number of digits. If a single 'server' were available to S, capable of analyzing only one digit at a time, then the order of input and output digits would be identical. Such a single server might fail to analyze a digit, but in that case the line of digits would close up and the order of the reported digits would still be correct. If the server made mistakes in analysis, order confusions could seem to occur. That is, if S were given a digit series such as ...,5,8,.., and saw '5' as an 8 and the '8' as a 5, he would report ..,8,5,... even though the order of his actual percepts was not wrong. If such mistakes were independent of one another, however, then the server might deliver an output of ..,8,8,... when given ..,5,8,..., so that S would report seeing the same digit twice. Apart from a few trials for AK, this did not occur. Secondly, the effect of such errors would be to replace any digit with another digit chosen randomly from the other positions in the critical set. This is because of random assignment of digits to digits positions. Even if an 8 were always seen for a 5, the position of the 8 would be random with respect to the position of the 5; and so the

effect would be the same as that of random guessing. In particular, P_i would be increased over all positions i. Evidence of order errors in conditions in which at least one P_i is very small is therefore evidence against the single-server with error notion. In fact, mean concordance is low -- about 75% -- in conditions in which P_1 is quite small (i.e. at digit SOAs of 144 and 214 msec).

For these reasons, every one of the models allows for a re-ordering of the detected digits by having more than one 'server' operating in parallel. Models 1 and 2 have at least m servers, for random permutation of m digits to be possible. In Model 3, there are four servers corresponding to the four responses. In Model 4, there must be as many servers as there are positions to be assigned V(i) values. "Visual code memory" has been discussed in terms of a slower rate of input of visual information, and a longer lasting duration, that the icon (Coltheart, 1972; Phillips, 1974). Whether or not it is exactly this memory that has several 'servers', allowing for the re-ordering of temporally distinct percepts, is not clear. Certainly the visual code memory suggested here is one that is conscious to S; it represents what he "sees", not what he remembers seeing. As such, it is taking a role normally assigned to iconic memory, that of providing visually conscious images. On the other hand, re-construction of visual information into an image in the absence of stimulation is possible for most persons; and it may be

that such imagery contains abstract features not associated with the icon. The idea of visual images re-constructed from the stimulation, in different temporal order than the stimuli, suggests a more active process than the passive storage suggested by Coltheart (1972) for visual code memory. The visual memory postulated here (in Assumption 11) is therefore both more active (temporal re-ordering) and more sensory (immediate imagery) than is usual.

One possible resolution of the seeming paradox that temporal information is lost while spatial information is retained in the images of the digits, is as follows. Due to extensive training, Ss may be assumed to build up excellent long-term memory templates of the digits. During exposure at a fast SOA, there is only time to analyze a few features of each digit. The few features are enough to allow for re-construction of the correct digit using the long-term memory information of spatial pattern. However, the features are not good enough to allow reconstruction of the correct temporal sequence of digits; since the sequence is randomized, there can be no long-term visual memory of the sequence itself. The remarkable increase in ability to perform the task with practice in this experiment, may be indirect evidence for a role of long-term memory in recognition of the stimuli. The present research, in which a fixed set of alphanumerics was used, cannot answer this question.

CHAPTER V

SUMMARY

A modified version of Wundt's (1874) complication experiment was used to measure the latency for the detection of a visual target, or 'critical character' (CC). In the traditional complication, the CC is embedded in a stream of stimuli. A second stream of 'comparison' stimuli is also presented (usually to a different sensory modality), and S is instructed to judge which of the comparison stimuli appears to be temporally simultaneous with the CC. The effect of changing the CC on the distribution of the simultaneity judgements is then used to estimate L_c, the detection latency of the CC. In the modified method, the task wac changed, so that S had to shift attention from the CC to the comparison stimuli, and then note the first comparison stimulus that he couls. The effect of changing the CC on the distribution of these 'noting responses' was then used to estimate L_c. It was argued that the change of task would improve the reliability of the method, by making the estimates of L_c less vulnerable to potential biases induced by 'prior entry' effects. The uncontrolled prior entry effects in the traditional complication may vitiate that method for obtaining detection latencies. In order to

further justify the 'attention shift' measure of latency, RTs to the identification of the CC were obtained, and two recall tasks were used to study S's visual memory of the compsrison stimuli.

The main finding was that attentional latency (T) and RT gave very similar estimates of the effects of changing CC on identification latency. This is evidence that the attention shift can be used to measure latency, despite the various problems introduced by using S's noting responses as the method of measurement of T. The similarity of the estimates of the CC effects on T and RT remained true, even when various statistical procedures were used to remove the potential biasing effects of guessing, memory for temporal order, truncation of the distribution of noting responses, and discrete sampling of points on that distribution. This result means that the attention shift is a reliable measure of latency. (Moreover, the other significant departure from the traditional complication, the use of only one sensory modality for presentation of the two streams, did not vitiate the method.)

Some limitations on the method should be stressed. First, presentation conditions must be such that an attention shift is forced on S: an instruction to "shift attention" by itself is probably not sufficient. Second, presentation rates should be such that only one type of sensory memory is used by S. In this research, only visual

memory was in use. Whether the method would apply to a purely auditory memory is not known, although the dichotic listening experiments suggest that it might. Third, the perceived order should be only poorly related to the presentation order of the comparison stimuli. If order memory were verdical, the method could break down if S used this memory. Fourth, Ss have to be well motivated and very well practiced for reliable data to be obtained. Fifth, the two streams should probably be separated physically, either by sensory modality, or, in this case, by an angular distance sufficient to eliminate sensory interactions between the streams, but not so large that motor movements (like eye movements) would be necessary in order to accomplish the shift of attention. Physical interleaving of two streams of distinct material, for example, might not allow a low-level attentional shift to be possible.

A secondary finding of interest was that RT and T were only slightly correlated, for a given condition of presentation and a given CC. This finding was interpreted by latency Model 2 to mean that RT and T both depend on the same, early stage of processing of the CC, but they depend on different and much more variable stages of subsequent processing. (An alternative hypothesis is that T is not correctly measured from the noting response distribution, because the order of the comparison stimuli is lost in memory, and S may generate a later 'noting response' than

the first comparison stimulus that he actually obtains. This hypothesis was rejected because it was found that RT and T were still only slightly correlated when T was defined by the distribution of EPs (earliest positions) in Recall 4. This latter measure is only very slightly vulnerable to the effects of lack of verdical temporal order memory.) The discovery that T and RT were only slightly correlated or a given CC could only have been made with the experimental method used here, since separate measurements of T and RT on different trials would have merely shown a strong correlation of their means. Whether the discovery means that T and RT can be used in an interesting way to disentangle different processing stages, or not, can only be answered by further research.

The finding that order information was non-veridical, even when item information was good, was a replication of a similar finding by Scarborough and Sternberg (1967) in a single-stream experiment. Non-veridical order was demonstrated independently in the Recall 4 task, and in the Recall 1 procedure in which S tried unsuccessfully to estimate the objective position of the noted comparison stimulus. It was assumed that the order was changed (permuted) in a stimulus encoding or central stage, rather than in a response execution stage, or in verbal processing. (In fact, Ss claimed that they reported exactly what they saw, as they were instructed.) The lack of veridical order

is important in the use of the complication to measure detection latency, because it means that Ss cannot bias their 'noting response', even if they try to use their memory to 'improve' their response. If memory for order were veridical, then a backward search through memory to retrieve the earliest seen comparison stimulus might have a larger effect than the effect of the attention shift, in determining the noting response.

A good fit to the recall orders, as measured by Kendal's Tau, was obtained with a model (Model 4) that assumed perceived order to be mainly a function of attention, and only secondarily a function of input order. Attentional determination of order is consistent with the 'Law of Prior Entry', which implies that an attended-to stimulus should be perceived more rapidly than an unattended stimulus. However, other models in which attention determined item information, but order was determined in a subsiduary stage that operated independently of attention, also gave reasonable fits to the data. Therefore the attentional-determination of order, as well as of the noting responses, cannot be assumed proven.

Whether or not the attention shift is responsible for the determination of order, the finding that the perceived order was often very different from the true order is itself important. For example, the 'iconic' images on which S is assumed to have based his recalls,

were in a different order from their corresponding retinal images. Therefore not all types of 'icons' are retinal, as has been claimed (Sakitt, 1976). The temporal disorganization of vision that was found in the conditions of this experiment is puzzling, because (1) 'local' temporal processing (over about 50 msec) was essentially veridical, in that features of successive stimuli were not intermingled; and (2) the perceived temporal separation between the stimuli was essentially veridical, in that the stimuli were seen rythmically with temporal seperations that were monotonically related to the real SOA. Thus, it seems that in response to successive stimulation, the visual system provides regularly spaced temporal 'slots', and veridical 'icons' to fill the slots; but somehow is unable to fill the correct slots with the correct icons. The assumption that prior-entry attentional effects are responsible for this finding, even if true, is only the very beginings of an explanation.

APPENDIX 1

APPARATUS AND STIMULI

S sat alone facing the VT15 Graphics Display Unit in a medium-sized experimental room 2.4m by 6m by 2.7m high. Lighting was from silver-white neon tubes mounted behind difussion screens in the ceiling for AR, and from warm-white neon tubes mounted above and in front of the Display Unit screen for GL and AK. Both arrangements lit the top of the screen slightly more than the bottom. Reflections on the screen surface were minimized by painting the walls opposite the scope face black and suspending a black velvet curtain in front of the lower portion of the screen. Ambient room illuminance was about .9 meter-candles at the eye for AR, and about .5 meter-candles for GL and AK. Ventilation and temperature controls were imperfect, causing some discomfort and irritating AK's eyes. Noise from the Display Unit fan and from the teletype was reduced by acoustic housing, but was still somewhat annoying. Session length was kept short to minimize the adverse effects of these physical discomforts.

The display unit screen of 33 cms by 25 cms was mounted with the centre 1.12m above the floor; that is,

about 5 cms below eye level for AR abd about 3.8 cms above eye level for AK and GL. Nominally, Ss sat .68m from the screen; no restraint was placed on their head movements since the natural range of movements (from .56m to .79m) did not influence results in pilot work. The teletype was positioned to the right of the Display Unit, with the keyboard about 25 cms from the right hand arm rest of the chair. S used the digit keys 0 through 9 mounted along the top row of the keyboard about 1.9 cms apart, the ALTMODE key to terminate a response, and a RUBOUT key to delete incorrect responses. S's had no trouble with this arrangement after practice, and very rarely used the RUBOUT ket. Ss could not operate the keyboard without averting their gaze from the screen. The RT key was mounted on a small movable table in front of S and level with the arm of S's chair. S pressed the key with the preferred finger of his preferred hand, but was not allowed to change finger during the experiment. The key operated a microswitch wired to respons only when S released the key, not when he pressed it.

The Display Unit used presents a flicker-free picture that appears to be spatially continuous. Lines can be painted .030 cms (1.2') apart, so that no separation can be detected between adjacent lines. Lines can be painted at the rate of .65 cms per -sec, and can be refreshed every 600 nano-sec. Despite the use of a phosphor (P 4) with

very fast decay, up to 208m of line can be painted without flicker. The hardware allows lines to be drawn on only four directions: at 0, 45, 90, and 135 degress to the horizontal. These lines appear as a high contrast blue-white on a blue-grey background under the lighting conditions used.

Stimuli were alphanumeric characters constructed from straight lines oriented in the four permitted directions. The characters contained between 1 and 10 major strokes and between 0 and 4 minor strokes, or serifs, each being composed from between 2 ans 5 adjacent lines. Reasonable approximations to curved letters such as B (Figure 15) were obtained. These strokes were between 2.4' and 6.0' in visual angle. The upright strokes in the letters B,D,E,F,H, etc., were varied in horizontal location and in width, and some letters were adorned with serifs, in order to increase discriminability. An attempt was made to generate digits that were equally discriminable from each other for the sake of experimental method; however, 3,5, and 8 remained slightly more confusable than the other digits. The CCs were chosen on the basis of pilot work on AR to be of different discriminability: the letter U was the hardest, C middling and the outline square was easiest. The overlap between each CC and the other 24 letters was found by superimposing a grid of 160 x 200 squares upon the CC and each letter in turn, and

finding the number of squares in common to both letters. The ratio of the number of overlapping squares to the total number of squares in the comparison letter was used as a measure of overlap between the CC and the comparison letter. The distribution of overlaps across letters was similar for each of the 3 CCs, and the mean overlap was .18 for each of the CCs. (The difference in discriminability between the CCs was therefore not due to differences in overlap with the other letters. It seems reasonable to account for the difference in discriminability on the basis of degree of shared 'shape' rather than on overlap: however, since no measure of shape was applied and since the small number of CCs made extraction of the relevant features from irrelevant differences between the CCs statistically unlikely, this possible explanation of the differences in discriminability was not pursued.)

The stimuli were presented in two adjacent areas either side of the fixation dot. All characters but the arrow were 1° 27' high; the arrow was 24' high. Letters were from 6' to 1° 51' wide and digits were from 60' to 1° 40' wide. Fixation was centered horizontally and vertically between the letters and digits. The fixation dot was 2' wide and high. Black screen surrounded the stimuli for 12° to left and right and for 10° up and down (Figure 25).

Luminance of the screen in candelas per meter squared was .096 for AR, abd .35 for GL and AK. Ambient room illuminance in meter-candles was about .93 for AR and .46 for GL and AK, measured in front of S. Stimuli were generated with an intensity of .33 cd-microsec per inch. The intensity of the characters, which was directly proportional to the length painted, varied from 1.92 cd-microsec (I) to 3.33 cd-microsec (W). The four critical characters, C, U, the outline square S, and the arrow A, were 1.98, 1.97, 1.13 and 1.58 cd-microsec, respectively.

Stimuli were painted for a constant short interval of 3.2 msec. During this interval, each stimulus was refreshed 3 times, each refresh lasting .4 msec on average with the screen blank for 1 msec between refreshes. This refresh rate (715) Hz) is too high to be visible. 'Simultaneous' presentation of a digit and a letter was achieved by first painting the letter for 3.2 msec, than waiting 1.8 msec, and then painting the digit, so that the SOA at simultaneity is in fact 5 msec. These times are shown in Figure 24. Exact values for the SOAs are given in Table 40. This table gives the SOAs for each 'cycle' of the presentation sequence, where a cycle is the time from one occurrence of objective simultaneity of a digit and a letter to the next occurrence of simultaneity. Each cycle contains up to two digit SOAs and two letter SOAs, which alternate in the pattern given in the column 5 and 6

of the Table. A digit cycle 1,2,2, for example, means that the digit SOAs are, in order, SOA_1, SOA_2, and SOA_3, as listed in columns 9 and 11 of the table. Figure 25 illustrates a test sequence with letter SOA of 214 msec and digit SOA of 109 msec. Digits and letters were always presented in phase, so that a letter and a digit were presented simultaneously at the beginning of each cycle. Thus, every second digit in the condition shown in Figure 25 was simultaneous with a letter. The phase relationships for every condition are given in Table 40 column 7, where the ratio of the number of digits per cycle to the number of letters is given. The onset time of the first digit presented was adjusted so that the CC would always begin a new phase and be presented simultaneously with a digit.

The duration of the test sequence averaged 4.3 secs for AR and GL and 5.1 secs for AK, with the minimum duration being 2.8 secs and the maximum duration 8.4 secs (Table 41). Following S's teletype response, feedback was given for 2 secs, and then S began the next trial in his own time. Ss averaged 4 to 5 trials per minute. Ss rested for about 1 minute between blocks of 50 trials.

APPENDIX 2

EARLY HISTORY

The purpose of this Appendix is to summarize the early researchs on the complication experiment, the prior-entry effect, and the temporal-order judgement (TOJ) experiment, in so far as they relate to the present research. The relevant research on the complication experiment is taken from Boring (1950, Chapter 8), and references that have been taken from this work that are not independently referenced here are starred in the text, as in 'Bessel*'. These references have been taken on trust, as I have not read the German source material.

The original problem of comparing arrival times in one input stream with those in another arose in the 1830s as a result of astronomer's difficulties with the 'Eye and Ear' method of Bradley of measuring stellar transits. The stellar transit was timed by noting when the star crossed a straight wire in the field of the telescope. The observer counted in seconds with the beats of a clock, and noted the positions of the star in the field of the telescope the second before and the second after it crossed the wire. He estimated the position of the wire in tenths between the two stellar positions, and added that number

of tenths to the time at which the first position was crossed in order to estimate transsit time. The method thus required the observer to co-ordinate discrete events in an auditory channel (beats) with continuous events in a visual channel (movements of the star). Bessel* (1784-1846) discovered that this method led to serious discrepancies; by comparing estimates of one observer with those of another (the 'Personal Equation'), he found that the average difference between two observers might be as much as one second. This was confirmed by Mitchel,* who in 1858 mounted an artificial star whose real motion across the field was known, and could thus measure both the observer's mean error and his variability.

Bessel, accepting with Johnannes Muller* the theory of instantaneous nervous conduction, postulated that 'mental' delays in perception and comparison of the visual and auditory sequences were occurring, in different degrees in different individuals. Bessell thought that perception of the first stimulus delayed perception of later stimuli; and that conparison was delayed by the time taken to 'carry over' the visual impression into an auditory impression. Muller explained the perceptual delay by a mental serial mechanism:

"When several impressions are made on the nerves at the same time, the sensorium takes cognizance of but only, or perceives them in succession. When, therefore,

hearing and sight are directed to one object, this object will be first heard and then seen."

In contrast, Nicolai* (1830) rejected the theory of mental delay and argued that nervous conduction took time: the rate of nervous conduction varied between eye and ear, and between different individuals. This view was supported by Helmholtz's* 1850 discovery of the relatively slow speed of nervous conduction; and by Wolf's* finding that the amount of mean error increased with the rate of movement of the star, compatible with a constant lag in the visual system. The importance of central mechanisms was in turn emphasized by Arago* (1843), who reduced the mean error to less than .1 sec by arranging for the observer to maintain his attention exclusively on the star but to pull a trigger at the moment of transit, and therefore claimed that the large error in the 'Eye and Ear' method was due to divided attention; and by Hartman*(1858), who reduced the mean error to nothing by having the observer repeatedly observe the same artificial transit and thus build up the correct 'expectation' of the transit time.

These experiments suggested that when the observer jusged the simultaneity of an event in one sequence of stimuli with an event in another sequence, a constant error in the judgment could arise from a) delays in the input channels, and b) delays in the central

comparison process; and that the central delays were influenced by attention and expectation. Wundt (1874) claimed that attention could also influence rate of processing of the input streams. In the classic demonstration, S watched a metronome pendulum swing, and indicated at what location the pendulum appeared when a bell was sounded. His attention to the bell 'speeded up' its processing relative to the pendulum, so that it appeared to ring earlier than it had. Wundt argued that the 'ripening' of attention speeded processing, since S could make his attention oscillate in time with the bell over the course of many trials. Von Tchisch* (1885) was able to get the effect when S did not know when the bell would sound, disproving the ripening theory. Geiger* (1902) showed that if S expected the bell, he tended to judge it is earlier than it was; and if he did not expect the bell but was asked after the trial, he judged it as later.

Following Wundt, Titchener (1908) formulated his Law of Prior Entry as:

"The stimulus for which we are prepared requires less time than a like stimulus, for which we are unprepared, to produce its full conscious effect." The law of prior entry does not explicitly state that preparation

or attention[1] influences peripheral processing, and indeed it could be explained by central mechanisms entirely. For example, attention might bias Bessel's comparison mechanism, so that onset times are judged relative to the attended-to stream, the other stream being delayed not in peripheral processing but in 'carrying over'. Again, Jems (1890) pointed out that in Wundt's experiment, S had to change mode from 'discrete perception' to 'continuous perception', since the pendulum was continuous and the bell discrete; this shift could absord time from a central processor.

Needham (1934) asked Ss to locate a single stimulus presented to one ear amongst a discrete (rather than continuous) series of stimuli in the other ear. When 6 Ss located a single 250 msec 3000 Hz tone in a series of 5 discrete 1000 Hz tones, each of 250 msec duration and seperated by 250 msec of silence, they averaged 70 msec prior entry of the single tone. The prior entry was somewhat less when the single tone was presented near the middle of the series of 5 tones, and was less when the single tone was presented at 1500 Hz. The DL of the psychometric function was 80 msec, which is large enough

---

[1]Titchener equated 'The stimulus for which we are prepared' with 'The object of attention' in the sentence following the statement of his law. In his replication of Wundt's pendulum experiment (p. 253), Titchener found a prior-entry effect of 9° of arc of the pendulum, which is equal to about 88 msec, due to attention to one or other of the bell and the pointed at the tip of the pendulum.

to mean that the 'prior entry' effect was reversed on about 25% of the trials. The function was obtained from Needham's data by converting S's category judgements into mesc. It was estimated that each category was worth 90 msec on average, and the centre category (simultaneity) was assigned the value 0 msec. The function was symmetrical and S-shaped, as in the single-stimulus experiment of Stone (1926), but with obviously greater variance than in Stone's and other TOJ experiments.

In a somewhat similar experiment, Ladeoged and Broadbent (1960) presented a single click whose position was to be judged in an auditory sequence of either ten digits or between 8 and 14 words. The click tended to be heard in the middle of the precedding word or digit. In a second experiment, the effect was replicated with a 40 msec long /s/ sound. The average prior entry (mean of the modes of their Figure 1) was 130 msec, but the exact value of the prior entry depended strongly on the stress pattern of the words, which in the second experiment formed a sentence. In sentences where the stress fell upon the simultaneous word, for example, the prior entry effect disappeared.

The complexity of the complication experiments might to some extent be the reason for the poor temporal resolution obtained; thus if James were correct, the switch from the continuously changing pendulum to the discrete

bell might be difficult at might interfere with S's time sense. Simplification of the experiment by requiring S to judge only two stimuli was a natural step. Exner* (1875) required S to judge whether two stimuli were simultaneous or successive, using a high criterion (10 judgements of successiveness in a row). He found that Ss judged two visual flashes to be successive at an SOA of 15 msec (flashed to two different retinal locations) or 44 msec (same location), and two clicks to be susseccive at 2 msec. (presented to both ears) or 64 msec (presented to one ear); the lower figure in each case being due to the summation of both stimuli into a single sensation with a spatio-temporal cue such as movement to give additional information about onset times (Hirsch and Sherrick, 1961). Later research has used an order judgment rather than a simulteneity judgement for two stimuli since Ss may claim to see simultaneity when in fact they can distinguish order than chance when forced to.

The major finding of recent research appears to be that while differences in mean latencies for different modalities are often quite large (e.g. 75 msec for a foveal-temporal flash pair; Rutschman, 1966), the difference thresholds seem remarkably constant at 18 msec (Hirsch and Sherrick, 1961; Rutschman, 1966) for pairs of brief stimuli presented to vision, touch and audition, within and between modalities. The implication of

constant varibility (from the constant DLs) is compatible with a lack of variability in the input channels; all the variability being contributed by a single common temporal-order judgement center. (This is not always obtained however; Oately, Robertson, and Scanlan (1969) found highly variable DLs, between 36 and 98 msec in 6 Ss, when only light onsets were presented.

The prior-entry effect has been found in the single-stimulus experiment. Stone (1926) obtained a prior-entry effect of 38, 47, and 61 msec in 3 Ss, who judged the order of a click and a tap when paying attention to one or the other, according to an analysis performed by Sternberg (1972). It attention is assumed to have a symmetrical effect, this implies prior entry effects of 19, 24, and 31 msec respectively, which is considerably less than the effects obtained in the multiple stimuli experiments (Needham's prior entry effect was 70 msec). With the same assumption of symmetry, Bertelson and Tisseyre (1969) found a prior entry effects of 23 msec in Ss who payed attention to a word or to a click when judging their temporal order: this figure is half of the R-0 mean minus the 0-R mean in their Figure 2, averaged over S,word frequency, and S's knowledge of the word, all of which had some effect upon the TOJ in their own right. It seems that in both sets of data, the prior entry effect is mainly upon the mean rather than the variance of the

psychometric function, since the functions in different conditions of attention are roughly parallel. This is consistent with Hirsch's finding of a constant DL over many different conditions of stimulation, and presumably of attentional bias since the latter was not controlled in his research. The data reviewed here is too sparse, however, for a firm conclusion to be drawn upon this point.

APPENDIX 3

STATISTICAL NOTES.

Note 1: Variance Confidence Intervals

The variances obtained for the various latency distributions have 95% confidence intervals as follows:

1. N= 400 (AR and GL): $.878\ s^2 < \sigma^2 < 1.161\ s^2$
2. N= 300 (AK): $.898\ s^2 < \sigma^2 < 1.161\ s^2$

These intervals are derived from the Chi^2 distribution as follows.

Let $p(Chi^2 > A) = .975$, and $p(Chi^2 > B) = .025$. Then,

$p\left(\frac{n}{B} \cdot s^2 < \sigma^2 < \frac{n}{A} \cdot s^2 \right) = .95$, (Hays, 1963, p 345),

where n is the degrees of freedom. The values of Chi^2 used to determine A and B were found from the normal approximation to Chi^2, $Chi^2_n = z\sqrt{2n} + n$

Note 2: The effect of the number of sampling points upon the estimated mean and variance of the standard Normal.

Let N(0,1) be the standard normal. N(o,1) is sampled from at n points each D z-scores apart upon the z axis. Suppose that z_o is the location of the mid-point of the first interval sampled. Then,

$$P_i\ (n,z_o) = \int_{z_o+D(i-1/2)}^{z_o+D(i+1/2)} N(0,1)$$

is the probability of sampling from the i^{th} interval given D and z_o. The P_i distributions were obtained for several parameter values over a fixed range of 6 s.d., so that $D = 6/n$. Values of n from 4 to 8, and values of z_o from .1 D to .9 D, were chosen, giving rise to 50 $P_i(n,z_o)$ distributions. For each distribution, mean M and variance V were computed. Obviously, M approaches 0 and V approaches 1 as n increases and as z_o approaches -3 s.d.s (giving rise to symmetrical sampling points around the mean).

In the present application, n is known but z_o is unknown. Treating z_o as a random variable allows the mean and variance of each set of 10 means and variances of $P_i(n,z_o)$ to be computed, where n is fixed. On the assumption that 10 sampling points for z_o are enough, the resulting s.d.s of the means and of the variances for a fixed n may be used to construct confidence intervals around the observed means

and variances for normal distributions of known n. The means and variances are given in Table 70 Panel A. The confidence intervals for the variances are given in Table 70 Panel B on the assumption of infinite sampling points; these were obtained from the Chi^2 values for .975 and .025 with 400 and 300 d.f. (Hays, 1963, p345). The Panel B confidence intervals plus twice the s.d.s of the variances in Panel A are given in Panel C.

Note 3: A Test of the Independence of $RT(t_e)$ and t_e

Independence of $RT(t_e)$ from t_e was tested by forming a Chi^2 statistic, with the expected number of observations of $RT(t_e)$ equal to $\underline{N} \cdot P_e \cdot P(t \leq RT < t+50)$, and the observed number equal to $\underline{N} \cdot P(t < RT \leq t+50 \mid t_e = t)$. Cases in the tails of the EP distribution, where less than 5 cases were expected, were added together in their own tail. Typically, there were 3 to 10 degrees of freedom at each t_e, since the RTs fell in a range from 3 x 50 to 10 x 50 msec. In each condition of digit SOA and CC, there were between 3 and 6 values of EP (and therefore of t_e), for which there were 5 or more expected cases. These values of EP were positions 1 through 3, 1 through 4, and so on, up to 1 through 6, in the positive set.

The advantage of a Chi^2 test over the correlations discussed in the text is that it allows the entire distribution to be tested. There 48,46, and 38 tests in all for AR, GL, and AK. Of these tests, independence was rejected by Chi^2 at the 5% level for .29, .11, and .32, in AR,GL, and AK. (Inevery S, rejections tended to increase with SOA. Rather interestingly, there was no clear pattern of rejections across values of t_e). Rejection of 24% of the tests (averaged over Ss) at the 5% level means that independence must be rejected. In the context of Model 2, this means that v_c may have a small variance, but cannot have a zero variance, because only v_c is contributing common variance to RT and to T.

APPENDIX 4

TABLES AND FIGURES

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STYLE SHEET FOR THE TABLES

STYLE	ARRANGEMENT OF THE TABLE BY ROWS AND COLUMNS		
1	Cols 1,2,3,4	:	S, SOA, CC, i_o respectively
	Cols 5 .. 12	:	Positions 1..7 of the Positive set
	Col 13	:	Negative set position
	Rows	:	Show the data specified under the cols
2	Cols 1,2,3,4	:	S, SOA, CC; i_o is not entered.
	Cols 5...8	:	Positions 1,2,3,4 of the response
	Rows	:	Show data specified under the cols
3 a	Cols 1,2	:	S, SOA
	Cols 3,4,5	:	CCs
	Rows	:	SOAs, and means over SOAs
3 b	Same as 3 a	:	except S and CC reversed
4	Cols 1,2,3	:	S, SOA, CC
	Cols 4	:	As specified by the col headings
	Rows	:	Show data specified under the cols
5	Col 1	:	S
	Col 2...7	:	2-way ANOVA headings
	Rows	:	Sources of variance in the ANOVA
6	Col 1	:	S
	Cols 2,3,4,5	:	Either CCs or SOAs as specified
7 a	Cols 1...6	:	S, Measure, Conditions (CCs or SOAs)
	Rows	:	Effects
7 b	Same as 7 a	:	with SOAs and measures inter-changed
8	Miscellaneous.		

NUMBER OF TRIALS PER CONDITION

TABLE 1

S	CONDITION SOA	CC	i_o	RECALL 4 N	DATA ** +	DATA ** -	EXCLUDED RT<.17	EXCLUDED RT>1.8	RECALL 1 N	DATA +	DATA -	EXCLUDED RT<.17	EXCLUDED RT>1.8
AR	75	C	1	420	.948	.038	.012	.002	440	.923	.050	.014	.014
		U	1	432	.943	.046	.009	.002	443	.928	.043	.018	.011
		S	1	415	.957	.031	.012	.000	406	.937	.042	.014	.007
		A	-2	451	.912	.080	.004	.004	427	*.937	.061	.002	.000
	109	C	0	414	.990	.005	.005	.000	419	.978	.010	.012	.000
		U	0	394	.979	.003	.013	.005	394	.979	.008	.010	.003
		S	0	414	.983	.010	.007	.000	416	.978	.012	.010	.000
		A	-2	409	.993	.007	.000	.000	412	.971	.027	.002	.029
	144	C	-1	415	.957	.005	.036	.002					
		U	-1	416	.897	.036	.038	.029					
		S	-1	442	.975	.000	.020	.005					
	214	C	-2	406	.963	.015	.017	.005					
		U	-2	417	.947	.007	.031	.014					
		S	-2	425	.969	.009	.019	.002					
GL	75	C	1	453	.914	.075	.011	.000	438	.904	.087	.002	.007
		U	1	415	.932	.058	.010	.000	443	.927	.063	.005	.005
		S	1	423	.950	.045	.005	.000	419	.945	.048	.005	.002
		A	0	446	.900	.087	.013	.000					
	109	C	0	433	.926	.058	.014	.002	413	.946	.039	.010	.005
		U	0	425	.965	.028	.007	.000	448	.958	.036	.002	.004
		S	0	411	.957	.036	.007	.000	404	.948	.045	.005	.002
		A	-2	410	.978	.010	.012	.000					
	144	C	-1	303	.944	.046	.007	.003					
		U	-1	337	.926	.065	.006	.003					
		S	-1	326	.933	.052	.015	.000					
	214	C	-2	337	.964	.018	.018	.000					
		U	-2	292	.969	.021	.010	.000					
		S	-2	310	.949	.035	.010	.006					
AK	109	C	1	328	.958	.024	.015	.003	348	.971	.018	.000	.011
		U	1	287	.955	.031	.014	.000	342	.968	.023	.000	.009
		S	1	322	.975	.022	.000	.003	244	.951	.049	.000	.000
		A	-2	309	.971	.026	.003	.000					
	144	C	-1	340	.982	.012	.006	.000	305	.970	.016	.007	.007
		U	-1	378	.981	.016	.003	.000	311	.965	.026	.003	.006
		S	-1	302	.984	.013	.003	.000	318	.962	.029	.000	.009
		A	-2	302	.993	.003	.003	.000					
	178	C	-2	323	.960	.009	.031	.000					
		U	-2	312	.885	.038	.074	.003					
		S	-2	327	.966	.012	.021	.000					

* i_o=-2

** These proportions sum to 1.0, over the 4 trial types.

TABLE 2

P_i IN RECALL 4

S	CONDITION SOA	CC	i_o	1	2	3	4	5	6	7
AR	75	C	1	.152	.254	.440	.729	.688	.505	.507
		U	1	.141	.220	.340	.623	.710	.642	.574
		S	1	.139	.324	.729	.856	.559	.407	.344
		A	-1	.463	.476	.554	.580	.546	.400	.361
	109	C	0	.058	.150	.752	.915	.757	.500	.459
		U	0	.065	.134	.620	.930	.791	.548	.494
		S	0	.063	.304	.966	.842	.623	.491	.377
		A	-1	.241	.446	.756	.894	.739	.355	.227
	144	C	-1	.065	.093	.644	.925	.837	.607	.551
		U	-1	.064	.072	.469	.838	.869	.678	.626
		S	-1	.074	.128	.912	.912	.807	.654	.346
	214	C	-2	.106	.194	**.771**	**.957**	.907	.662	.219
		U	-2	.148	.156	.651	.947	.897	.724	.289
		S	-2	.101	.147	.935	.976	.916	.656	.123
GL	75	C	1	.212	.225	.221	.533	.721	.761	.652
		U	1	.241	.212	.243	.538	.718	.769	.625
		S	1	.204	.221	.333	.779	.762	.594	.570
		A	0	.225	.323	.386	.657	.793	.566	.420
	109	C	0	.127	.124	.657	.892	.732	.477	.460
		U	0	.107	.128	.706	.882	.777	.531	.403
		S	0	.130	.179	.900	.828	.659	.449	.368
		A	-2	.143	.240	.486	.748	.830	.570	.373
	144	C	-1	.173	.350	.930	.853	.687	.340	.250
		U	-1	.168	.290	.907	.886	.686	.428	.228
		S	-1	.181	.698	.841	.813	.561	.312	.243
	214	C	-2	.151	.175	.952	.958	.722	.653	.248
		U	-2	.114	.173	.958	.924	.734	.644	.249
		S	-2	.151	.207	.993	.908	.777	.636	.164
AK	109	C	1	.174	.329	.612	.817	.683	.537	.379
		U	1	.134	.283	.580	.852	.689	.544	.385
		S	1	.178	.458	.776	.760	.561	.430	.343
		A	-2	.127	.133	.409	.461	.695	.688	.607
	144	C	-1	.077	.118	.704	.935	.678	.429	.337
		U	-1	.072	.101	.674	.897	.682	.469	.345
		S	-1	.076	.193	.841	.860	.645	.352	.292
		A	-2	.113	.468	.741	.837	.801	.445	.153
	178	C	-2	.102	.067	.409	.725	.786	.613	.419
		U	-2	.069	.094	.337	.722	.795	.594	.514
		S	-2	.091	.128	.556	.772	.750	.525	.419

P_i IN RECALL 4 CUMULATED. TABLE 3

S	CONDITION		1	2	3	4	5	6	7
AR	75	C 1	.039	.099	.208	.389	.561	.689	.818
		U 1	.038	.089	.173	.329	.508	.666	.809
		S 1	.035	.116	.298	.511	.652	.752	.835
		A -1	.113	.222	.366	.516	.653	.750	.833
	109	C 0	.014	.052	.240	.468	.657	.782	.897
		U 0	.016	.049	.205	.438	.635	.773	.896
		S 0	.015	.092	.332	.544	.701	.823	.916
		A -2	.061	.172	.361	.585	.769	.858	.915
	144	C -1	.017	.040	.201	.432	.642	.793	.931
		U -1	.016	.033	.150	.361	.582	.753	.913
		S -1	.019	.051	.278	.507	.709	.872	.958
	214	C -2	.026	.076	.266	.505	.732	.899	.954
		U -2	.037	.077	.240	.477	.703	.884	.955
		S -2	.026	.062	.294	.537	.766	.932	.963
GL	75	C 1	.053	.110	.165	.298	.479	.669	.832
		U 1	.060	.113	.174	.309	.488	.680	.837
		S 1	.051	.107	.190	.385	.575	.724	.867
		A 0	.056	.137	.234	.398	.596	.738	.843
	109	C 0	.032	.062	.227	.450	.633	.752	.867
		U 0	.027	.059	.236	.456	.650	.783	.884
		S 0	.033	.077	.302	.509	.674	.786	.878
		A -2	.036	.096	.217	.404	.612	.754	.847
	144	C -1	.044	.131	.364	.577	.749	.834	.897
		U -1	.042	.115	.342	.563	.735	.842	.899
		S -1	.045	.220	.431	.634	.774	.852	.912
	214	C -2	.036	.081	.319	.558	.739	.902	.964
		U -2	.029	.072	.312	.542	.726	.887	.949
		S -2	.038	.090	.338	.565	.759	.919	.960
AK	109	C 1	.044	.126	.279	.483	.654	.788	.883
		U 1	.034	.105	.250	.462	.635	.770	.867
		S 1	.045	.159	.353	.543	.684	.791	.877
		A -2	.032	.065	.167	.283	.456	.628	.780
	144	C -1	.019	.045	.218	.450	.620	.727	.811
		U -1	.013	.041	.208	.431	.601	.718	.808
		S -1	.019	.063	.272	.486	.646	.732	.807
		A -2	.028	.145	.330	.540	.740	.851	.889
	178	C -2	.026	.042	.145	.326	.522	.675	.780
		U -2	.017	.041	.125	.306	.504	.653	.781
		S -2	.023	.055	.194	.387	.574	.706	.810

TABLE 4

P_i IN RECALL 1.

PANEL A: P_i

S	CONDITION			1	2	3	4	5	6	7	N
AR	75	C	1	.012	.021	.098	.269	.308	.161	.079	.051
		U	1	.009	.016	.085	.258	.298	.193	.098	.044
		S	1	.010	.045	.245	.475	.146	.043	.010	.025
		A	-2	.038	.052	.052	.195	.247	.233	.125	.059
	109	C	0	.000	.022	.461	.389	.080	.036	.002	.010
		U	0	.005	.023	.296	.530	.095	.033	.010	.008
		S	0	.002	.087	.663	.204	.019	.010	.002	.012
		A	-2	.036	.078	.328	.355	.153	.015	.007	.027
GL	75	C	1	.039	.012	.030	.180	.265	.247	.141	.088
		U	1	.016	.023	.034	.132	.314	.294	.123	.064
		S	1	.024	.007	.050	.377	.269	.154	.070	.048
	109	C	0	.022	.007	.256	.477	.125	.057	.017	.039
		U	0	.016	.016	.321	.436	.128	.034	.013	.036
		S	0	.032	.045	.611	.204	.047	.010	.005	.045
AK	109	C	1	.015	.273	.433	.235	.026	.000	.000	.017
		U	1	.003	.283	.407	.242	.018	.021	.003	.024
		S	1	.049	.422	.328	.135	.008	.008	.000	.049
	144	C	-1	.043	.090	.525	.199	.066	.053	.007	.017
		U	-1	.039	.081	.562	.156	.084	.042	.010	.026
		S	-1	.067	.146	.476	.171	.070	.035	.006	.029

PANEL B: P_i CUMMULATED.

S	CONDITION			1	2	3	4	5	6	7	N
AR	75	C	1	.012	.033	.131	.400	.708	.869	.948	1.0
		U	1	.009	.025	.109	.367	.665	.858	.956	1.0
		S	1	.010	.055	.300	.775	.921	.964	.974	1.0
		A	-2	.038	.090	.142	.337	.584	.817	.942	1.0
	109	C	0	.000	.022	.483	.872	.952	.988	.990	1.0
		U	0	.005	.028	.329	.854	.949	.982	.992	1.0
		S	0	.002	.089	.752	.956	.975	.985	.987	1.0
		A	-2	.036	.114	.442	.797	.950	.965	.972	1.0
GL	75	C	1	.039	.051	.081	.261	.526	.773	.914	1.0
		U	1	.016	.039	.073	.205	.519	.813	.936	1.0
		S	1	.024	.031	.081	.458	.727	.881	.951	1.0
	109	C	0	.022	.029	.285	.762	.887	.944	.961	1.0
		U	0	.016	.032	.353	.789	.917	.951	.964	1.0
		S	0	.032	.077	.688	.892	.939	.949	.954	1.0
AK	109	C	1	.015	.288	.721	.956	.982	.982	.982	1.0
		U	1	.003	.286	.693	.935	.953	.974	.977	1.0
		S	1	.049	.471	.799	.934	.942	.950	.950	1.0
	144	C	-1	.043	.133	.658	.857	.923	.976	.983	1.0
		U	-1	.039	.120	.682	.838	.922	.964	.974	1.0
		S	-1	.067	.213	.689	.860	.930	.965	.971	1.0

P_e IN RECALL 4.

TABLE 5

S	CONDITION		1	2	3	4	5	6	7
AR	75	C 1	.152	.217	.312	.244	.072	.002	.000
		U 1	.141	.200	.242	.263	.127	.030	.000
		S 1	.139	.303	.418	.127	.010	.005	.000
		A -1	.454	.228	.206	.083	.027	.002	.000
	109	C 0	.059	.144	.598	.192	.010	.000	.000
		U 0	.065	.127	.511	.290	.010	.000	.000
		S 0	.063	.292	.624	.023	.000	.000	.000
		A -2	.240	.335	.330	.088	.007	.000	.000
	144	C -1	.065	.088	.558	.261	.025	.005	.000
		U -1	.065	.070	.419	.341	.098	.010	.000
		S -1	.074	.121	.734	.073	.000	.000	.000
	214	C -2	.106	.182	.561	.134	.018	.003	.000
		U -2	.149	.141	.471	.214	.020	.004	.005
		S -2	.101	.133	.717	.051	.000	.000	.000
GL	75	C 1	.212	.183	.165	.261	.165	.016	.000
		U 1	.234	.183	.168	.271	.120	.027	.000
		S 1	.205	.183	.219	.340	.055	.000	.000
		A 0	.225	.259	.227	.230	.057	.002	.000
	109	C 0	.127	.118	.524	.214	.014	.005	.000
		U 0	.105	.124	.579	.183	.012	.000	.000
		S 0	.128	.155	.661	.059	.000	.000	.000
		A -2	.143	.200	.316	.254	.086	.000	.000
	144	C -1	.174	.311	.486	.030	.003	.000	.000
		U -1	.168	.270	.522	.042	.000	.000	.000
		S -1	.181	.593	.220	.006	.003	.000	.000
	214	C -2	.152	.147	.693	.012	.000	.000	.000
		U -2	.115	.142	.739	.007	.000	.000	.000
		S -2	.151	.174	.678	.000	.000	.000	.000
AK	109	C 1	.174	.289	.303	.183	.050	.003	.000
		U 1	.135	.270	.358	.202	.039	.000	.000
		S 1	.178	.390	.347	.072	.006	.009	.000
		A -2	.127	.123	.328	.208	.192	.023	.000
	144	C -1	.077	.105	.572	.228	.021	.000	.000
		U -1	.072	.098	.561	.242	.029	.000	.000
		S -1	.077	.183	.626	.114	.003	.000	.000
		A -2	.113	.419	.399	.063	.007	.000	.000
	178	C -2	.096	.064	.357	.329	.115	.042	.000
		U -2	.070	.087	.286	.397	.115	.042	.007
		S -2	.078	.113	.438	.286	.066	.022	.000

P(+) IN RECALL 1 AND RECALL 4. **TABLE 6**

P(+) = p(S reports an item in the window of 7 positions)

PANEL A: P(+) IN EACH CONDITION.

S	SOA	Recall 4					Recall 1			
		C	U	S	A	Mean of C,U,S.	C	U	S	Mean C,U,S
AR	75	.819	.812	.840	.845	.824	.949	.956	.974	.960
	109	.898	.895	.917	.914	.903	.990	.992	.988	.990
	144	.930	.904	.958		.931				
	214	.954	.953	.963		.957				
	Mean	.900	.891	.920	.880	.904	.970	.974	.981	.975
GL	75	.831	.836	.866	.843	.844	.904	.932	.949	.928
	109	.867	.883	.878	.848	.876	.959	.963	.953	.958
	144	.896	.898	.912		.902				
	214	.965	.949	.959		.958				
	Mean	.890	.892	.904	.846	.895	.932	.948	.951	.943
AK	109	.883	.867	.876	.780	.875	.982	.976	.948	.965
	144	.820	.810	.815	.890	.815	.983	.973	.971	.977
	178	.780	.781	.810		.790				
	Mean	.828	.819	.834	.835	.827	.983	.975	.960	.972

PANEL B: MEAN P(+) OVER CONDITIONS.

	CC	C	U	S			C	U	S
AR		.900	.891	.920			.970	.974	.981
GL		.890	.892	.904			.932	.948	.951
AK		.828	.819	.834			.983	.975	.960
	SOA	75	109	144	178	214	75	109	144
AR		.824	.903	.931		.957	.960	.990	
GL		.844	.876	.902		.895	.928	.958	
AK			.875	.815	.790			.965	.977

PANEL C: CC AND SOA EFFECTS ON P(+).

Average effect = $1/n \left(\sum_{i=1}^{n} |X_i - \bar{X}|\right)$

RECALL 4.	CC effect.	SOA effect.	SOAxCC 'interaction'.
AR	.011	.040	.007
GL	.006	.026	.008
AK	.005	.032	.006

MEAN RESPONSE $M_j^{\dagger}$ TO THE POSITIVE SET IN RECALL 4. TABLE 7

S	CONDITION SOA	CC	i_0	RESPONSE POSITION 1	2	3	4
AR	75	C	1	5.342	5.798	5.508	5.597
		U	1	5.725	6.056	5.627	5.661
		S	1	4.607	5.296	5.526	5.437
		A	-1	1.246	1.775	2.272	2.252
	109	C	0	3.595	4.343	5.190	5.209
		U	0	3.780	4.477	5.348	5.141
		S	0	3.098	3.931	5.041	5.213
		A	-2	1.308	1.965	2.367	2.201
	144	C	-1	2.768	3.532	4.467	4.255
		U	-1	3.087	3.896	4.645	4.139
		S	-1	2.223	3.255	4.267	4.218
	214	C	-2	1.432	2.235	2.990	2.885
		U	-2	1.637	2.413	3.196	2.672
		S	-2	1.216	1.995	2.943	3.024
GL	75	C	1	6.104	6.289	5.648	5.312
		U	1	6.028	6.288	5.634	5.167
		S	1	5.525	6.039	5.755	5.379
		A	0	4.232	4.591	4.557	4.377
	109	C	0	3.833	4.384	5.217	4.748
		U	0	3.734	4.398	5.114	4.928
		S	0	3.285	4.128	4.966	5.020
		A	-2	2.192	2.603	2.855	2.409
	144	C	-1	2.119	2.680	3.645	3.704
		U	-1	2.026	2.705	3.847	3.838
		S	-1	1.549	2.347	3.422	3.906
	214	C	-2	1.068	1.758	2.916	3.396
		U	-2	1.028	1.851	2.956	3.502
		S	-2	0.986	1.632	2.887	3.281
AK	109	C	1	4.713	5.399	5.799	5.422
		U	1	4.931	5.360	5.922	5.459
		S	1	4.130	5.215	5.556	5.527
		A	-2	2.303	3.621	3.140	2.554
	144	C	-1	2.566	3.323	4.160	4.090
		U	-1	2.663	3.504	4.263	3.778
		S	-1	2.182	3.225	4.044	4.028
		A	-2	0.933	2.230	2.659	2.557
	178	C	-2	2.119	2.850	3.263	3.231
		U	-2	2.054	2.970	3.458	3.515
		S	-2	1.766	2.640	3.130	3.378

TABLE 8

MEAN RESPONSE M_j^+ TO THE POSITIVE SET IN RECALL 4, AVERAGED OVER CC, LESS THE GRAND MEAN.

PANEL A. C, U AND S

S	SOA	RESPONSE POSITION 1	2	3	4	MEAN ABSOLUTE $M_j^+ - \mu$
AR	75	-.291	.202	.039	.050	.146
	109	-1.037	-.281	.662	.656	.659
	144	-1.038	-.168	.731	.475	.853
	214	-0.959	-.172	.657	.474	.566
GL	75	.122	.441	-.085	-.478	.282
	109	-.863	-.177	.619	.421	.520
	144	-1.085	-.405	.656	.834	.745
	214	-1.244	-.525	.648	1.121	.885
AK	109	-.695	.039	.473	.183	.348
	144	-1.014	-.135	.670	.479	.575
	178	-.884	-.045	.419	.510	.465
		PANEL B. ARROW.				
AR	75	-.640	-.111	.386	.365	.376
	109	-.652	.005	.407	.240	.326
GL	75	-.207	.152	.118	-.063	.135
	109	-.323	.088	.340	-.105	.214
AK	109	-.602	.717	.236	-.351	.477
	144	-1.161	.135	.564	.462	.581

$t(P_i)$ IN RECALL 4 TABLE 9

Table entries are $t = SOA \cdot \sum_i^8 (i \cdot P_i)$. (Negative set included as the ultimate position.)

S	SOA	C	U	S	Mean	D*
AR	75	463	478	435	459	
	109	533	544	499	525	
	144	569	606	519	564	
	214	543	565	516	541	
	Mean	527	548	492	522	5.7
GL	75	480	475	458	471	
	109	542	535	517	531	
	144	491	496	451	479	
	214	512	532	499	514	
	Mean	506	510	481	499	5.4
AK	109	626	641	605	624	
	144	585	597	566	583	
	178	620	636	579	612	
	Mean	611	624	583	606	4.4

t(NP) IN RECALL 4 AND RECALL 1. TABLE .10

S	CONDITION		RECALL 1 * (1) MEAN	SD	RECALL 4 * (2) MEAN	SD	DIFFERENCE (1)-(2) MEAN	SD
AR	75	C	441	105	414	103	27	2
		U	450	102	442	101	8	1
		S	375	86	358	93	17	-7
	109	C	406	101	397	96	9	5
		U	423	102	418	84	5	18
		S	362	95	351	91	11	4
GL	75	C	479	118	477	109	2	9
		U	481	104	467	109	14	-5
		S	438	102	421	106	17	-4
	109	C	458	139	447	156	11	-17
		U	435	133	422	130	13	3
		S	382	140	379	143	3	-3
AK	109	C	452	115	528	145	-76	-30
		U	462	129	557	144	-95	-15
		S	430	158	469	133	-39	25
	144	C	351	180	381	134	-30	46
		U	355	188	393	131	-38	57
		S	334	199	328	129	6	70

* $t(\overline{SJ}) = t(p_I)$ in Recall 1 and $= t(p_{I1})$ in Recall 4.

t(NP) AND t(EP) IN RECALL 4. MEANS AND S.D.s

TABLE 11

S	CONDITION		t(NP) MEAN	t(NP) S.D.	t(EP) MEAN	t(EP) S.D.	$t(\overline{SJ})-t(\overline{EJ})$
AR	75	C	414	103	291	88	123
		U	442	101	310	100	132
		S	358	93	269	70	89
		A	197	158	76	84	121
	109	C	397	96	322	83	75
		U	418	84	334	91	84
		S	351	91	285	69	66
		A	142	114	31	104	111
	144	C	406	116	304	122	102
		U	463	148	342	143	121
		S	328	78	261	95	67
	214	C	326	203	169	187	139
		U	367	219	182	223	185
		S	277	156	155	150	122
GL	75	C	477	109	303	108	174
		U	467	109	296	108	171
		S	421	106	290	93	131
		A	343	133	198	92	145
	109	C	447	156	315	104	132
		U	422	130	314	94	108
		S	379	143	290	83	89
		A	243	133	102	128	141
	144	C	338	195	200	116	138
		U	340	218	208	116	132
		S	265	219	154	95	111
	214	C	247	212	122	159	125
		U	242	213	138	144	104
		S	251*	275	114	156	137
AK	109	C	528	145	399	122	129
		U	557	144	409	113	148
		S	469	133	368	101	101
		A	262	146	140	143	122
	144	C	381	134	291	120	90
		U	393	131	298	122	95
		S	328	129	258	106	70
		A	137	142	63	115	74
	178	C	385	220	256	210	129
		U	396	239	278	208	118
		S	325	208	218	186	107

* Value inflated by atypical P_{18}. True value estimated as 190 (see text).

$t(P_i)$ IN RECALL 1. TABLE 12

MEANS

S	CC	C	U	S
AR		424	437	369
GL		469	458	410
AK		402	409	382
	SOA	75	109	144
AR		422	397	
GL		466	425	
AK			448	347

ANALYSIS OF VARIANCE

S	Effect	SS	df	MS	F	$Omega^2$
AR	CC	2084800	2	1042400	107.9*	.089
	SOA	375000	1	375000	15.1*	.016
	CCxSOA	49600	2	24800	2.5	.001
	Error	23323548	2394	9743		
	Total	25832948	2399			
GL	CC	1556400	2	778200	50.9*	.039
	SOA	1008600	1	1008600	15.5*	.027
	CCxSOA	130000	2	65000	4.3*	.002
	Error	36609852	2394	15292		
	Total	39304852	2399			
AK	CC	226302	2	113151	4.3*	.005
	SOA	1539253	1	1539253	338.3*	.031
	CCxSOA	9100	2	4550	.1	.000
	Error	47753597	1794	26618		
	Total	49528252	1799			

t(NP) IN RECALL 4

TABLE 13

MEANS

S	CC	C	U	S	
AR		386	423	329	
GL		377	367	328	
AK		431	449	374	
	SOA	75	109	144	178/214
AR		405	389	399	323
GL		455	416	314	247
AK			518	367	369

ANALYSIS OF VARIANCE

S	Effect	SS	df	MS	F	Omega^2
AR	CC	7180867	2	3590434	212.4*	.074
	SOA	5101166	3	1700389	19.6*	.053
	CCxSOA	520733	6	86789	5.1*	.003
	Error	80948580	4788	16907		
	Total	93751348	4799			
GL	CC	2090600	2	1045300	31.7*	.012
	SOA	32489868	3	10829956	62.1*	.145
	CCxSOA	1046733	6	174456	5.3*	.005
	Error	158056280	4788	33011		
	Total	193683480	4799			
AK	CC	2748800	2	1374400	47.6*	.029
	SOA	13500802	2	6750401	521.3*	.129
	CCxSOA	51800	4	12950	0.5	.001
	Error	77737916	2691	28888		
	Total	94039318				

t(EP) IN RECALL 4

TABLE 14

MEANS

S	CC	C	U	S	
AR		272	292	243	
GL		235	239	212	
AK		315	328	281	
S	SOA	75	109	144	178/214
AR		290	314	302	169
GL		296	306	187	125
AK			392	282	251

ANALYSIS OF VARIANCE

S	Effect	SS	df	MS	F	Omega^2
AR	CC	1979467	2	989733	61.2*	.020
	SOA	16336267	3	5445422	96.4*	.165
	CCxSOA	338933	6	56489	3.5*	.003
	Error	77458276	4788	16178		
	Total	96112944	4799			
GL	CC	679467	2	339733	24.7*	.007
	SOA	27762402	3	9254134	177.1*	.294
	CCxSOA	313600	6	52267	3.8*	.003
	Error	65758403	4788	13734		
	Total	94513872	4799			
AK	CC	1060200	2	530100	23.8*	.015
	SOA	9901401	2	4950700	487.8*	.139
	CCxSOA	40600	4	10150	0.5	.000
	Error	59899874	2691	22259		
	Total	70902074	2699			

$t(\overline{NP})$ AND $t(\overline{EP})$ IN RECALL 4

TABLE 15

S	SOA	$t(\overline{EP})$ C	U	S	Mean	$t(\overline{NP})$ C	U	S	Mean
AR	75	291	310	269	290	414	442	358	405
	109	322	334	285	314	397	418	351	389
	144	304	342	261	302	406	463	328	399
	214	169	182	155	169	326	367	277	323
	Mean	272	292	243	269	386	423	329	379
GL	75	303	296	290	296	477	467	421	455
	109	315	314	290	306	447	422	379	416
	144	200	208	154	187	338	340	265	314
	214	122	138	114	125	247	242	251	247
	Mean	235	239	212	229	377	367	328	358
AK	109	399	409	368	392	528	557	469	518
	144	291	298	258	282	381	393	328	367
	178	256	278	218	251	385	396	325	369
	Mean	315	328	281	308	431	449	374	418

COMPARISON OF NP IN RECALL 4 AND RECALL 1 TABLE 16

D_i = P(NP=i | R=(i,j,k,l) in Recall 4) - P(NP=i | R=(i) in Recall 1)

MD = mean absolute D_i

D = Max (cumulated D_i)

S	CONDITION		MD	|D|
AR	75	C	.052	.138 *
		U	.068	.056
		S	.145	.166 *
	109	C	.012	.036
		U	.012	.031
		S	.014	.073 *
GL	75	C	.017	.028
		U	.025	.072 *
		S	.033	.087 *
	109	C	.021	.084 *
		U	.016	.060
		S	.007	.016
AK	109	C	.093	.273 *
		U	.114	.350 *
		S	.056	.231 *
	144	C	.058	.195 *
		U	.066	.260 *
		S	.047	.132 *

* D significant at .05, 2-tailed Kolgomorov-Smirnov test.

TABLE 17

P'_i RECALL 4

P'_i = The probability of reporting stimulus position i, after correction for guessing. The Sum of P'_i must be equal to or less than the number of responses: i.e., 4.
The window size is optimal.

S	CONDITION		1	2	3	4	5	6	7	$4-\sum P'_i$
AR	75	C 1	0	.049	.254	.628	.592	.346	.352	1.779
		U 1	0	-.010	.136	.487	.605	.528	.448	1.806
		S 1	0	.149	.647	.808	.442	.254	.177	1.524
		A -1	.286	.255	.429	.462	.389	.186	.125	1.869
	109	C 0	0	.040	.706	.893	.714	.413	.367	.868
		U 0	0	.016	.557	.917	.750	.471	.401	.888
		S 0	0	.220	.964	.808	.560	.412	.292	.744
		A -2	.136	.362	.713	.870	.691	.260	.124	.844
	144	C -1	0	.005	.586	.908	.812	.562	.493	.633
		U -1	0	-.048	.372	.772	.820	.628	.560	.896
		S -1	.018	.073	.903	.900	.786	.619	.295	.406
	214	C -2	.049	.140	.740	.946	.893	.619	.170	.443
		U -2	.089	.099	.616	.932	.875	.688	.240	.460
		S -2	.052	.100	.920	.972	.906	.617	.074	.359
GL	75	C 1	0	.008	.000	.368	.616	.672	.524	1.812
		U 1	0	.000	.016	.380	.600	.684	.484	1.836
		S 1	0	.040	.180	.712	.692	.476	.452	1.448
		A 0	.040	.156	.230	.545	.727	.439	.261	1.602
	109	C 0	0	-.048	.552	.848	.644	.348	.328	1.328
		U 0	0	-.020	.632	.848	.716	.420	.292	1.112
		S 0	0	.029	.868	.780	.552	.316	.212	1.244
		A -2	0	.064	.357	.675	.772	.442	.217	1.472
	144	C -1	.047	.239	.916	.820	.617	.221	.124	.020
		U -1	.042	.163	.881	.857	.602	.320	.094	.040
		S -1	.078	.645	.803	.775	.482	.201	.130	.887
	214	C -2	.112	.138	.945	.950	.691	.613	.206	.345
		U -2	.053	.113	.954	.912	.697	.584	.195	.493
		S -2	.102	.161	.992	.897	.745	.593	.127	.383
AK	109	C 1	.028	.206	.495	.757	.623	.442	.260	1.189
		U 1	0	.132	.463	.795	.595	.442	.256	1.317
		S 1	.018	.334	.718	.683	.447	.303	.204	1.293
		A -2	0	0	.221	.274	.579	.576	.468	1.882
	144	C -1	0	0	.643	.916	.587	.278	.178	1.398
		U -1	0	0	.594	.868	.590	.328	.190	1.430
		S -1	0	0	.787	.805	.517	.162	.110	1.619
		A -2	0	.367	.689	.801	.745	.334	.018	1.045
	178	C -2	0	0	.225	.605	.699	.484	.254	1.733
		U -2	0	0	.128	.593	.702	.462	.360	1.755
		S -2	0	0	.415	.692	.657	.378	.255	1.603

MEAN PROBABILITY OF GUESSING IN RECALL 4

TABLE 18

Panel A $1 - \frac{1}{4}\sum_{i=1}^{7} P'_i$

S	SOA	C	U	S	A
AR	75	.445	.452	.381	.467
	109	.217	.222	.186	.211
	144	.158	.224	.102	
	214	.111	.115	.090	
GL	75	.453	.459	.362	.401
	109	.332	.278	.311	.368
	144	.005	.010	.222	
	214	.086	.123	.096	
AK	109	.297	.329	.323	.471
	144	.350	.358	.405	.261
	178	.433	.439	.401	

Panel B 10. Min ($\frac{1}{4}P_i$, $(1-\frac{1}{4}\sum_i P_i)/3$) , for i=1.,.7.

AR	75	.38	.35	.34	.52
	109	.14	.16	.16	.29
	144	.16	.16	.14	
	214	.15	.16	.12	
GL	75	.53	.55	.45	.52
	109	.31	.27	.32	.35
	144	.35	.34	.29	
	214	.12	.17	.14	
AK	109	.39	.33	.41	.32
	144	.19	.18	.19	.28
	178	.25	.17	.23	

RELATIVE CORRECT P_i IN RECALL 4. **TABLE 19**

Table gives P'_i / P_i

S	CONDITION			1	2	3	4	5	6	7
AR	75	C	1	0	.193	.577	.862	.860	.685	.694
		U	1	0	.000	.400	.782	.852	.831	.780
		S	1	0	.460	.888	.994	.791	.624	.514
		A	-1	.630	.588	.744	.770	.710	.483	.378
	109	C	0	0	.267	.939	.976	.943	.826	.800
		U	0	0	.119	.898	.986	.948	.859	.812
		S	0	0	.727	.959	.961	.899	.843	.767
		A	-2	.567	.810	.943	.975	.939	.728	.551
	144	C	-1	0	.054	.910	.982	.970	.926	.895
		U	-1	0	.000	.797	.919	.947	.926	.893
		S	-1	.243	.570	.990	.987	.974	.952	.853
	214	C	-2	.462	.722	.960	.989	.985	.945	.776
		U	-2	.601	.642	.946	.984	.975	.957	.830
		S	-2	.515	.680	.986	.996	.989	.941	.602
GL	75	C	1	0	.000	.000	.636	.705	.869	.801
		U	1	0	0	.070	.573	.679	.886	.778
		S	1	0	.186	.535	.918	.907	.800	.791
		A	0	.178	.483	.596	.830	.917	.776	.621
	109	C	0	0	.000	.842	.953	.881	.725	.717
		U	0	0	.000	.894	.961	.923	.795	.717
		S	0	0	.162	.966	.945	.839	.702	.636
		A	-2	0	.267	.735	.902	.930	.775	.582
	144	C	-1	.271	.683	.985	.961	.898	.650	.496
		U	-1	.250	.562	.971	.967	.878	.748	.412
		S	-1	.431	.924	.955	.953	.859	.644	.535
	214	C	-2	.742	.789	.993	.992	.957	.939	.831
		U	-2	.465	.653	.996	.987	.950	.913	.783
		S	-2	.695	.778	.999	.988	.959	.932	.774
AK	109	C	1	.161	.626	.822	.927	.912	.823	.686
		U	1	0	.466	.798	.933	.864	.813	.665
		S	1	.101	.729	.925	.899	.797	.705	.595
		A	-2	0	0	.540	.505	.682	.837	.771
	144	C	-1	0	0	.913	.916	.866	.648	.528
		U	-1	0	0	.881	.874	.846	.699	.551
		S	-1	0	0	.936	.907	.780	.460	.377
		A	-2	0	.784	.930	.957	.935	.751	.124
	178	C	-2	0	0	.550	.768	.775	.790	.606
		U	-2	0	0	.393	.724	.770	.778	.700
		S	-2	0	0	.746	.759	.777	.733	.609

P(EP')=P'$_o$ IN RECALL 4 TABLE 20

S	CONDITION			1	2	3	4	5	6	7
	SOA	CC	i_o							
AR	75	C	1	0	.049	.221	.425	.237	.017	.051
		U	1	0	-.010	.101	.347	.288	.273	.000
		S	1	0	.149	.533	.276	.020	.023	.000
		A	-1	.260	.127	.257	.158	.151	.047	.000
	109	C	0	0	.040	.637	.280	.008	-.017	.051
		U	0	0	.016	.543	.409	.032	.000	.000
		S	0	0	.221	.747	.032	.000	.000	.000
		A	-2	.103	.261	.409	.193	.034	.000	.000
	144	C	-1	0	.005	.560	.352	.048	.035	.000
		U	-1	0	-.050	.374	.356	.164	.102	.054
		S	-1	.018	.071	.811	.100	.000	.000	.000
	214	C	-2	.049	.134	.580	.191	.041	.000	.000
		U	-2	.089	.089	.488	.265	.041	.023	.000
		S	-2	.052	.091	.770	.087	.000	.000	.000
GL	75	C	1	0	.000	.057	.318	.490	.125	.000
		U	1	0	0	.017	.355	.301	.143	-.020
		S	1	0	.041	.167	.593	.188	.011	.000
		A	0	.040	.167	.241	.383	.148	.021	.000
	109	C	0	0	-.054	.541	.390	-.019	.093	.049
		U	0	0	-.021	.636	.310	.074	.000	.000
		S	0	0	.029	.853	.096	-.013	-.017	.051
		A	-2	0	.064	.306	.396	.233	.000	.000
	144	C	-1	.047	.240	.654	.048	.008	.000	.000
		U	-1	.042	.174	.704	.081	.000	.000	.000
		S	-1	.078	.609	.286	.021	.007	.000	.000
	214	C	-2	.112	.121	.743	.024	.000	.000	.000
		U	-2	.053	.099	.837	.010	.000	.000	.000
		S	-2	.102	.142	.756	.000	.000	.000	.000
AK	109	C	1	.028	.209	.275	.283	.196	.000	.000
		U	1	0	.132	.334	.360	.140	.033	.000
		S	1	.018	.329	.448	.111	.007	.087	.000
		A	-2	0	0	.262	.250	.401	.087	.000
	144	C	-1	0	0	.643	.326	.031	.000	.000
		U	-1	0	0	.594	.335	.056	-.007	.022
		S	-1	0	0	.787	.164	.012	-.019	.056
		A	-2	0	.321	.526	.142	.008	.000	0
	178	C	-2	0	0	.225	.337	.339	.072	.027
		U	-2	0	0	.128	.415	.185	.156	.117
		S	-2	0	0	.415	.332	.123	.131	.000

$t(P'_o)$ IN RECALL 4. MEAN AND STANDARD DEVIATION. TABLE 21

S	CONDITION		MEAN	SD
AR	75	C	387	81
		U	431	70
		S	322	60
	109	C	377	101
		U	382	64
		S	311	51
	144	C	370	108
		U	377	156
		S	290	71
	214	C	231	177
		U	253	221
		S	192	131
GL	75	C	426	57
		U	423	52
		S	372	56
	109	C	424	115
		U	384	65
		S	355	92
	144	C	255	95
		U	267	90
		S	187	95
	214	C	148	150
		U	173	114
		S	149	140
AK	109	C	484	121
		U	504	108
		S	445	126
	144	C	350	79
		U	367	110
		S	345	130
	178	C	421	176
		U	485	216
		C	355	185

$t(P'_{e})$ IN RECALL 4.

TABLE 22

S	SOA	C	U	S	Mean
AR	75	387	431	322	380
	109	377	382	311	357
	144	370	377	290	346
	214	231	253	192	225
	Mean	341	361	279	327
GL	75	426	423	372	407
	109	424	384	355	388
	144	255	267	187	236
	214	148	173	143	155
	Mean	313	312	264	296
AK	109	484	504	445	478
	144	350	367	345	354
	178	421	485	355	420
	Mean	418	452	382	417

$t(P'_e)$ IN RECALL 4. TABLE 23

MEANS

S	CC	C	U	S	
AR		341	361	279	
GL		313	312	264	
AK		418	452	382	
	SOA	75	109	144	178/214
AR		380	357	346	225
GL		407	388	236	155
AK			478	354	420

ANALYSIS OF VARIANCE

S	Effect	SS	df	MS	F	Omega^2
AR	CC	5872058	2	2936029	206.9*	.064
	SOA	17248264	3	5749422	81.7*	.188
	CCxSOA	422136	6	70356	4.9*	.004
	Error	67960872	4788	14194		
	Total	91503330	4799			
GL	CC	2485012	2	1242506	128.3*	.024
	SOA	53111169	3	17703723	117.0*	.514
	CCxSOA	907729	6	151288	15.6*	.008
	Error	46383271	4788	9687		
	Total	102887181	4799			
AK	CC	2227417	2	1113708	53.1*	.033
	SOA	6894375	2	3447188	14.9*	.104
	CCxSOA	927842	4	231960	11.1*	.013
	Error	56484090	2691	20990		
	Total	66533724	2699			

NORMAL FIT TO RESPONSE 1, N(1). TABLE 24

S	CONDITION		RECALL 4 MEAN	SD	D	RMS	RECALL 1 MEAN	SD	D	RMS
AR	75	C	446	93	.037	.036	484	97	.030	.029
		U	483	91	.031	.031	492	97	.020	.023
		S	389	76	.041	.044	406	69	.036	.054
		A	173	141	.053	.057	265	124	.031	.025
	109	C	438	74	.022	.006	457	79	.044	.063
		U	477	71	.018	.015	474	82	.041	.046
		S	390	55	.040	.039	401	60	.036	.045
		A	199	106	.028	.030	251	114	.030	.025
	144	C	469	94	.031	.020				
		U	520	116	.053	.071				
		S	394	58	.024	.039				
	214	C	408	134	.029	.017				
		U	479	165	.036	.030				
		S	379	75	.022	.023				
GL	75	C	514	101	.022	.017	523	121	.033	.025
		U	506	97	.032	.026	518	91	.030	.021
		S	446	88	.069*	.074	473	84	.058	.070
		A	371	133	.042	.043				
	109	C	485	129	.080*	.079	489	111	.057	.070
		U	474	101	.044	.046	485	103	.046	.053
		S	413	86	.072*	.126	413	77	.067	.115*
		A	302	124	.010	.007				
	144	C	384	117	.058	.082				
		U	385	137	.074*	.106				
		S	300	142	.051	.055				
	214	C	336	107	.047	.047				
		U	331	107	.044	.043				
		S	319	131	.064*	.106				
AK	109	C	577	127	.037	.039	491	89	.021	.024
		U	601	119	.049	.055	503	104	.042	.033
		S	497	104	.040	.037	452	95	.053	.060
		A	317	147	.039	.045				
	144	C	443	101	.028	.016	396	126	.072	.097*
		U	455	97	.027	.018	399	132	.081	.139*
		S	399	79	.032	.036	379	145	.059	.084
		A	195	115	.030	.048				
	178	C	459	198	.034	.041				
		U	470	185	.059	.071				
		S	402	173	.052	.060				

* Reject at .05 of Kolgomorov-Smirnov D statistic.

TABLE 25

MAIN EFFECTS OF SOA AND CC ON THE MEAN OF THE NORMAL FIT TO RESPONSE 1

S	RECALL 4				RECALL 1		
	Main effect of Letter CC.						
	C	U	S		C	U	S
AR	1	51	-51		18	31	-49
GL	22	16	-38		23	18	-40
AK	15	31	-45		7	15	-21
	Main effect of SOA.						
	75	109	144	178/214	75	109	144
AR	0	-4	22	-17	8	-8	
GL	81	49	-52	-79	21	-21	
AK		80	-46	-34	46	-45	

All main effects and interactions are significant by ANOVA at the .05 level, with seperate ANOVAs for each S.

NORMAL FIT TO RESPONSE 1. TABLE 26

MEANS

S		RECALL 4					RECALL 1		
	CC	C	U	S			C	U	S
AR		440	490	388			471	483	404
GL		430	424	370			506	502	443
AK		493	509	433			444	451	416
	SOA	75	109	144	178	214	75	109	144
AR		439	435	461		422	461	444	
GL		489	457	356		329	505	462	
AK			558	432	444			482	391

ANALYSIS OF VARIANCE

S	Recall	Effect	SS	df	MS	F	Omega^2
AR	4	CC	8280000	2	4140000	441 *	.15
		SOA	946000	3	315000	5.3 *	.01
		CCxSOA	360000	6	60000	6.4 *	.006
		Error	44970000	4788	9392		
		Total	54556000				
	1	CC	2920000	2	1460000	219 *	.15
		SOA	167000	1	167000	6.8 *	.008
		CCxSOA	48900	2	24450	3.7 *	.002
		Error	16020000	2394	6691		
		Total	19155900				
GL	4	CC	3540000	2	1770000	138 *	.04
		SOA	21480000	3	7160000	58.3*	.25
		CCxSOA	736000	6	123000	9.5 *	.007
		Error	61550000	4788	12860		
		Total	87306000				
	1	CC	1980000	2	988000	101 *	.07
		SOA	1080000	1	1080000	22.9*	.04
		CCxSOA	93700	2	46860	4.8 *	.003
		Error	23480000	2394	9806		
		Total	26633700				
AK	4	CC	2900000	2	1450000	76.4*	.05
		SOA	8750000	2	4375000	86.7*	.14
		CCxSOA	201700	4	50433	2.7 *	.002
		Error	51030000	2691	18962		
		Total	62881700				
	1	CC	420000	2	210000	15.4*	.01
		SOA	3700000	1	3700000	96.9*	.13
		CCxSOA	76300	2	38150	2.8	.001
		Error	24540000	1794	13681		
		Total	28736300				

SUMMARY TABLE OF CC-SOA EFFECTS ON MEASURES OF LATENCY. TABLE 27 p.1.

PANEL A. CC EFFECTS (CONDITION MEAN - GRAND MEAN)

S	MEASURE	RECALL 4			RECALL 1			POOLED S.E. OF THE MEAN
		C	U	S	C	U	S	
AR	RT	8	29	-38	11	17	-28	
	N(1)	1	51	-52	18	31	-49	
	t(NP)	7	43	-50	14	27	-41	
	t(EP)	3	23	-26				
	t(EP')	11	31	-42				
	Mean	6	35	-41	14	25	-39	3
GL	RT	11	21	-33	10	16	-27	
	N(1)	22	16	-38	23	18	-40	
	t(NP)	21	9	-30	23	12	-35	
	t(EP)	7	10	-17				
	t(EP')	17	16	-33				
	Mean	16	14	-30	19	15	-34	3
AK	RT	2	18	-20	6	15	-21	
	N(1)	15	31	-46	6	15	-21	
	t(NP)	14	30	-44	4	11	-15	
	t(EP)	7	20	-27				
	t(EP')	1	35	-36				
	Mean	8	26	-44	5	14	-19	4

PANEL B. MEAN ABSOLUTE CC EFFECT PER MEASURE.

RECALL	S	N(1)	t(EP')	t(NP)	RT	t(EP)	MEAN
4	AR	34	28	27	25	17	26
	GL	25	22	20	22	11	20
	AK	30	25	29	13	18	23
	Mean	30	25	25	20	15	23
1	AR	33		27	19		26
	GL	27		23	18		23
	AK	14		10	14		13
	Mean	25		20	17		21

SUMMARY TABLE OF CC-SOA EFFECTS ON MEASURES OF LATENCY. TABLE 27 p. 2.

PANEL C. SOA EFFECTS (CONDITION MEAN - GRAND MEAN).

S	MEASURE	RECALL 4				RECALL 1			POOLED S.E. OF THE MEAN
		75	109	144	178/214	75	109	144	
AR	RT	-7	-19	15	11	-1	1		
	N(1)	0	-4	21	-17	8	-8		
	t(NP)	26	10	20	-56	13	-13		
	t(EP)	21	45	34	-100				
	t(EP')	53	30	19	-102				
	Mean	19	12	22	-53	7	-7		3
GL	RT	-19	-1	10	10	5	-5		
	N(1)	81	49	-51	-79	21	-21		
	t(NP)	97	58	-44	-111	21	-21		
	t(EP)	68	78	-41	-105				
	t(EP')	110	91	-60	-141				
	Mean	66	54	-37	-83	9	-9		3
AK	RT		-14	5	9		-9	9	
	N(1)		80	-46	-34		8	-8	
	t(NP)		100	-51	-49		51	-51	
	t(EP)		84	-26	-58				
	t(EP')		61	-63	2				
	Mean		62	-37	-25		17	-17	4

PANEL D. MEAN ABSOLUTE SOA EFFECT PER MEASURE.

RECALL	S	t(EP')	t(EP)	t(NP)	N(1)	RT	MEAN
4	AR	51	50	28	11	13	31
	GL	101	73	77	65	10	64
	AK	42	56	66	53	9	45
	Mean	65	60	57	43	11	47
1	AR			13	8	1	7
	GL			21	21	5	16
	AK			51	8	9	22
	Mean			28	12	5	15

POOLED STANDARD DEVIATIONS FOR RECALL 4 LATENCY MEASURES TABLE 28 p.1

PANEL A: CC EFFECTS (S.D.s POOLED OVER SOAs).

MEASURE	S	C	U	S	Average Absolute Effect
RT	AR	91	102	75	10
	GL	48	56	46	4
	AK	78	79	75	2
N(1)	AR	101	116	67	18
	GL	114	112	115	1
	AK	148	139	125	8
t(NP)	AR	136	148	109	15
	GL	173	174	197	10
	AK	171	178	161	6
t(EP)	AR	127	149	101	16
	GL	124	117	110	5
	AK	156	154	137	8
t(EP')	AR	138	143	84	25
	GL	110	84	100	9
	AK	131	153	149	9

PANEL B: SOA EFFECTS(S.D.s POOLED OVER CCs)

MEASURE	S	75	109	144	178/214	Average Absolute Effect
RT	AR	66	77	88	120	16
	GL	48	51	50	52	1
	AK		89	56	82	13
N(1)	AR	87	67	92	130	18
	GL	95	107	132	116	12
	AK		117	93	186	36
t(NP)	AR	99	90	118	195	35
	GL	108	143	211	235	49
	AK		141	131	223	39
t(EP)	AR	87	82	122	189	36
	GL	103	94	109	153	19
	AK		112	116	202	39
t(EP')	AR	71	75	140	180	44
	GL	55	93	93	136	21
	AK		119	108	193	35

POOLED STANDARD DEVIATIONS FOR RECALL 4 LATENCY MEASURES. TABLE 28 p.2.

PANEL C : POSITION EFFECTS (SOA EFFECT / SOA)

MEASURE	S	75	109	144	178/214
RT	AR	.88	.71	.61	.56
	GL	.64	.47	.35	.24
	AK		.82	.39	.46
N(1)	AR	1.16	.61	.64	.61
	GL	1.27	.98	.92	.54
	AK		1.07	.65	1.04
t(NP)	AR	1.32	.83	.82	.91
	GL	1.44	1.31	1.47	1.10
	AK		1.29	.91	1.25
t(EP)	AR	1.16	.75	.85	.88
	GL	1.37	.86	.76	.71
	AK		1.03	.81	1.13
t(EP')	AR	.95	.69	.97	.84
	GL	.73	.85	.65	.64
	AK		1.09	.75	1.08

PANEL D: INTERACTION EFFECTS (CCxSOA)

MEASURE	S	N cells outside 95% Confidence Interval		Ratio of average absolute interaction to average variance of all cells
		a	b	
RT	AR	8	8	.172
	GL	4	4	.128
	AK	8	8	.146
N(1)	AR	6	6	.251
	GL	6	5	.185
	AK	0	0	.032
t(NP)	AR	7	6	.208
	GL	5	5	.168
	AK	1	1	.055
t(EP)	AR	6	5	.166
	GL	0	0	.069
	AK	0	0	.038
t(EP')	AR	10	9	.328
	GL	7	5	.161
	AK	7	4	.165

*N cells is 3x4=12 for AR and GL, 3x3=9 for AK.

a From Table Panel B.
b From Table Panel C.

LATENCY IN THE ARROW EXPERIMENT IN RECALL 4. TABLE 29 p.1.

CONDITION		t(EP')	t(EP)	t(NP)	N(1)	RT	MEAN OF MEANS WITH RT	MEAN OF MEANS WITHOUT RT
		PANEL A MEANS						
AR	75	147	76	197	173	411	201	149
	109	87	31	142	199	313	154	114
GL	75	262	198	343	371	259	287	294
	109	196	102	243	302	265	222	211
AK	109	252	140	262	317	318	258	243
	144	121	63	137	195	324	168	129
		PANEL B S.D.s						
AR	75	115	84	158	141	83		
	109	107	104	114	106	49		
GL	75	84	92	133	133	43		
	109	95	128	133	195	44		
AK	109	104	143	146	147	47		
	144	99	115	142	115	48		
		PANEL C MEAN OF C, U AND S, MINUS MEAN OF A.						
AR	75	233	214	208	266	75	199	230
	109	270	283	247	236	161	239	259
GL	75	145	98	112	118	95	114	119
	109	192	204	177	155	107	167	182
AK	109	226	252	256	241	91	213	244
	144	233	219	230	237	104	205	230
		PANEL D SOA EFFECT (FOR THE TWO FASTEST SOAs*) ON A AND ON THE MEAN OF C, U AND S.						
AR	A	30	23	28	-13	49	23	17
	C,U,S	12	-12	8	2	3	3	3
GL	A	33	48	50	35	-3	26	42
	C,U,S	10	-5	18	16	-9	6	10
AK	A	66	39	63	61	-3	45	57
	C,U,S	62	55	75	63	-11	49	64

* Half of the difference between the mean at 75 msec and the mean at 109 msec (109 and 144 msec for AK).

LATENCY IN THE ARROW EXPERIMENT IN RECALL 4. TABLE 29 p.2.

CONDITION		t(EP')	t(EP)	t(NP)	N(1)	RT	MEAN OF MEANS WITH RT	MEAN OF MEANS WITHOUT RT
		PANEL E AVERAGE S.D. IN C,U AND S, MINUS THE S.D. IN A						
AR	75	44	-3	59	54	17	34	39
	109	32	22	24	39	-28	18	29
GL	75	29	-11	25	38	-5	15	21
	109	2	34	-10	88	-7	21	29
AK	109	-15	31	5	30	-42	1	13
	144	-9	-1	9	22	-8	3	6
Mean		14	12	19	45	-12	15	23

TABLE 30 p.1.

$\bar{C}(e)$= CONCORDANCE⊕CONDITIONAL ON EP IN RECALL 4. PANEL A. . . .

S	CONDITION		1 **	2	3	4	5	Mean	$r_{\bar{C}(e),e}$
AR	75	C 1	.504	.497	.632	.698	.761	.608	.967 *
		U 1	.500	.476	.570	.680	.699	.589	.890 *
		S 1	.496	.592	.710	.790		.652	.998 *
	109	C 0	.551	.603	.782	.774		.742	.928 *
		U 0	.487	.582	.740	.840		.733	.995 *
		S 0	.571	.712	.827	.889		.779	.986 *
	144	C -1	.474	.590	.781	.797	.783	.748	.895 *
		U -1	.475	.479	.719	.807	.775	.720	.906 *
		S -1	.547	.638	.844	.833		.797	.935 *
	214	C -2	.663	.567	.814	.912		.764	.835 *
		U -2	.588	.586	.776	.845		.732	.939 *
		S -2	.595	.573	.878	.913		.811	.900 *
GL	75	C 1	.406	.416	.486	.631	.673	.531	.962 *
		U 1	.433	.438	.500	.624	.708	.536	.942 *
		S 1	.467	.463	.535	.745	.652	.586	.838 *
	109	C 0	.448	.537	.748	.826		.700	.982 *
		U 0	.496	.497	.799	.791		.726	.889 *
		S 0	.608	.594	.815	.782		.753	.834 *
	144	C -1	.560	.687	.846	.833		.747	.934 *
		U -1	.589	.731	.839	.760		.765	.768
		S -1	.659	.797	.828			.774	.939 *
	214	C -2	.660	.628	.926			.841	.813
		U -2	.671	.675	.907			.847	.873
		S -2	.659	.796	.904			.848	.998 *
AK	109	C 1	.509	.598	.752	.777	.708	.666	.810 *
		U 1	.495	.518	.780	.794	.745	.673	.833 *
		S 1	.498	.723	.797	.825		.716	.919 *
	144	C -1	.481	.624	.874	.875		.813	.949 *
		U -1	.489	.563	.837	.932		.807	.973 *
		S -1	.643	.661	.882	.900		.824	.925 *
	178	C -2	.589	.640	.795	.900	.889	.814	.955 *
		U -2	.583	.643	.826	.879	.879	.816	.939 *
		S -2	.553	.653	.852	.896	.830	.815	.859 *

* r signficant at .05, one-tailed T test.

⊕ Negative set responses included as position 8.

** Position of EP in the positive set. To obtain true position, relative to CC, add i_o.

CONCORDANCE⊕ CONDITIONAL ON EP IN RECALL 4 TABLE 30 p.2.

PANEL B. MEAN CONCORDANCE CONDITIONED ON EP AND AVERAGED OVER CCs C, U AND S.

S	SOA	i_o	1*	2	3	4
AR	75	1	.500	.522	.637	.723
	109	0	.536	.632	.783	.834
	144	-1	.494	.569	.781	.812
	214	-2	.615	.575	.823	.890
GL	75	1	.435	.439	.501	.667
	109	0	.517	.543	.787	.799
	144	-1	.603	.738	.838	
	214	-2	.663	.699	.912	
AK	109	1	.501	.613	.776	.799
	144	-1	.538	.616	.864	.902
	178	-2	.575	.645	.824	.892

⊕ Negative Set responses included as position 8. of the positive set.

* Position in the positive set. To obtain the true position relative to CC, add i_o.

MEAN CONCORDANCE IN RECALL 4 TABLE 31

PANEL A. MEAN CONCORDANCE: negative set responses included in position 8.

S	SOA	C	U	S	Mean CUS	A
AR	75	.608	.589	.652	.616	.651
	109	.742	.733	.779	.751	.655
	144	.748	.720	.797	.755	
	214	.764	.732	.811	.769	
	Mean	.715	.694	.760	.723	
GL	75	.531	.536	.586	.551	.584
	109	.700	.726	.753	.726	.604
	144	.747	.765	.774	.762	
	214	.841	.847	.848	.845	
	Mean	.705	.719	.740	.721	
AK	109	.666	.673	.716	.685	.629
	144	.813	.807	.824	.815	.793
	178	.814	.816	.815	.815	
	Mean	.764	.765	.785	.772	

PANEL B. MEAN CONCORDANCE: positive set responses only

AR	75	.556	.528	.615	.566	.613
	109	.737	.717	.777	.744	.641
	144	.736	.716	.788	.747	
	214	.765	.725	.811	.767	
	Mean	.699	.672	.748	.706	
GL	75	.462	.457	.538	.486	.536
	109	.677	.697	.742	.705	.578
	144	.744	.774	.789	.769	
	214	.847	.854	.864	.855	
	Mean	.683	.696	.733	.704	
AK	109	.636	.629	.697	.654	.604
	144	.754	.735	.778	.756	.739
	178	.753	.790	.769	.771	
	Mean	.714	.718	.748	.727	

MEAN COVARIANCE OF STIMULI IN RECALL 4 TABLE 32

Define $Cov_{ij} = p(i \& j) - p_i \cdot p_j$, where $p(i \& j) = p(S \text{ reports both } i,j)$.

Table entries are the mean of the Cov_{ij} for each position,

$$Cov = \frac{1}{42} \sum_{i \neq j} \sum_{=1}^{7} (Cov_{ij})$$

In the data, all Cov_{ij} in all conditions were $\leq +.002$, so that the absolute value of the Cov = the mean of the absolute value of the Cov_{ij}, to three significant figures.

S	SOA	C	U	S	A
AR	75	-.018	-.021	-.018	-.023
	109	-.017	-.015	-.020	-.020
	144	-.019	-.018	-.015	
	214	-.017	-.019	-.011	
GL	75	-.017	-.017	-.016	-.018
	109	-.015	-.015	-.016	-.019
	144	-.016	-.015	-.015	
	214	-.017	-.017	-.016	
AK	109	-.023	-.022	-.020	-.016
	144	-.016	-.016	-.018	-.017
	178	-.017	-.016	-.017	
Arithmetic grand mean				-.017	
Geometric grand mean				-.017	

$P_{\bar{i}}(j)$ IN RECALL 1. TABLE 33

PANEL A. $P_{\bar{I}}(j) + i_o$

S	SOA	CONDITION	j 1	2	3	4	$P_{\bar{i}}$
AR	75	C	6.75	6.65	6.74	7.11	6.73
		U	6.95	6.85	6.82	7.06	6.95
		S	5.78	5.91	5.85	6.06	5.89
		A	3.80	3.84	3.97	3.76	3.80
	109	C	4.48	4.63	4.77	4.54	4.65
		U	4.50	4.84	4.98	4.89	4.83
		S	4.14	4.23	4.13	4.11	4.19
		A	2.36	2.59	2.71	2.68	2.60
GL	75	C	6.80	6.97	7.09	7.28	7.11
		U	7.00	7.06	7.18	7.50	7.22
		S	6.08	6.43	6.86	7.00	6.68
	109	C	4.40	4.68	5.05	5.29	4.95
		U	4.33	4.53	4.94	5.48	4.83
		S	3.91	4.16	4.42	4.59	4.25
AK	109	C	4.42	4.81	5.36	5.94	4.99
		U	4.46	4.87	5.46	6.08	5.06
		S	4.19	4.68	5.31	6.33	4.64
	144	C	2.72	3.15	3.75	4.63	3.35
		U	2.92	3.10	3.96	5.10	3.34
		S	2.69	3.04	3.77	5.22	3.17

PANEL B. $P_{\bar{I}}(j)$, AVERAGED OVER CC , MINUS GRAND MEAN.

S	SOA	1	2	3	4
AR	75	-.06	-.07	-.07	.20
	109	-.15	-.05	.11	-.01
GL	75	-.30	-.12	.10	.32
	109	-.43	-.19	.15	.47
AK	109	-.80	-.37	.22	.95
	144	-.89	-.57	.16	1.30

EFFECT OF ESTIMATE j ON $P_i(j)$ IN RECALL 1. TABLE 34

PANEL A. DISTANCE D(j,k).

$$D(j,k) = .5\left(\sum_i (|P_i(j) - P_i(k)|)\right)$$

S	SOA	D(1,2)			D(2,3)			D(3,4)		
		C	U	S	C	U	S	C	U	S
AR	75	.138	.201	.232	.088	.073	.108	.244	.200	.173
	109	.071	.220	.162	.130	.060	.133	.172	.184	.580
GL	75	.223	.201	.347	.176	.112	.170	.222	.228	.186
	109	.296	.129	.194	.130	.246	.149	.153	.300	.328
AK	109	.187	.213	.303	.400	.301	.473	.392	.315	.492
	144	.326	.153	.255	.393	.514	.451	.467	.562	.511

PANEL B. REGRESSION OF $P_i(j)$ ON j.

S	SOA	Correlation of $P_i(j)$ with j			Slope of the linear regression of $P_i(j)$ on j		
		C	U	S	C	U	S
AR	75	.647	.678	.862	.155	.193	.078
	109	.293	.801	-.364	.028	.130	-.015
GL	75	.989	.947	.985	.155	.165	.320
	109	.997	.980	.996	.302	.385	.225
AK	109	.997	.996	.986	.510	.545	.708
	144	.987	.959	.959	.630	.739	.835

Note: correct estimates would yeild D(j,k) = 1.0; Regression slope = 1.0, and correlation 1.0. Random estimates would yeild D(j,k)=0, slope =0 and correlation=0.

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 1

CONDITION		1	2	3	4	5	6	7	8
HR	75 C	Ø.Ø14	Ø.Ø41	Ø.152	Ø.331	Ø.290	Ø.Ø82	Ø.Ø51	Ø.Ø39
		Ø.Ø35	Ø.Ø40	Ø.Ø85	Ø.135	Ø.188	Ø.176	Ø.143	Ø.148
		Ø.Ø6Ø	Ø.Ø68	Ø.1Ø8	Ø.1Ø8	Ø.1Ø8	Ø.133	Ø.143	Ø.271
		Ø.Ø45	Ø.Ø95	Ø.Ø9Ø	Ø.1Ø1	Ø.1Ø1	Ø.123	Ø.178	Ø.266
		Ø.Ø38	Ø.Ø61	Ø.1Ø9	Ø.181	Ø.172	Ø.128	Ø.129	Ø.181
	75 D	Ø.ØØ9	Ø.Ø21	Ø.Ø89	Ø.288	Ø.314	Ø.159	Ø.Ø73	Ø.Ø47
		Ø.Ø32	Ø.Ø42	Ø.Ø74	Ø.128	Ø.177	Ø.2Ø1	Ø.177	Ø.17Ø
		Ø.Ø64	Ø.Ø61	Ø.Ø79	Ø.13Ø	Ø.125	Ø.118	Ø.17Ø	Ø.253
		Ø.Ø42	Ø.Ø83	Ø.Ø91	Ø.Ø81	Ø.Ø96	Ø.155	Ø.152	Ø.295
		Ø.Ø37	Ø.Ø53	Ø.Ø83	Ø.157	Ø.178	Ø.158	Ø.143	Ø.191
	75 S	Ø.ØØ7	Ø.Ø86	Ø.371	Ø.363	Ø.1Ø2	Ø.Ø24	Ø.Ø12	Ø.Ø32
		Ø.Ø2Ø	Ø.Ø63	Ø.166	Ø.262	Ø.199	Ø.Ø91	Ø.Ø83	Ø.116
		Ø.Ø53	Ø.Ø73	Ø.1Ø1	Ø.131	Ø.146	Ø.174	Ø.1Ø8	Ø.214
		Ø.Ø58	Ø.1Ø1	Ø.Ø91	Ø.Ø98	Ø.116	Ø.111	Ø.139	Ø.287
		Ø.Ø35	Ø.Ø81	Ø.182	Ø.214	Ø.141	Ø.1ØØ	Ø.Ø86	Ø.162
	75 A	Ø.199	Ø.128	Ø.217	Ø.143	Ø.125	Ø.Ø72	Ø.Ø36	Ø.Ø81
		Ø.1Ø7	Ø.116	Ø.159	Ø.213	Ø.152	Ø.Ø83	Ø.Ø65	Ø.1Ø5
		Ø.Ø72	Ø.Ø92	Ø.116	Ø.152	Ø.161	Ø.139	Ø.1Ø1	Ø.168
		Ø.Ø76	Ø.Ø98	Ø.Ø85	Ø.Ø92	Ø.11Ø	Ø.Ø92	Ø.13Ø	Ø.318
		Ø.115	Ø.1Ø8	Ø.144	Ø.15Ø	Ø.137	Ø.Ø96	Ø.Ø83	Ø.168
	1Ø9 C	Ø.ØØ5	Ø.Ø41	Ø.425	Ø.437	Ø.Ø68	Ø.ØØ7	Ø.Ø12	Ø.ØØ5
		Ø.ØØ7	Ø.Ø34	Ø.19Ø	Ø.3Ø7	Ø.263	Ø.Ø83	Ø.Ø56	Ø.Ø59
		Ø.Ø2Ø	Ø.Ø27	Ø.Ø61	Ø.Ø95	Ø.261	Ø.198	Ø.168	Ø.171
		Ø.Ø24	Ø.Ø49	Ø.Ø78	Ø.Ø75	Ø.163	Ø.215	Ø.222	Ø.176
		Ø.Ø14	Ø.Ø38	Ø.138	Ø.228	Ø.189	Ø.126	Ø.114	Ø.1Ø3
	1Ø9 D	Ø.ØØ3	Ø.Ø18	Ø.315	Ø.543	Ø.1Ø1	Ø.Ø16	Ø.ØØ3	Ø.ØØ3
		Ø.ØØ8	Ø.Ø34	Ø.14Ø	Ø.285	Ø.313	Ø.1Ø1	Ø.Ø57	Ø.Ø62
		Ø.Ø21	Ø.Ø39	Ø.Ø62	Ø.Ø52	Ø.225	Ø.246	Ø.215	Ø.14Ø
		Ø.Ø31	Ø.Ø44	Ø.1Ø4	Ø.Ø52	Ø.15Ø	Ø.187	Ø.218	Ø.215
		Ø.Ø16	Ø.Ø34	Ø.155	Ø.233	Ø.197	Ø.137	Ø.123	Ø.1Ø5
	1Ø9 S	Ø.ØØ7	Ø.1ØØ	Ø.718	Ø.134	Ø.Ø22	Ø.ØØ5	Ø.ØØ5	Ø.Ø1Ø
		Ø.Ø12	Ø.Ø38	Ø.15Ø	Ø.514	Ø.1Ø8	Ø.Ø61	Ø.Ø25	Ø.Ø42
		Ø.Ø2Ø	Ø.Ø54	Ø.Ø49	Ø.125	Ø.283	Ø.216	Ø.135	Ø.118
		Ø.Ø22	Ø.Ø64	Ø.Ø44	Ø.Ø74	Ø.214	Ø.2Ø9	Ø.2Ø6	Ø.167
		Ø.Ø15	Ø.Ø77	Ø.24Ø	Ø.212	Ø.157	Ø.123	Ø.Ø93	Ø.Ø84
	1Ø9 A	Ø.Ø57	Ø.126	Ø.384	Ø.347	Ø.Ø64	Ø.Ø17	Ø.ØØ5	Ø.ØØØ
		Ø.Ø44	Ø.Ø74	Ø.19Ø	Ø.333	Ø.268	Ø.Ø47	Ø.Ø25	Ø.Ø2Ø
		Ø.Ø52	Ø.111	Ø.Ø96	Ø.14Ø	Ø.251	Ø.143	Ø.Ø86	Ø.121
		Ø.Ø89	Ø.135	Ø.Ø86	Ø.Ø74	Ø.155	Ø.148	Ø.111	Ø.2Ø2
		Ø.Ø61	Ø.111	Ø.189	Ø.223	Ø.185	Ø.Ø89	Ø.Ø57	Ø.Ø86

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 2

CONDITION	1	2	3	4	5	6	7	8
144 C	Ø.ØØ5	Ø.ØØØ	Ø.376	Ø.491	Ø.100	Ø.Ø23	Ø.ØØ3	Ø.ØØ5
	Ø.Ø1Ø	Ø.Ø2Ø	Ø.138	Ø.319	Ø.312	Ø.116	Ø.Ø63	Ø.Ø23
	Ø.Ø1Ø	Ø.Ø35	Ø.Ø63	Ø.Ø53	Ø.251	Ø.251	Ø.246	Ø.Ø93
	Ø.Ø43	Ø.Ø4Ø	Ø.Ø68	Ø.Ø6Ø	Ø.176	Ø.216	Ø.241	Ø.156
	Ø.Ø16	Ø.Ø23	Ø.161	Ø.231	Ø.21Ø	Ø.151	Ø.138	Ø.Ø69
144 D	Ø.ØØ3	Ø.ØØØ	Ø.219	Ø.534	Ø.155	Ø.Ø52	Ø.Ø18	Ø.Ø21
	Ø.ØØ8	Ø.Ø11	Ø.Ø91	Ø.215	Ø.384	Ø.148	Ø.Ø99	Ø.Ø43
	Ø.ØØ5	Ø.Ø22	Ø.Ø51	Ø.Ø48	Ø.196	Ø.263	Ø.288	Ø.126
	Ø.Ø46	Ø.Ø38	Ø.1Ø5	Ø.Ø48	Ø.148	Ø.223	Ø.234	Ø.159
	Ø.Ø15	Ø.Ø18	Ø.116	Ø.211	Ø.221	Ø.172	Ø.16Ø	Ø.Ø87
144 S	Ø.ØØ2	Ø.Ø21	Ø.756	Ø.195	Ø.Ø23	Ø.ØØ2	Ø.ØØØ	Ø.ØØØ
	Ø.Ø19	Ø.Ø42	Ø.Ø95	Ø.497	Ø.23Ø	Ø.Ø77	Ø.Ø35	Ø.Ø07
	Ø.ØØ9	Ø.Ø26	Ø.Ø3Ø	Ø.158	Ø.295	Ø.29Ø	Ø.148	Ø.Ø44
	Ø.Ø44	Ø.Ø39	Ø.Ø3Ø	Ø.Ø65	Ø.26Ø	Ø.285	Ø.162	Ø.116
	Ø.Ø13	Ø.Ø32	Ø.228	Ø.228	Ø.2Ø2	Ø.163	Ø.Ø86	Ø.Ø42
214 C	Ø.Ø3Ø	Ø.Ø15	Ø.494	Ø.4Ø6	Ø.Ø28	Ø.Ø1Ø	Ø.ØØ3	Ø.Ø15
	Ø.Ø18	Ø.Ø28	Ø.13Ø	Ø.435	Ø.275	Ø.Ø66	Ø.Ø23	Ø.Ø25
	Ø.Ø1Ø	Ø.Ø48	Ø.Ø61	Ø.Ø99	Ø.389	Ø.3Ø3	Ø.Ø51	Ø.Ø38
	Ø.Ø46	Ø.1Ø9	Ø.Ø76	Ø.Ø15	Ø.216	Ø.288	Ø.142	Ø.1Ø7
	Ø.Ø26	Ø.Ø5Ø	Ø.19Ø	Ø.239	Ø.227	Ø.167	Ø.Ø55	Ø.Ø46
214 D	Ø.Ø28	Ø.Ø33	Ø.342	Ø.477	Ø.Ø75	Ø.Ø25	Ø.Ø13	Ø.ØØ8
	Ø.Ø2Ø	Ø.Ø15	Ø.129	Ø.353	Ø.353	Ø.Ø84	Ø.Ø36	Ø.Ø1Ø
	Ø.Ø2Ø	Ø.Ø28	Ø.Ø56	Ø.Ø76	Ø.325	Ø.338	Ø.Ø99	Ø.Ø58
	Ø.Ø81	Ø.Ø81	Ø.127	Ø.Ø43	Ø.15Ø	Ø.277	Ø.137	Ø.1Ø4
	Ø.Ø37	Ø.Ø39	Ø.163	Ø.237	Ø.226	Ø.181	Ø.Ø71	Ø.Ø45
214 S	Ø.Ø1Ø	Ø.Ø1Ø	Ø.75Ø	Ø.2Ø9	Ø.ØØ7	Ø.ØØØ	Ø.ØØ5	Ø.Ø1Ø
	Ø.Ø19	Ø.Ø31	Ø.1Ø2	Ø.646	Ø.15Ø	Ø.Ø24	Ø.Ø1Ø	Ø.Ø17
	Ø.Ø22	Ø.Ø39	Ø.Ø31	Ø.Ø8Ø	Ø.535	Ø.242	Ø.Ø29	Ø.Ø22
	Ø.Ø51	Ø.Ø65	Ø.Ø44	Ø.Ø39	Ø.225	Ø.397	Ø.Ø8Ø	Ø.Ø99
	Ø.Ø25	Ø.Ø36	Ø.232	Ø.244	Ø.229	Ø.166	Ø.Ø31	Ø.Ø37

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 3

CONDITION		1	2	3	4	5	6	7	8
GL	75 C	Ø.Ø22	Ø.Ø13	Ø.Ø36	Ø.199	Ø.281	Ø.250	Ø.123	Ø.Ø76
		Ø.Ø27	Ø.Ø27	Ø.Ø33	Ø.132	Ø.21Ø	Ø.250	Ø.194	Ø.127
		Ø.Ø71	Ø.Ø83	Ø.Ø67	Ø.1Ø9	Ø.143	Ø.156	Ø.17Ø	Ø.2Ø1
		Ø.Ø92	Ø.1Ø3	Ø.Ø85	Ø.Ø94	Ø.Ø87	Ø.1Ø5	Ø.165	Ø.27Ø
		Ø.Ø55	Ø.Ø56	Ø.Ø55	Ø.153	Ø.18Ø	Ø.19Ø	Ø.163	Ø.168
	75 D	Ø.Ø27	Ø.Ø24	Ø.Ø34	Ø.178	Ø.328	Ø.248	Ø.1Ø2	Ø.Ø58
		Ø.Ø54	Ø.Ø22	Ø.Ø51	Ø.124	Ø.2Ø2	Ø.251	Ø.219	Ø.Ø97
		Ø.Ø85	Ø.Ø83	Ø.Ø49	Ø.117	Ø.1Ø5	Ø.146	Ø.187	Ø.229
		Ø.Ø95	Ø.Ø83	Ø.1Ø9	Ø.119	Ø.Ø83	Ø.124	Ø.117	Ø.27Ø
		Ø.Ø6Ø	Ø.Ø55	Ø.Ø61	Ø.155	Ø.18Ø	Ø.192	Ø.156	Ø.163
	75 S	Ø.Ø31	Ø.Ø24	Ø.Ø31	Ø.4Ø9	Ø.261	Ø.Ø83	Ø.Ø67	Ø.Ø45
		Ø.Ø14	Ø.Ø38	Ø.Ø57	Ø.197	Ø.254	Ø.2ØØ	Ø.159	Ø.Ø81
		Ø.Ø18	Ø.Ø67	Ø.Ø83	Ø.Ø88	Ø.135	Ø.181	Ø.192	Ø.176
		Ø.Ø81	Ø.Ø9Ø	Ø.112	Ø.Ø86	Ø.112	Ø.131	Ø.152	Ø.235
		Ø.Ø51	Ø.Ø55	Ø.Ø8Ø	Ø.195	Ø.191	Ø.149	Ø.142	Ø.134
	75 M	Ø.Ø45	Ø.Ø91	Ø.1Ø5	Ø.252	Ø.257	Ø.1Ø7	Ø.Ø55	Ø.Ø89
		Ø.Ø48	Ø.Ø5Ø	Ø.Ø82	Ø.211	Ø.268	Ø.15Ø	Ø.Ø93	Ø.Ø93
		Ø.Ø52	Ø.Ø91	Ø.1ØØ	Ø.114	Ø.15Ø	Ø.173	Ø.132	Ø.189
		Ø.Ø8Ø	Ø.Ø91	Ø.1ØØ	Ø.Ø8Ø	Ø.118	Ø.136	Ø.136	Ø.259
		Ø.Ø56	Ø.Ø81	Ø.Ø97	Ø.164	Ø.198	Ø.141	Ø.1Ø5	Ø.157
	1Ø9 C	Ø.Ø19	Ø.Ø21	Ø.329	Ø.399	Ø.113	Ø.Ø26	Ø.Ø35	Ø.Ø59
		Ø.ØØ7	Ø.Ø16	Ø.176	Ø.355	Ø.296	Ø.1Ø3	Ø.Ø33	Ø.Ø35
		Ø.Ø23	Ø.Ø16	Ø.Ø82	Ø.115	Ø.2ØØ	Ø.211	Ø.197	Ø.155
		Ø.Ø77	Ø.Ø7Ø	Ø.Ø7Ø	Ø.Ø45	Ø.124	Ø.136	Ø.195	Ø.282
		Ø.Ø51	Ø.Ø31	Ø.164	Ø.223	Ø.183	Ø.119	Ø.115	Ø.133
	1Ø9 D	Ø.Ø24	Ø.Ø19	Ø.37Ø	Ø.389	Ø.128	Ø.Ø36	Ø.ØØ7	Ø.Ø28
		Ø.ØØ7	Ø.Ø14	Ø.192	Ø.346	Ø.258	Ø.Ø92	Ø.Ø62	Ø.Ø28
		Ø.Ø12	Ø.Ø36	Ø.Ø83	Ø.1Ø9	Ø.265	Ø.2Ø1	Ø.164	Ø.13Ø
		Ø.Ø64	Ø.Ø59	Ø.Ø62	Ø.Ø58	Ø.126	Ø.2Ø1	Ø.171	Ø.28Ø
		Ø.Ø27	Ø.Ø32	Ø.177	Ø.22Ø	Ø.194	Ø.133	Ø.1Ø1	Ø.116
	1Ø9 S	Ø.Ø39	Ø.Ø54	Ø.593	Ø.139	Ø.Ø59	Ø.Ø17	Ø.Ø12	Ø.Ø37
		Ø.Ø15	Ø.Ø25	Ø.194	Ø.4Ø9	Ø.24Ø	Ø.Ø51	Ø.Ø22	Ø.Ø44
		Ø.Ø22	Ø.Ø39	Ø.Ø74	Ø.152	Ø.228	Ø.2Ø6	Ø.135	Ø.145
		Ø.Ø54	Ø.Ø61	Ø.Ø59	Ø.Ø78	Ø.132	Ø.174	Ø.199	Ø.262
		Ø.Ø32	Ø.Ø45	Ø.225	Ø.2Ø7	Ø.165	Ø.112	Ø.Ø92	Ø.122
	1Ø9 M	Ø.Ø17	Ø.Ø49	Ø.19Ø	Ø.341	Ø.277	Ø.Ø94	Ø.Ø22	Ø.Ø1Ø
		Ø.Ø2Ø	Ø.Ø44	Ø.116	Ø.247	Ø.3Ø9	Ø.175	Ø.Ø64	Ø.Ø25
		Ø.Ø4Ø	Ø.Ø54	Ø.Ø86	Ø.1Ø1	Ø.138	Ø.17Ø	Ø.158	Ø.252
		Ø.Ø67	Ø.Ø91	Ø.Ø94	Ø.Ø59	Ø.1Ø6	Ø.131	Ø.128	Ø.323
		Ø.Ø36	Ø.Ø59	Ø.121	Ø.167	Ø.2Ø7	Ø.142	Ø.Ø93	Ø.152

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 4

CONDITION	1	2	3	4	5	6	7	8
144 U	Ø.Ø43	Ø.117	Ø.543	Ø.200	Ø.037	Ø.Ø10	Ø.ØØ3	Ø.Ø47
	Ø.Ø17	Ø.Ø77	Ø.287	Ø.457	Ø.1ØØ	Ø.Ø2Ø	Ø.Ø13	Ø.Ø3Ø
	Ø.Ø51	Ø.Ø47	Ø.Ø63	Ø.157	Ø.56Ø	Ø.143	Ø.Ø57	Ø.117
	Ø.Ø77	Ø.11Ø	Ø.Ø51	Ø.Ø4Ø	Ø.17Ø	Ø.167	Ø.177	Ø.223
	Ø.Ø43	Ø.Ø33	Ø.232	Ø.214	Ø.172	Ø.Ø85	Ø.Ø62	Ø.1Ø4
144 D	Ø.Ø6Ø	Ø.126	Ø.53Ø	Ø.183	Ø.Ø21	Ø.Ø15	Ø.ØØØ	Ø.Ø66
	Ø.Ø13	Ø.Ø6Ø	Ø.296	Ø.452	Ø.1Ø5	Ø.Ø13	Ø.Ø15	Ø.Ø36
	Ø.Ø21	Ø.Ø55	Ø.Ø66	Ø.165	Ø.368	Ø.195	Ø.Ø72	Ø.Ø81
	Ø.Ø69	Ø.Ø72	Ø.Ø15	Ø.Ø67	Ø.192	Ø.2Ø1	Ø.141	Ø.225
	Ø.Ø42	Ø.Ø75	Ø.227	Ø.222	Ø.171	Ø.1Ø7	Ø.Ø57	Ø.1Ø2
144 S	Ø.Ø31	Ø.424	Ø.312	Ø.115	Ø.ØØ9	Ø.ØØØ	Ø.ØØ6	Ø.Ø53
	Ø.Ø54	Ø.15Ø	Ø.355	Ø.35Ø	Ø.Ø62	Ø.Ø16	Ø.Ø12	Ø.Ø4Ø
	Ø.Ø16	Ø.Ø78	Ø.1Ø3	Ø.268	Ø.271	Ø.121	Ø.Ø59	Ø.Ø84
	Ø.Ø5Ø	Ø.Ø47	Ø.Ø72	Ø.1ØØ	Ø.218	Ø.174	Ø.165	Ø.174
	Ø.Ø45	Ø.175	Ø.21Ø	Ø.2Ø3	Ø.14Ø	Ø.Ø78	Ø.Ø6Ø	Ø.Ø88
214 U	Ø.Ø48	Ø.Ø45	Ø.716	Ø.148	Ø.Ø15	Ø.ØØ6	Ø.ØØ3	Ø.Ø18
	Ø.Ø18	Ø.Ø3Ø	Ø.184	Ø.7Ø7	Ø.Ø39	Ø.ØØ6	Ø.ØØ3	Ø.Ø12
	Ø.Ø3Ø	Ø.Ø3Ø	Ø.Ø42	Ø.Ø79	Ø.538	Ø.215	Ø.Ø39	Ø.Ø27
	Ø.Ø54	Ø.Ø69	Ø.ØØ9	Ø.Ø24	Ø.13Ø	Ø.426	Ø.2Ø2	Ø.Ø85
	Ø.Ø51	Ø.Ø43	Ø.238	Ø.239	Ø.13Ø	Ø.163	Ø.Ø62	Ø.Ø36
214 D	Ø.Ø45	Ø.Ø66	Ø.713	Ø.131	Ø.Ø21	Ø.ØØ3	Ø.ØØØ	Ø.Ø21
	Ø.Ø14	Ø.Ø17	Ø.197	Ø.671	Ø.Ø73	Ø.Ø21	Ø.ØØ3	Ø.ØØ3
	Ø.Ø21	Ø.Ø35	Ø.Ø38	Ø.Ø97	Ø.5Ø2	Ø.173	Ø.Ø73	Ø.Ø62
	Ø.Ø35	Ø.Ø55	Ø.Ø1Ø	Ø.Ø24	Ø.138	Ø.446	Ø.173	Ø.118
	Ø.Ø29	Ø.Ø43	Ø.24Ø	Ø.231	Ø.183	Ø.161	Ø.Ø62	Ø.Ø51
214 S	Ø.Ø46	Ø.111	Ø.695	Ø.Ø79	Ø.ØØ7	Ø.ØØ7	Ø.Ø2Ø	Ø.Ø36
	Ø.Ø3Ø	Ø.Ø43	Ø.275	Ø.593	Ø.Ø39	Ø.ØØ7	Ø.Ø1Ø	Ø.ØØ3
	Ø.Ø2Ø	Ø.Ø33	Ø.Ø2Ø	Ø.161	Ø.5Ø8	Ø.157	Ø.Ø56	Ø.Ø46
	Ø.Ø56	Ø.Ø2Ø	Ø.ØØ3	Ø.Ø75	Ø.223	Ø.466	Ø.Ø79	Ø.Ø79
	Ø.Ø33	Ø.Ø52	Ø.248	Ø.227	Ø.194	Ø.159	Ø.Ø41	Ø.Ø41

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 5

CONDITION		1	2	3	4	5	6	7	8
AA	109 C	Ø.Ø22	Ø.Ø87	Ø.339	Ø.317	Ø.146	Ø.Ø43	Ø.Ø22	Ø.Ø25
		Ø.Ø16	Ø.Ø47	Ø.143	Ø.317	Ø.224	Ø.137	Ø.Ø53	Ø.Ø65
		Ø.Ø43	Ø.Ø68	Ø.Ø75	Ø.127	Ø.211	Ø.196	Ø.143	Ø.137
		Ø.Ø93	Ø.127	Ø.Ø56	Ø.Ø56	Ø.102	Ø.161	Ø.161	Ø.242
		Ø.Ø43	Ø.Ø82	Ø.153	Ø.2Ø4	Ø.171	Ø.134	Ø.Ø95	Ø.117
	109 D	Ø.Ø18	Ø.Ø39	Ø.236	Ø.392	Ø.138	Ø.Ø74	Ø.Ø21	Ø.Ø32
		Ø.Ø25	Ø.Ø49	Ø.159	Ø.297	Ø.233	Ø.102	Ø.Ø78	Ø.Ø57
		Ø.Ø32	Ø.Ø71	Ø.Ø78	Ø.113	Ø.198	Ø.2Ø1	Ø.17Ø	Ø.138
		Ø.Ø6Ø	Ø.124	Ø.Ø57	Ø.Ø49	Ø.12Ø	Ø.166	Ø.117	Ø.3Ø7
		Ø.Ø54	Ø.Ø71	Ø.145	Ø.213	Ø.172	Ø.136	Ø.Ø96	Ø.133
	109 S	Ø.Ø19	Ø.221	Ø.452	Ø.215	Ø.Ø47	Ø.Ø12	Ø.Ø12	Ø.Ø22
		Ø.Ø16	Ø.Ø75	Ø.131	Ø.3Ø8	Ø.178	Ø.115	Ø.Ø56	Ø.Ø72
		Ø.Ø47	Ø.Ø78	Ø.Ø73	Ø.165	Ø.212	Ø.156	Ø.1Ø6	Ø.159
		Ø.Ø97	Ø.Ø84	Ø.Ø65	Ø.Ø72	Ø.125	Ø.146	Ø.168	Ø.243
		Ø.Ø45	Ø.114	Ø.194	Ø.19Ø	Ø.141	Ø.1Ø7	Ø.Ø86	Ø.124
	109 A	Ø.Ø13	Ø.Ø29	Ø.247	Ø.251	Ø.299	Ø.127	Ø.Ø29	Ø.Ø26
		Ø.ØØØ	Ø.Ø13	Ø.Ø36	Ø.Ø68	Ø.266	Ø.256	Ø.253	Ø.1Ø1
		Ø.Ø32	Ø.Ø39	Ø.Ø65	Ø.Ø84	Ø.Ø81	Ø.185	Ø.185	Ø.328
		Ø.Ø75	Ø.Ø52	Ø.Ø62	Ø.Ø78	Ø.Ø49	Ø.12Ø	Ø.14Ø	Ø.425
		Ø.Ø31	Ø.Ø3Ø	Ø.1Ø2	Ø.115	Ø.174	Ø.172	Ø.152	Ø.22Ø
	144 C	Ø.ØØ7	Ø.Ø33	Ø.423	Ø.447	Ø.Ø6Ø	Ø.Ø1Ø	Ø.ØØ7	Ø.Ø13
		Ø.ØØ7	Ø.ØØØ	Ø.18Ø	Ø.39Ø	Ø.28Ø	Ø.Ø77	Ø.Ø4Ø	Ø.Ø23
		Ø.Ø17	Ø.Ø47	Ø.Ø6Ø	Ø.Ø77	Ø.267	Ø.2Ø7	Ø.17Ø	Ø.157
		Ø.Ø43	Ø.Ø23	Ø.Ø27	Ø.Ø17	Ø.Ø73	Ø.133	Ø.12Ø	Ø.563
		Ø.Ø18	Ø.Ø26	Ø.172	Ø.233	Ø.17Ø	Ø.1Ø7	Ø.Ø84	Ø.189
	144 D	Ø.ØØ6	Ø.Ø15	Ø.4Ø1	Ø.468	Ø.Ø82	Ø.ØØ9	Ø.ØØ6	Ø.Ø15
		Ø.ØØ6	Ø.Ø12	Ø.126	Ø.348	Ø.348	Ø.Ø91	Ø.Ø47	Ø.Ø23
		Ø.Ø2Ø	Ø.Ø26	Ø.Ø85	Ø.Ø61	Ø.216	Ø.251	Ø.134	Ø.155
		Ø.Ø41	Ø.Ø38	Ø.Ø56	Ø.Ø15	Ø.Ø32	Ø.117	Ø.126	Ø.576
		Ø.Ø13	Ø.Ø23	Ø.167	Ø.223	Ø.17Ø	Ø.117	Ø.Ø91	Ø.192
	144 S	Ø.Ø33	Ø.Ø48	Ø.Ø19	Ø.275	Ø.Ø11	Ø.ØØØ	Ø.ØØØ	Ø.Ø15
		Ø.ØØØ	Ø.Ø26	Ø.165	Ø.421	Ø.278	Ø.Ø37	Ø.Ø29	Ø.Ø44
		Ø.Ø15	Ø.Ø62	Ø.Ø37	Ø.125	Ø.234	Ø.194	Ø.15Ø	Ø.183
		Ø.Ø29	Ø.Ø37	Ø.Ø15	Ø.Ø37	Ø.117	Ø.114	Ø.121	Ø.531
		Ø.Ø19	Ø.Ø43	Ø.2Ø9	Ø.214	Ø.16Ø	Ø.Ø86	Ø.Ø75	Ø.193
	144 A	Ø.Ø17	Ø.Ø39	Ø.4Ø5	Ø.189	Ø.Ø27	Ø.Ø17	Ø.ØØ3	Ø.ØØ3
		Ø.Ø1Ø	Ø.Ø3Ø	Ø.156	Ø.392	Ø.349	Ø.Ø53	Ø.ØØ7	Ø.ØØ3
		Ø.Ø23	Ø.Ø43	Ø.113	Ø.196	Ø.289	Ø.196	Ø.Ø66	Ø.Ø73
		Ø.Ø63	Ø.Ø56	Ø.Ø66	Ø.Ø6Ø	Ø.136	Ø.179	Ø.Ø76	Ø.362
		Ø.Ø28	Ø.117	Ø.185	Ø.2Ø9	Ø.2ØØ	Ø.111	Ø.Ø38	Ø.11Ø

P(I,J) MATRIX IN RECALL 4 TABLE 35 P. 6

CONDITION	1	2	3	4	5	6	7	8
178 C	0.022	0.026	0.233	0.396	0.195	0.080	0.038	0.010
	0.013	0.003	0.064	0.259	0.335	0.169	0.070	0.086
	0.035	0.019	0.064	0.064	0.201	0.236	0.182	0.198
	0.032	0.019	0.048	0.006	0.054	0.128	0.128	0.585
	0.025	0.017	0.102	0.181	0.196	0.153	0.104	0.220
178 U	0.017	0.035	0.205	0.444	0.163	0.066	0.028	0.042
	0.007	0.007	0.045	0.184	0.448	0.149	0.073	0.087
	0.017	0.024	0.059	0.059	0.146	0.235	0.198	0.212
	0.028	0.028	0.028	0.035	0.058	0.094	0.215	0.535
	0.017	0.024	0.084	0.180	0.199	0.148	0.128	0.219
178 S	0.016	0.037	0.394	0.350	0.119	0.050	0.022	0.013
	0.019	0.012	0.091	0.272	0.375	0.131	0.047	0.053
	0.025	0.041	0.047	0.134	0.181	0.225	0.166	0.181
	0.051	0.037	0.025	0.016	0.075	0.119	0.184	0.513
	0.023	0.032	0.139	0.195	0.187	0.131	0.105	0.190

P(I,J) MATRIX IN RECALL 1 TABLE 36 P. 1

CONDITION		1	2	3	4	5	6	7	8
AA	75 C	Ø.ØØØ	Ø.Ø42	Ø.Ø83	Ø.333	Ø.292	Ø.125	Ø.125	Ø.ØØØ
		Ø.Ø15	Ø.Ø25	Ø.Ø95	Ø.281	Ø.347	Ø.156	Ø.255	Ø.Ø25
		Ø.ØØØ	Ø.Ø18	Ø.Ø96	Ø.275	Ø.281	Ø.156	Ø.Ø78	Ø.Ø9Ø
		Ø.Ø26	Ø.ØØØ	Ø.132	Ø.132	Ø.237	Ø.237	Ø.184	Ø.Ø53
		Ø.Ø12	Ø.Ø21	Ø.1Ø2	Ø.255	Ø.289	Ø.168	Ø.111	Ø.Ø42
	75 D	Ø.ØØØ	Ø.ØØØ	Ø.Ø91	Ø.182	Ø.364	Ø.136	Ø.Ø91	Ø.136
		Ø.Ø11	Ø.Ø16	Ø.Ø8Ø	Ø.276	Ø.294	Ø.214	Ø.Ø86	Ø.Ø21
		Ø.ØØØ	Ø.Ø13	Ø.Ø94	Ø.265	Ø.3Ø6	Ø.165	Ø.Ø83	Ø.Ø65
		Ø.Ø59	Ø.Ø2Ø	Ø.Ø59	Ø.196	Ø.255	Ø.235	Ø.176	Ø.Ø2Ø
		Ø.Ø12	Ø.Ø15	Ø.Ø81	Ø.23Ø	Ø.3Ø5	Ø.188	Ø.11Ø	Ø.Ø61
	75 S	Ø.Ø27	Ø.Ø27	Ø.4Ø5	Ø.297	Ø.162	Ø.Ø81	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ5	Ø.Ø25	Ø.262	Ø.5ØØ	Ø.144	Ø.Ø35	Ø.Ø1Ø	Ø.Ø2Ø
		Ø.Ø16	Ø.Ø3Ø	Ø.2ØØ	Ø.456	Ø.144	Ø.Ø48	Ø.ØØ8	Ø.Ø48
		Ø.ØØØ	Ø.ØØ2	Ø.125	Ø.594	Ø.156	Ø.Ø31	Ø.Ø31	Ø.ØØØ
		Ø.Ø12	Ø.Ø49	Ø.246	Ø.462	Ø.151	Ø.Ø49	Ø.Ø12	Ø.Ø17
	1Ø9 C	Ø.ØØØ	Ø.Ø48	Ø.524	Ø.357	Ø.Ø48	Ø.Ø24	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.Ø16	Ø.484	Ø.368	Ø.Ø85	Ø.Ø31	Ø.ØØ4	Ø.Ø12
		Ø.ØØØ	Ø.Ø3Ø	Ø.36Ø	Ø.455	Ø.Ø79	Ø.Ø59	Ø.ØØØ	Ø.Ø1Ø
		Ø.ØØØ	Ø.ØØØ	Ø.538	Ø.385	Ø.Ø77	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.Ø23	Ø.478	Ø.391	Ø.Ø72	Ø.Ø29	Ø.ØØ1	Ø.ØØ5
	1Ø9 D	Ø.Ø22	Ø.ØØØ	Ø.478	Ø.457	Ø.Ø43	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ4	Ø.Ø3Ø	Ø.275	Ø.547	Ø.Ø93	Ø.Ø34	Ø.ØØ8	Ø.ØØ8
		Ø.ØØØ	Ø.Ø2Ø	Ø.255	Ø.52Ø	Ø.133	Ø.Ø41	Ø.Ø2Ø	Ø.Ø1Ø
		Ø.ØØØ	Ø.ØØØ	Ø.333	Ø.556	Ø.ØØØ	Ø.111	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ6	Ø.Ø13	Ø.336	Ø.52Ø	Ø.Ø67	Ø.Ø46	Ø.ØØ7	Ø.ØØ5
	1Ø9 S	Ø.ØØØ	Ø.Ø51	Ø.78Ø	Ø.153	Ø.Ø17	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ4	Ø.Ø91	Ø.617	Ø.235	Ø.Ø21	Ø.Ø12	Ø.ØØ4	Ø.Ø16
		Ø.ØØØ	Ø.Ø8Ø	Ø.75Ø	Ø.14Ø	Ø.Ø2Ø	Ø.Ø1Ø	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.3ØØ	Ø.2ØØ	Ø.4ØØ	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.1ØØ
		Ø.ØØ1	Ø.15Ø	Ø.587	Ø.232	Ø.Ø14	Ø.ØØ6	Ø.ØØ1	Ø.Ø29

P(I,J) MATRIX IN RECALL 1 TABLE 36 P. 2

CONDITION		1	2	3	4	5	6	7	8
GL	75 C	0.000	0.000	0.000	0.400	0.400	0.200	0.000	0.000
		0.027	0.000	0.009	0.277	0.357	0.143	0.116	0.071
		0.047	0.005	0.026	0.189	0.268	0.242	0.142	0.079
		0.039	0.031	0.055	0.071	0.173	0.346	0.165	0.118
		0.028	0.009	0.023	0.234	0.300	0.233	0.106	0.067
	75 O	0.000	0.000	0.000	0.222	0.333	0.222	0.000	0.222
		0.023	0.008	0.030	0.175	0.383	0.218	0.090	0.075
		0.016	0.021	0.032	0.142	0.332	0.300	0.105	0.053
		0.009	0.047	0.047	0.056	0.196	0.383	0.206	0.056
		0.012	0.019	0.027	0.148	0.311	0.281	0.100	0.102
	75 S	0.000	0.071	0.143	0.571	0.000	0.071	0.071	0.071
		0.036	0.000	0.048	0.448	0.261	0.121	0.024	0.055
		0.011	0.000	0.054	0.352	0.310	0.174	0.087	0.033
		0.038	0.019	0.019	0.264	0.226	0.208	0.151	0.075
		0.021	0.024	0.066	0.404	0.199	0.144	0.083	0.059
	109 C	0.000	0.000	0.500	0.333	0.000	0.000	0.000	0.167
		0.023	0.021	0.343	0.462	0.084	0.028	0.007	0.028
		0.016	0.000	0.246	0.475	0.148	0.071	0.016	0.027
		0.027	0.000	0.093	0.520	0.160	0.080	0.040	0.080
		0.018	0.005	0.295	0.448	0.098	0.045	0.016	0.075
	109 O	0.000	0.067	0.533	0.400	0.000	0.000	0.000	0.000
		0.016	0.011	0.460	0.407	0.058	0.011	0.000	0.037
		0.017	0.017	0.214	0.520	0.139	0.035	0.012	0.046
		0.015	0.015	0.162	0.309	0.324	0.103	0.059	0.015
		0.012	0.027	0.342	0.409	0.130	0.037	0.018	0.024
	109 S	0.061	0.030	0.818	0.061	0.000	0.000	0.000	0.030
		0.023	0.054	0.662	0.176	0.023	0.005	0.005	0.054
		0.036	0.045	0.541	0.207	0.099	0.027	0.009	0.036
		0.057	0.000	0.314	0.514	0.086	0.000	0.000	0.029
		0.044	0.032	0.584	0.239	0.052	0.008	0.003	0.037

P(I,J) MATRIX IN RECALL 1 TABLE 36 P. 3

CONDITION		1	2	3	4	5	6	7	8
AA	109 C	Ø.Ø25	Ø.537	Ø.388	Ø.Ø25	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.Ø25
		Ø.Ø15	Ø.37Ø	Ø.415	Ø.163	Ø.Ø22	Ø.ØØØ	Ø.ØØØ	Ø.Ø15
		Ø.Ø11	Ø.Ø11	Ø.587	Ø.391	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.ØØØ	Ø.216	Ø.568	Ø.162	Ø.ØØØ	Ø.ØØØ	Ø.Ø54
		Ø.Ø13	Ø.23Ø	Ø.4Ø1	Ø.287	Ø.Ø46	Ø.ØØØ	Ø.ØØØ	Ø.Ø23
	109 J	Ø.ØØØ	Ø.515	Ø.394	Ø.Ø15	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.Ø76
		Ø.ØØ7	Ø.365	Ø.412	Ø.176	Ø.Ø14	Ø.ØØ7	Ø.ØØ7	Ø.Ø14
		Ø.ØØØ	Ø.Ø81	Ø.455	Ø.4Ø4	Ø.Ø2Ø	Ø.Ø3Ø	Ø.ØØØ	Ø.Ø1Ø
		Ø.ØØØ	Ø.ØØØ	Ø.231	Ø.577	Ø.Ø77	Ø.115	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ2	Ø.24Ø	Ø.373	Ø.293	Ø.Ø28	Ø.Ø38	Ø.ØØ2	Ø.Ø25
	109 S	Ø.Ø84	Ø.579	Ø.196	Ø.Ø28	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.112
		Ø.Ø52	Ø.441	Ø.344	Ø.133	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.ØØØ	Ø.714	Ø.257	Ø.Ø29	Ø.ØØØ	Ø.ØØØ	Ø.ØØØ
		Ø.ØØØ	Ø.ØØØ	Ø.222	Ø.444	Ø.111	Ø.222	Ø.ØØØ	Ø.ØØØ
		Ø.Ø29	Ø.255	Ø.369	Ø.228	Ø.Ø35	Ø.Ø56	Ø.ØØØ	Ø.Ø28
	144 C	Ø.113	Ø.245	Ø.453	Ø.Ø94	Ø.Ø19	Ø.ØØØ	Ø.Ø19	Ø.Ø57
		Ø.Ø32	Ø.Ø57	Ø.7Ø3	Ø.146	Ø.Ø38	Ø.ØØ6	Ø.ØØ6	Ø.Ø13
		Ø.Ø17	Ø.Ø5Ø	Ø.35Ø	Ø.417	Ø.Ø83	Ø.Ø83	Ø.ØØØ	Ø.ØØØ
		Ø.Ø33	Ø.Ø67	Ø.Ø67	Ø.233	Ø.267	Ø.333	Ø.ØØØ	Ø.ØØØ
		Ø.Ø49	Ø.1Ø5	Ø.393	Ø.222	Ø.1Ø2	Ø.1Ø6	Ø.ØØ6	Ø.Ø17
	144 J	Ø.Ø38	Ø.212	Ø.577	Ø.Ø96	Ø.Ø58	Ø.ØØØ	Ø.ØØØ	Ø.Ø19
		Ø.Ø45	Ø.Ø71	Ø.696	Ø.1Ø9	Ø.Ø49	Ø.Ø16	Ø.ØØØ	Ø.Ø16
		Ø.Ø21	Ø.Ø21	Ø.271	Ø.437	Ø.167	Ø.Ø83	Ø.ØØØ	Ø.ØØØ
		Ø.Ø42	Ø.ØØØ	Ø.Ø83	Ø.Ø83	Ø.25Ø	Ø.25Ø	Ø.125	Ø.167
		Ø.Ø36	Ø.Ø76	Ø.4Ø7	Ø.181	Ø.131	Ø.Ø87	Ø.Ø31	Ø.Ø51
	144 S	Ø.122	Ø.256	Ø.444	Ø.Ø56	Ø.Ø44	Ø.Ø22	Ø.ØØØ	Ø.Ø56
		Ø.Ø57	Ø.14Ø	Ø.586	Ø.153	Ø.Ø13	Ø.Ø38	Ø.ØØØ	Ø.Ø13
		Ø.Ø19	Ø.Ø19	Ø.333	Ø.389	Ø.2Ø4	Ø.ØØØ	Ø.ØØØ	Ø.Ø37
		Ø.ØØØ	Ø.ØØØ	Ø.ØØØ	Ø.286	Ø.357	Ø.214	Ø.143	Ø.ØØØ
		Ø.Ø5Ø	Ø.1Ø4	Ø.341	Ø.221	Ø.155	Ø.Ø69	Ø.Ø36	Ø.Ø26

P'(I,J) MATRIX IN RECALL 4 TABLE 37 P. 1

CONDITION		1	2	3	4	5	6	7	8
AA	75 C	Ø.ØØØ	Ø.Ø28	Ø.139	Ø.318	Ø.277	Ø.Ø69	Ø.Ø37	Ø.ØØØ
		Ø.ØØØ	-Ø.ØØ6	Ø.242	Ø.152	Ø.167	Ø.125	Ø.Ø92	Ø.ØØØ
		Ø.ØØØ	Ø.ØØ3	Ø.Ø29	Ø.Ø73	Ø.Ø71	Ø.Ø71	Ø.Ø88	Ø.ØØØ
		Ø.ØØØ	Ø.Ø24	Ø.Ø44	Ø.Ø85	Ø.Ø77	Ø.Ø81	Ø.135	Ø.ØØØ
		Ø.ØØØ	Ø.Ø12	Ø.Ø64	Ø.157	Ø.148	Ø.Ø87	Ø.Ø88	Ø.ØØØ
	75 J	Ø.ØØØ	Ø.ØØ6	Ø.Ø75	Ø.274	Ø.3ØØ	Ø.145	Ø.Ø59	Ø.ØØØ
		Ø.ØØØ	-Ø.ØØ5	Ø.Ø29	Ø.Ø89	Ø.134	Ø.169	Ø.146	Ø.ØØØ
		Ø.ØØØ	-Ø.ØØ8	Ø.Ø13	Ø.Ø31	Ø.1Ø1	Ø.Ø85	Ø.118	Ø.ØØØ
		Ø.ØØØ	-Ø.ØØ5	Ø.Ø19	Ø.Ø43	Ø.Ø7Ø	Ø.129	Ø.125	Ø.ØØØ
		Ø.ØØØ	-Ø.ØØ3	Ø.Ø34	Ø.122	Ø.151	Ø.152	Ø.112	Ø.ØØØ
	75 S	Ø.ØØØ	Ø.Ø78	Ø.361	Ø.354	Ø.Ø93	Ø.Ø15	Ø.ØØ2	Ø.ØØØ
		Ø.ØØØ	Ø.Ø31	Ø.139	Ø.247	Ø.169	Ø.Ø51	Ø.Ø45	Ø.ØØØ
		Ø.ØØØ	Ø.Ø12	Ø.Ø78	Ø.11Ø	Ø.1Ø5	Ø.122	Ø.Ø52	Ø.ØØØ
		Ø.ØØØ	Ø.Ø28	Ø.Ø69	Ø.Ø97	Ø.Ø75	Ø.Ø66	Ø.Ø78	Ø.ØØØ
		Ø.ØØØ	Ø.Ø57	Ø.162	Ø.2Ø2	Ø.111	Ø.Ø64	Ø.Ø44	Ø.ØØØ
	75 A	Ø.17Ø	Ø.Ø98	Ø.188	Ø.114	Ø.Ø96	Ø.Ø43	Ø.ØØØ	Ø.ØØØ
		Ø.Ø75	Ø.Ø8Ø	Ø.131	Ø.178	Ø.114	Ø.Ø42	Ø.ØØØ	Ø.ØØØ
		Ø.Ø18	Ø.Ø54	Ø.Ø68	Ø.119	Ø.12Ø	Ø.Ø84	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ3	Ø.Ø14	Ø.Ø19	Ø.Ø55	Ø.Ø49	Ø.ØØ1	Ø.ØØØ	Ø.ØØØ
		Ø.Ø66	Ø.Ø56	Ø.1Ø2	Ø.111	Ø.Ø95	Ø.Ø42	Ø.ØØØ	Ø.ØØØ
	1Ø9 C	Ø.ØØØ	Ø.Ø39	Ø.422	Ø.434	Ø.Ø66	Ø.ØØ5	Ø.Ø1Ø	Ø.ØØØ
		Ø.ØØØ	Ø.Ø18	Ø.179	Ø.298	Ø.249	Ø.Ø67	Ø.Ø43	Ø.ØØØ
		Ø.ØØØ	-Ø.Ø18	Ø.Ø4Ø	Ø.Ø86	Ø.244	Ø.156	Ø.124	Ø.ØØØ
		Ø.ØØØ	Ø.ØØ1	Ø.Ø65	Ø.Ø75	Ø.155	Ø.185	Ø.19Ø	Ø.ØØØ
		Ø.ØØØ	Ø.Ø1Ø	Ø.177	Ø.223	Ø.179	Ø.1Ø3	Ø.Ø92	Ø.ØØØ
	1Ø9 J	Ø.ØØØ	Ø.Ø17	Ø.314	Ø.541	Ø.Ø99	Ø.Ø14	Ø.ØØ1	Ø.ØØØ
		Ø.ØØØ	Ø.Ø16	Ø.126	Ø.273	Ø.299	Ø.Ø83	Ø.Ø39	Ø.ØØØ
		Ø.ØØØ	Ø.ØØ2	Ø.Ø41	Ø.Ø52	Ø.21Ø	Ø.213	Ø.177	Ø.ØØØ
		Ø.ØØØ	-Ø.Ø19	Ø.Ø7Ø	Ø.Ø51	Ø.142	Ø.Ø16	Ø.184	Ø.ØØØ
		Ø.ØØØ	Ø.ØØ4	Ø.139	Ø.229	Ø.187	Ø.Ø82	Ø.1ØØ	Ø.ØØØ
	1Ø9 S	Ø.ØØØ	Ø.Ø95	Ø.714	Ø.1ØØ	Ø.Ø18	Ø.ØØ1	Ø.ØØ1	Ø.ØØØ
		Ø.ØØØ	Ø.Ø7Ø	Ø.155	Ø.5ØØ	Ø.Ø94	Ø.Ø47	Ø.Ø11	Ø.ØØØ
		Ø.ØØØ	Ø.Ø2Ø	Ø.Ø49	Ø.114	Ø.251	Ø.183	Ø.111	Ø.ØØØ
		Ø.ØØØ	Ø.Ø25	Ø.Ø46	Ø.Ø64	Ø.197	Ø.181	Ø.169	Ø.ØØØ
		Ø.ØØØ	Ø.Ø55	Ø.241	Ø.2Ø2	Ø.14Ø	Ø.1Ø3	Ø.Ø73	Ø.ØØØ
	1Ø9 A	Ø.Ø53	Ø.122	Ø.378	Ø.342	Ø.Ø61	Ø.Ø14	Ø.ØØØ	Ø.ØØØ
		Ø.Ø35	Ø.Ø63	Ø.182	Ø.33Ø	Ø.256	Ø.Ø39	Ø.ØØØ	Ø.ØØØ
		Ø.ØØ1	Ø.Ø66	Ø.Ø73	Ø.128	Ø.225	Ø.Ø95	Ø.ØØØ	Ø.ØØØ
		Ø.Ø14	Ø.Ø83	Ø.Ø62	Ø.Ø65	Ø.138	Ø.Ø89	Ø.ØØØ	Ø.ØØØ
		Ø.Ø26	Ø.Ø83	Ø.174	Ø.216	Ø.17Ø	Ø.Ø59	Ø.ØØØ	Ø.ØØØ

P(I,J) MATRIX IN RECALL 4 TABLE 37 P. 2

CONDITION	1	2	3	4	5	6	7	8
144 C	0.000	-0.002	0.374	0.489	0.098	0.021	0.001	0.000
	0.000	0.012	0.129	0.316	0.301	0.108	0.054	0.000
	0.000	0.006	0.044	0.047	0.242	0.235	0.221	0.000
	0.000	-0.011	0.039	0.056	0.171	0.198	0.217	0.000
	0.000	0.001	0.146	0.227	0.203	0.141	0.123	0.000
144 U	0.000	-0.006	0.213	0.523	0.149	0.046	0.012	0.000
	0.000	-0.008	0.071	0.198	0.361	0.134	0.087	0.000
	0.000	-0.015	0.016	0.023	0.182	0.238	0.254	0.000
	0.000	-0.019	0.072	0.022	0.128	0.210	0.207	0.000
	0.000	-0.012	0.095	0.193	0.205	0.157	0.140	0.000
144 S	0.000	0.020	0.756	0.194	0.023	0.002	-0.001	0.000
	0.000	0.036	0.096	0.490	0.223	0.070	0.029	0.000
	0.000	0.011	0.026	0.157	0.287	0.275	0.135	0.000
	0.000	0.001	0.026	0.059	0.251	0.265	0.129	0.000
	0.000	0.017	0.226	0.225	0.196	0.153	0.073	0.000
214 C	0.000	0.004	0.482	0.394	0.016	-0.001	-0.009	0.000
	0.000	0.014	0.145	0.422	0.265	0.052	-0.006	0.000
	0.000	0.036	0.057	0.115	0.376	0.291	0.038	0.000
	0.000	0.066	0.056	0.009	0.227	0.262	0.107	0.000
	0.000	0.030	0.185	0.235	0.221	0.151	0.032	0.000
214 U	0.000	0.024	0.333	0.469	0.067	0.016	0.004	0.000
	0.000	0.006	0.126	0.347	0.340	0.076	0.026	0.000
	0.000	0.004	0.038	0.070	0.308	0.318	0.080	0.000
	0.000	0.038	0.103	0.042	0.149	0.254	0.114	0.000
	0.000	0.018	0.150	0.232	0.216	0.166	0.056	0.000
214 S	0.000	0.005	0.745	0.204	0.002	-0.005	0.000	0.000
	0.000	0.022	0.114	0.631	0.141	0.015	0.001	0.000
	0.000	0.030	0.036	0.092	0.528	0.226	0.017	0.000
	0.000	0.031	0.035	0.045	0.233	0.368	0.042	0.000
	0.000	0.022	0.232	0.243	0.226	0.151	0.015	0.000

P'(I,J) MATRIX IN RECALL 4 TABLE 37 P. 3

CONDITION	1	2	3	4	5	6	7	8
UL 75 C	Ø.ØØØ	-Ø.Ø11	Ø.Ø11	Ø.174	Ø.257	Ø.225	Ø.Ø98	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø14	-Ø.ØØ6	Ø.Ø98	Ø.179	Ø.226	Ø.160	Ø.ØØØ
	Ø.ØØØ	Ø.Ø09	-Ø.ØØ6	Ø.Ø54	Ø.113	Ø.127	Ø.121	Ø.ØØØ
	Ø.ØØØ	Ø.Ø24	Ø.ØØ1	Ø.Ø42	Ø.Ø67	Ø.Ø94	Ø.145	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ2	Ø.ØØØ	Ø.Ø92	Ø.154	Ø.168	Ø.131	Ø.ØØØ
75 U	Ø.ØØØ	Ø.ØØ3	Ø.Ø13	Ø.156	Ø.3Ø7	Ø.227	Ø.Ø81	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø13	Ø.Ø17	Ø.Ø93	Ø.178	Ø.233	Ø.196	Ø.ØØØ
	Ø.ØØØ	Ø.Ø11	-Ø.Ø3Ø	Ø.Ø62	Ø.Ø73	Ø.1Ø9	Ø.145	Ø.ØØØ
	Ø.ØØØ	-Ø.ØØ1	Ø.Ø16	Ø.Ø69	Ø.Ø42	Ø.115	Ø.Ø62	Ø.ØØØ
	Ø.ØØØ	Ø.ØØØ	Ø.ØØ4	Ø.Ø95	Ø.15Ø	Ø.171	Ø.121	Ø.ØØØ
75 S	Ø.ØØØ	Ø.ØØ5	Ø.Ø62	Ø.39Ø	Ø.242	Ø.Ø64	Ø.Ø48	Ø.ØØØ
	Ø.ØØØ	Ø.Ø16	Ø.Ø37	Ø.184	Ø.241	Ø.177	Ø.139	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ7	Ø.Ø31	Ø.Ø71	Ø.114	Ø.14Ø	Ø.15Ø	Ø.ØØØ
	Ø.ØØØ	Ø.Ø12	Ø.Ø5Ø	Ø.Ø67	Ø.Ø95	Ø.Ø95	Ø.115	Ø.ØØØ
	Ø.ØØØ	Ø.Ø1Ø	Ø.Ø45	Ø.178	Ø.173	Ø.119	Ø.113	Ø.ØØØ
75 M	Ø.ØØØ	Ø.Ø57	Ø.Ø71	Ø.219	Ø.223	Ø.Ø73	Ø.Ø21	Ø.ØØØ
	Ø.ØØØ	Ø.Ø18	Ø.Ø53	Ø.19Ø	Ø.252	Ø.121	Ø.Ø63	Ø.ØØØ
	Ø.ØØØ	Ø.Ø47	Ø.Ø56	Ø.Ø88	Ø.139	Ø.139	Ø.Ø84	Ø.ØØØ
	Ø.ØØØ	Ø.Ø21	Ø.Ø38	Ø.Ø34	Ø.1Ø3	Ø.Ø88	Ø.Ø78	Ø.ØØØ
	Ø.ØØØ	Ø.Ø36	Ø.Ø54	Ø.133	Ø.179	Ø.1Ø5	Ø.Ø61	Ø.ØØØ
1Ø5 C	Ø.ØØØ	Ø.ØØ2	Ø.3Ø9	Ø.38Ø	Ø.Ø93	Ø.ØØ6	Ø.Ø16	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ4	Ø.171	Ø.3Ø2	Ø.287	Ø.Ø92	Ø.Ø21	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø34	Ø.Ø53	Ø.1Ø6	Ø.173	Ø.172	Ø.156	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø2Ø	Ø.Ø19	Ø.Ø3Ø	Ø.Ø91	Ø.Ø78	Ø.135	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø12	Ø.138	Ø.212	Ø.161	Ø.Ø87	Ø.Ø82	Ø.ØØØ
1Ø5 U	Ø.ØØØ	Ø.ØØ6	Ø.357	Ø.376	Ø.115	Ø.Ø23	-Ø.ØØ6	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ6	Ø.136	Ø.342	Ø.25Ø	Ø.Ø85	Ø.Ø53	Ø.ØØØ
	Ø.ØØØ	Ø.ØØØ	Ø.Ø61	Ø.1Ø6	Ø.251	Ø.172	Ø.132	Ø.ØØØ
	Ø.ØØØ	-Ø.ØØ2	Ø.Ø28	Ø.Ø24	Ø.1ØØ	Ø.14Ø	Ø.113	Ø.ØØØ
	Ø.ØØØ	-Ø.ØØ5	Ø.158	Ø.212	Ø.179	Ø.1Ø5	Ø.Ø73	Ø.ØØØ
1Ø5 S	Ø.ØØØ	Ø.ØØ5	Ø.574	Ø.17Ø	Ø.Ø4Ø	-Ø.ØØ2	-Ø.ØØ7	Ø.ØØØ
	Ø.ØØØ	Ø.Ø12	Ø.197	Ø.4Ø4	Ø.228	Ø.Ø38	-Ø.ØØ9	Ø.ØØØ
	Ø.ØØØ	Ø.ØØØ	Ø.Ø68	Ø.147	Ø.198	Ø.17Ø	Ø.Ø94	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø19	Ø.Ø29	Ø.Ø59	Ø.Ø86	Ø.11Ø	Ø.116	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ7	Ø.217	Ø.195	Ø.138	Ø.Ø79	Ø.Ø48	Ø.ØØØ
1Ø5 M	Ø.ØØØ	Ø.Ø43	Ø.183	Ø.3Ø4	Ø.27Ø	Ø.Ø87	Ø.Ø15	Ø.ØØØ
	Ø.ØØØ	Ø.Ø3Ø	Ø.1Ø8	Ø.245	Ø.3Ø2	Ø.165	Ø.Ø54	Ø.ØØØ
	Ø.ØØØ	-Ø.Ø12	Ø.Ø41	Ø.Ø76	Ø.1Ø8	Ø.117	Ø.Ø93	Ø.ØØØ
	Ø.ØØØ	-Ø.ØØ3	Ø.Ø25	Ø.Ø2Ø	Ø.Ø92	Ø.Ø73	Ø.Ø55	Ø.ØØØ
	Ø.ØØØ	Ø.Ø16	Ø.Ø89	Ø.169	Ø.193	Ø.11Ø	Ø.Ø54	Ø.ØØØ

P(I, J) MATRIX IN RECALL 4 TABLE 37 P. 4

CONDITION	1	2	3	4	5	6	7	8
144 C	Ø.ØØØ	Ø.Ø94	Ø.521	Ø.177	Ø.Ø14	-Ø.Ø12	-Ø.Ø19	Ø.ØØØ
	Ø.ØØØ	Ø.Ø66	Ø.291	Ø.451	Ø.Ø38	Ø.ØØ7	Ø.ØØ1	Ø.ØØØ
	Ø.ØØØ	Ø.Ø1Ø	Ø.Ø61	Ø.151	Ø.348	Ø.1Ø1	Ø.Ø14	Ø.ØØØ
	Ø.ØØØ	Ø.Ø53	Ø.Ø39	Ø.Ø37	Ø.158	Ø.112	Ø.112	Ø.ØØØ
	Ø.ØØØ	Ø.Ø57	Ø.228	Ø.2Ø4	Ø.152	Ø.Ø52	Ø.Ø27	Ø.ØØØ
144 U	Ø.ØØØ	Ø.Ø94	Ø.499	Ø.151	-Ø.Ø1Ø	-Ø.Ø16	-Ø.Ø31	Ø.ØØØ
	Ø.ØØØ	Ø.Ø46	Ø.299	Ø.447	Ø.Ø91	Ø.ØØ3	Ø.ØØØ	Ø.ØØØ
	Ø.ØØØ	Ø.ØØ9	Ø.Ø72	Ø.166	Ø.356	Ø.178	Ø.Ø51	Ø.ØØØ
	Ø.ØØØ	Ø.ØØØ	Ø.ØØ2	Ø.Ø8Ø	Ø.163	Ø.151	Ø.Ø64	Ø.ØØØ
	Ø.ØØØ	Ø.Ø37	Ø.218	Ø.211	Ø.150	Ø.Ø79	Ø.Ø21	Ø.ØØØ
144 S	Ø.ØØØ	Ø.39Ø	Ø.278	Ø.Ø82	-Ø.Ø24	-Ø.Ø33	-Ø.Ø27	Ø.ØØØ
	Ø.ØØØ	Ø.146	Ø.343	Ø.318	Ø.Ø42	-Ø.ØØ5	-Ø.ØØ8	Ø.ØØØ
	Ø.ØØØ	Ø.Ø7Ø	Ø.Ø94	Ø.272	Ø.255	Ø.Ø94	Ø.Ø32	Ø.ØØØ
	Ø.ØØØ	Ø.Ø28	Ø.Ø75	Ø.Ø98	Ø.191	Ø.124	Ø.114	Ø.ØØØ
	Ø.ØØØ	Ø.158	Ø.197	Ø.193	Ø.116	Ø.Ø45	Ø.Ø28	Ø.ØØØ
214 C	Ø.ØØØ	Ø.Ø29	Ø.699	Ø.131	-Ø.ØØ2	-Ø.Ø11	-Ø.Ø14	Ø.ØØØ
	Ø.ØØØ	Ø.Ø24	Ø.192	Ø.7Ø7	Ø.Ø32	-Ø.ØØ1	-Ø.ØØ4	Ø.ØØØ
	Ø.ØØØ	Ø.Ø19	Ø.Ø45	Ø.Ø83	Ø.526	Ø.2Ø4	Ø.Ø24	Ø.ØØØ
	Ø.ØØØ	Ø.Ø4Ø	Ø.ØØ4	Ø.Ø23	Ø.112	Ø.4Ø4	Ø.178	Ø.ØØØ
	Ø.ØØØ	Ø.Ø28	Ø.235	Ø.236	Ø.167	Ø.149	Ø.Ø46	Ø.ØØØ
214 U	Ø.ØØØ	Ø.Ø49	Ø.696	Ø.115	Ø.ØØ4	-Ø.Ø13	-Ø.Ø16	Ø.ØØØ
	Ø.ØØØ	Ø.Ø14	Ø.2Ø7	Ø.672	Ø.Ø69	Ø.Ø16	Ø.ØØØ	Ø.ØØØ
	Ø.ØØØ	Ø.Ø13	Ø.Ø4Ø	Ø.Ø97	Ø.486	Ø.152	Ø.Ø53	Ø.ØØØ
	Ø.ØØØ	Ø.Ø23	Ø.ØØ5	Ø.Ø2Ø	Ø.129	Ø.417	Ø.143	Ø.ØØØ
	Ø.ØØØ	Ø.Ø26	Ø.237	Ø.226	Ø.172	Ø.143	Ø.Ø45	Ø.ØØØ
214 S	Ø.ØØØ	Ø.Ø91	Ø.675	Ø.Ø58	-Ø.Ø14	-Ø.Ø14	-Ø.ØØ1	Ø.ØØØ
	Ø.ØØØ	Ø.Ø35	Ø.292	Ø.587	Ø.Ø32	Ø.ØØ2	Ø.ØØØ	Ø.ØØØ
	Ø.ØØØ	Ø.Ø21	Ø.Ø22	Ø.171	Ø.499	Ø.141	Ø.Ø41	Ø.ØØØ
	Ø.ØØØ	-Ø.ØØ1	Ø.ØØ4	Ø.Ø76	Ø.219	Ø.447	Ø.Ø56	Ø.ØØØ
	Ø.ØØØ	Ø.Ø35	Ø.248	Ø.223	Ø.184	Ø.144	Ø.Ø24	Ø.ØØØ

P'(I,J) MATRIX IN RECALL 4 TABLE 37 P. 5

CONDITION		1	2	3	4	5	6	7	8
AA	169 C	0.000	0.074	0.327	0.305	0.134	0.032	0.010	0.000
		0.000	0.030	0.121	0.300	0.200	0.121	0.034	0.000
		0.000	0.030	0.043	0.115	0.190	0.166	0.102	0.000
		0.000	0.050	0.000	0.025	0.072	0.110	0.093	0.000
		0.000	0.046	0.125	0.186	0.149	0.107	0.060	0.000
	169 D	0.000	0.027	0.274	0.360	0.125	0.062	0.009	0.000
		0.000	0.031	0.139	0.284	0.217	0.086	0.060	0.000
		0.000	0.031	0.050	0.107	0.173	0.168	0.139	0.000
		0.000	0.043	0.000	0.024	0.030	0.126	0.048	0.000
		0.000	0.035	0.116	0.199	0.149	0.111	0.064	0.000
	169 S	0.000	0.211	0.442	0.205	0.037	0.002	0.002	0.000
		0.000	0.057	0.168	0.291	0.157	0.094	0.037	0.000
		0.000	0.041	0.060	0.151	0.175	0.114	0.061	0.000
		0.000	0.022	0.042	0.038	0.071	0.082	0.102	0.000
		0.000	0.080	0.178	0.171	0.110	0.073	0.050	0.000
	169 R	0.000	0.019	0.237	0.221	0.289	0.117	0.019	0.000
		0.000	-0.015	0.011	0.044	0.248	0.237	0.230	0.000
		0.000	0.015	-0.004	0.014	0.044	0.141	0.135	0.000
		0.000	0.000	-0.023	-0.005	-0.003	0.081	0.084	0.000
		0.000	0.005	0.055	0.068	0.144	0.144	0.117	0.000
	144 C	0.000	0.024	0.427	0.445	0.048	0.004	0.001	0.000
		0.000	-0.001	0.175	0.402	0.272	0.064	0.028	0.000
		0.000	0.010	0.044	0.065	0.245	0.178	0.133	0.000
		0.000	0.000	-0.013	0.004	0.017	0.025	0.006	0.000
		0.000	0.008	0.158	0.229	0.146	0.068	0.042	0.000
	144 D	0.000	0.011	0.390	0.469	0.074	0.003	0.000	0.000
		0.000	0.003	0.129	0.348	0.337	0.086	0.038	0.000
		0.000	-0.018	0.065	0.049	0.198	0.216	0.139	0.000
		0.000	0.018	0.010	0.002	-0.019	0.023	0.013	0.000
		0.000	0.003	0.148	0.217	0.148	0.082	0.047	0.000
	144 S	0.000	0.042	0.610	0.262	-0.001	-0.011	-0.011	0.000
		0.000	0.021	0.166	0.419	0.255	0.040	0.016	0.000
		0.000	0.010	0.015	0.115	0.224	0.139	0.104	0.000
		0.000	-0.091	-0.005	0.012	0.039	-0.008	0.003	0.000
		0.000	-0.003	0.197	0.201	0.129	0.040	0.028	0.000
	144 R	0.000	0.304	0.400	0.164	0.022	0.012	-0.002	0.000
		0.000	0.029	0.155	0.391	0.348	0.049	0.000	0.000
		0.000	0.023	0.105	0.190	0.277	0.173	0.042	0.000
		0.000	-0.019	0.059	0.036	0.098	0.100	-0.025	0.000
		0.000	0.092	0.175	0.200	0.186	0.083	0.004	0.000

P(I,J) MATRIX IN RECALL 4 TABLE 37 P. 6

CONDITION	1	2	3	4	5	6	7	8
178 c	0.000	0.018	0.225	0.388	0.187	0.072	0.030	0.000
	0.000	-0.023	0.340	0.241	0.318	0.151	0.048	0.000
	0.000	0.023	0.005	0.022	0.166	0.196	0.136	0.000
	0.000	0.000	-0.045	-0.046	0.028	0.065	0.040	0.000
	0.000	0.004	0.056	0.151	0.175	0.121	0.064	0.000
178 d	0.000	0.020	0.190	0.430	0.148	0.051	0.013	0.000
	0.000	-0.018	0.017	0.162	0.433	0.129	0.052	0.000
	0.000	-0.056	-0.001	0.018	0.110	0.250	0.155	0.000
	0.000	0.056	-0.078	-0.017	0.011	0.032	0.140	0.000
	0.000	0.000	0.052	0.148	0.176	0.115	0.090	0.000
178 s	0.000	0.030	0.387	0.343	0.112	0.043	0.015	0.000
	0.000	-0.005	0.076	0.258	0.364	0.114	0.031	0.000
	0.000	-0.015	0.006	0.115	0.162	0.137	0.122	0.000
	0.000	0.015	-0.054	-0.024	0.019	0.034	0.087	0.000
	0.000	0.006	0.104	0.173	0.164	0.094	0.064	0.000

CORRECTNESS OF ORDER IN RECALL 4 AND RECALL 1 TABLE 38

PANEL A. C, D AND M BY CONDITION.**

S	CONDITION		RECALL 4	RECALL 1	
	SOA	CC	C	D	M
AR	75	C	.608	.157	.361
		U	.589	.158	.116
		S	.652	.171	.028
	109	C	.742	.124	.006
		U	.733	.155	.390
		S	.779	.292	.003
GL	75	C	.531	.207	.048
		U	.536	.180	.050
		S	.586	.234	.092
	109	C	.700	.193	.089
		U	.726	.225	.115
		S	.753	.224	.068
AK	109	C	.666	.326	.152
		U	.673	.276	.162
		S	.716	.423	.214
	144	C	.813	.395	.191
		U	.807	.410	.218
		S	.824	.406	.253

PANEL B. CORRELATION OF C WITH D AND C WITH M.

S	$r_{C,D}$	$T_{C,D}$	$r_{C,M}$	$T_{C,M}$
AR	.447	.999	-.398	.867
GL	.385	.834	.622	1.587
AK	.406	2.146*	.785	2.531*

* One-tailed T test of r, with significance level of 5%.

** C is Concordance in Recall 4 (Table 30)
D is the mean of the D(j,j+1) given in Table 34 Panel A, for j=1,2,3.
M is p_I (4) - p_I (1) from Table 33 Panel A.

WITHIN-TRIAL ERGODICITY IN RECALL 4 TABLE 39

PANEL A PROBABILITY OF A +VE. SET RESPONSE OVER TRIAL QUADRANTS.

CONDITION		QUADRANT 1	2	3	4
AR	75	.810	.832	.829	.821
	109	.920	.910	.878	.908
	144	.912	.942	.915	.959
	214	.960	.971	.969	.927
	Mean	.901	.914	.898	.904
GL	75	.840	.853	.832	.851
	109	.871	.875	.879	.879
	144	.889	.907	.912	.900
	214	.960	.949	.953	.970
	Mean	.890	.896	.894	.900
AK	109	.871	.869	.875	.889
	144	.820	.811	.813	.812
	178	.788	.795	.781	.800
	Mean	.826	.825	.823	.834

PANEL B MEAN CONCORDANCE IN THE +VE SET OVER TRIAL QUADRANTS

AR	75	.576	.608	.513	.595
	109	.750	.745	.745	.729
	144	.737	.746	.755	.749
	214	.772	.757	.782	.763
	Mean	.709	.714	.699	.709
GL	75	.470	.481	.507	.489
	109	.717	.724	.726	.652
	144	.761	.782	.791	.747
	214	.833	.863	.850	.879
	Mean	.695	.712	.719	.692
AK	109	.652	.656	.663	.621
	144	.748	.753	.742	.749
	178	.779	.788	.759	.753
	Mean	.726	.732	.721	.708

DIGIT AND LETTER SOAs — TABLE 40

CONDITION		MEAN SOA ø		CYLE PATTERN#		PHASE*	SOA_1		SOA_2	
S	SOA	L ø	D	L	D		L	D	L	D
AR/ GL	75	224.0	74.7	1	1,2,2	3/1	224	78	-	73
	109	219.0	109.5	1	1,2	2/1	219	112	-	107
	144	216.5.	144.3	1,2	1,1,2	3/2	219	146	214	141
	214	214.0	214.0	1	1	1/1	214	214	-	-
AK	109	272.5	109.0	1,2	1,2,1,2,2	5/2	275	112	270	107
	144	270.0	143.7	1	1,(1,2)	15/8	270	146	265	141
	178	267.5	178.3	1,2	1,1,2	3/2	270	180	265	175

Notes. ø L and D refer to letters and digits.

\# The cycle pattern gives the order of SOA durations in one cycle. Thus 1,2 means SOA_1 followed by SOA_2. The notation 1, (1,2) for AK at 144 msec means that after SOA_1, SOA_1 and SOA_2 alternate throughout the 15 digit cycle.

* The phase relationship is the number of digits presented/ the number of letters presented in one cycle. At the start of each cycle, a letter and a digit are presented simultaneously.

ø The mean SOA is the mean over one cycle. This mean differs slightly from the mean SOA over the 7 positions of the positive set of digits.

SEQUENCE DURATION* — TABLE 41

CONDITION		T(Max)	$\bar{T}$	T(Min)
S	SOA L			
AR/GL	214	6.970	4.334	2.800
AK	270	8.360	5.118	3.248

*Time for presentation of the trial sequence excluding feedback, in secs.

$\underline{T}(Max) = Max(RT) + SOA.Max(CC_p) + 910$ in msec.
$\bar{T} = Mean(RT) + SOA.Mean(CC_p) + 910$
$T(Min) = Min(RT) + SOA.Min(CC_p) + 910$

where Max(RT) = 1870 msec., Min(RT) = 170 msec., 910 is the time from RT to the end of the sequence, and CC_p is the position of CC in the letter sequence.
All these quantities are experimentally determined except for the mean RT, which is 428 msec. over Ss and conditions.

OPTIMAL WINDOW SIZE IN RECALL 4. TABLE 42

Table of the first and last positions used in computing P'^{*}_{i}.

S	SOA	i_o	CC			
			C	U	S	A
AR	75	1	2,7*	2,7	2,7	1,7
	109	0	2,7	2,7	2,7	1,7
	144	-1	2,7	2,7	1,7	
	214	-2	1,7	1,7	1,7	
GL	75	1	2,7	3,7	2,7	1,7
	109	0	2,7	2,7	2,7	2,7
	144	-1	1,7	1,7	1,7	
	214	-2	1,7	1,7	1,7	
AK	109	1	1,7	2,7	1,7	3,7
	144	-1	3,7	3,7	3,7	2,7
	178	-2	3,7	3,7	3,7	

* Positions in the positive set. To obtain the true positions relative to CC, add i_o.

TABLE OF POSITIVE SET POSITIONS. TABLE 43.

CONDITIONS	i_o	PANEL A: TRUE POSITIONS.*										
		-2	-1	0	1	2	3	4	5	6	7	8
**												
TYPE a	1					1	2	3	4	5	6	7
TYPE b	0				1	2	3	4	5	6	7	
TYPE c	-1			1	2	3	4	5	6	7		
TYPE d	-2		1	2	3	4	5	6	7			

TYPE	i_o	S	PANEL B: TYPES AND CONDITIONS. C,U,S CONDITIONS	A CONDITIONS.
TYPE a	1	AR	75 Msec	
		GL	75 Msec	
		AK	109 Msec	
TYPE b	0	AR	109 Msec	
		GL	109 Msec	75 Msec
		AK		
TYPE c	-1	AR	144 Msec	75 Msec ***
		GL	144 Msec	
		AK	144 Msec	
TYPE d	-2	AR	214 Msec	109 Msec
		GL	214 Msec	109 Msec
		AK	178 Msec	109 And 144 Msec

* Positive set positions are entered into the Table. To obtain the true position relative to CC, add i_o.

** This designation of 'TYPES' is used in this Table only, for typographic convenience. Types are discriminated by SOA and by type of CC (A or C,U,S), but not by Recall task or by individual CC (C, U, or S) in the C,U, and S conditions.

*** In a subsiduary experiment, AR was run in Recall 1 with the arrow (A): in this experiment, the trials were type d.

REACTION TIMES: UNCORRECTED FOR ORDER. TABLE 44

S	CONDITION SOA	CC	RECALL 4 MEAN	MED	SD	r_1	r_e	RECALL 1 MEAN	MED	SD	$r_1 = r_e$
AR	75	C	496	486	63	.13	-.01	473	469	95	.05
		U	510	503	72	.25	.08	482	486	90	.02
		S	453	440	64	.16	.08	424	426	87	-.13
		A	411	410	83	-.26	-.11	299	290	48	.15
	109	C	436	426	86	.13	.01	436	426	73	.10
		U	434	424	77	.10	-.01	444	436	70	.12
		S	392	392	67	-.13	-.21	406	401	72	-.08
		A	313	310	49	.12	.14	313	307	56	.07
	144	C	511	503	85	.33	.32				
		U	545	520	103	.58	.22				
		S	464	452	72	.13	.10				
	214	C	509	486	122	.26	.29				
		U	539	503	140	.46	.30				
		S	462	452	93	.12	.20				
GL	75	C	367	358	45	.06	-.10	391	384	48	.13
		U	371	367	59	-.06	-.04	401	392	86	.05
		S	324	316	39	.14	-.05	360	350	85	.05
		A	259	265	43	.11	.08				
	109	C	385	384	54	.16	.05	389	384	50	.13
		U	393	384	53	.16	-.03	391	384	49	.20
		S	340	333	45	.17	.12	345	333	47	.12
		A	265	265	44	.16	.02				
	144	C	393	392	45	.12	.11				
		U	406	401	56	.02	.10				
		S	346	341	48	.17	.13				
	214	C	392	392	46	.06	.07				
		U	401	392	57	.01	-.02				
		S	352	341	52	.02	.08				
AK	109	C	458	426	85	.30	.09	413	409	42	.34
		U	466	443	87	.16	-.11	420	418	40	.31
		S	428	401	95	.31	.27	389	384	36	.26
		A	318	316	47	.22	.06				
	144	C	432	426	53	.41	.24	489	452	135	.26
		U	438	435	53	.36	.10	483	443	100	.51
		S	414	409	63	.08	.13	455	418	109	.43
		A	324	316	48	.27	.15				
	178	C	469	443	90	.55	.31				
		U	472	452	91	.46	.25				
		S	430	418	61	.27	.25				

r_1 = correlation between RT and the stimulus in the first response.

r_e = correlation between RT and the earliest stimulus in the response.

RT BY SESSIONS OF 100 TRIALS (Approx). **TABLE 45**

Table gives average RT over 300 trials, 100 trials each of C,U, and S.

S	SOA	RECALL 4				RECALL 1			
	SESSION	1	2	3	4	1	2	3	4
AR	75	494	504	474	474	484	490	484	383
	109	480	468	373*	360*	467	456	406	384
	144	505	531	489	502				
	214	580	486	473	475				
	Mean (All)	515	497	452	453	476	473	445	384
	Mean (not*)	515	497	479	484	476	473	445	384
GL	75	362	359	345	352	355	378	417	389
	109	405	340	365	381	364	381	389	366
	144	415	370	371	370				
	214	410	370	374	375				
	Mean (All)	398	360	364	370	360	380	403	378
AK	109	534*	412	406		404	405	414	
	144	433	427	426		577*	418	430	
	178	507*	420	444					
	Mean(All)	491	420	425		491	412	422	
	Mean(not*)	433	420	425		404	412	422	

REACTION TIME DISTRIBUTIONS IN RECALL 4 TABLE 46 P.1

S	SOA	CC	150	200	250	300	350	400	450	500	550	600
AK	75	C	0.002	0.002	0.005	0.027	0.188	0.285	0.295	0.140	0.034	0.021
	75	D	0.002	0.000	0.000	0.012	0.162	0.248	0.319	0.164	0.077	0.017
	75	S	0.000	0.000	0.015	0.120	0.405	0.241	0.139	0.044	0.032	0.004
	75	A	0.013	0.199	0.407	0.282	0.072	0.016	0.007	0.000	0.000	0.000
	109	C	0.002	0.024	0.141	0.175	0.231	0.170	0.180	0.049	0.012	0.016
	109	D	0.000	0.023	0.096	0.230	0.225	0.207	0.158	0.041	0.013	0.008
	109	S	0.000	0.075	0.221	0.212	0.316	0.097	0.068	0.012	0.000	0.000
	109	A	0.130	0.667	0.188	0.015	0.000	0.000	0.000	0.000	0.000	0.000
	144	C	0.003	0.005	0.005	0.030	0.085	0.293	0.308	0.158	0.063	0.051
	144	D	0.000	0.003	0.000	0.008	0.077	0.258	0.284	0.147	0.088	0.136
	144	S	0.007	0.005	0.009	0.077	0.318	0.329	0.151	0.067	0.023	0.013
	214	C	0.005	0.000	0.018	0.086	0.184	0.237	0.191	0.118	0.058	0.104
	214	D	0.000	0.005	0.015	0.065	0.128	0.226	0.196	0.128	0.085	0.150
	214	S	0.005	0.014	0.046	0.142	0.216	0.286	0.166	0.050	0.036	0.039
GL	75	C	0.002	0.029	0.259	0.498	0.181	0.018	0.004	0.002	0.004	0.002
	75	D	0.005	0.032	0.195	0.563	0.183	0.020	0.002	0.000	0.000	0.000
	75	S	0.014	0.290	0.449	0.207	0.036	0.002	0.000	0.000	0.002	0.000
	75	A	0.475	0.375	0.125	0.020	0.002	0.002	0.000	0.000	0.000	0.000
	109	C	0.007	0.005	0.141	0.446	0.268	0.075	0.014	0.007	0.002	0.005
	109	D	0.005	0.007	0.137	0.424	0.325	0.076	0.019	0.002	0.000	0.004
	109	S	0.012	0.203	0.353	0.326	0.083	0.022	0.000	0.000	0.000	0.000
	109	A	0.420	0.410	0.133	0.027	0.007	0.000	0.000	0.000	0.002	0.000
	144	C	0.000	0.007	0.107	0.450	0.353	0.063	0.017	0.000	0.000	0.003
	144	D	0.000	0.018	0.084	0.359	0.386	0.087	0.036	0.021	0.009	0.000
	144	S	0.012	0.118	0.417	0.355	0.078	0.009	0.003	0.003	0.000	0.003
	214	C	0.000	0.012	0.130	0.405	0.356	0.069	0.027	0.000	0.000	0.000
	214	D	0.000	0.014	0.121	0.374	0.343	0.090	0.038	0.007	0.014	0.000
	214	S	0.016	0.111	0.374	0.325	0.134	0.033	0.000	0.000	0.007	0.000
MK	109	C	0.000	0.003	0.040	0.233	0.267	0.137	0.140	0.093	0.071	0.015
	109	D	0.000	0.000	0.014	0.148	0.364	0.173	0.159	0.088	0.032	0.021
	109	S	0.000	0.006	0.140	0.312	0.224	0.090	0.121	0.056	0.034	0.015
	109	A	0.045	0.338	0.373	0.188	0.049	0.006	0.000	0.000	0.000	0.000
	144	C	0.000	0.000	0.056	0.202	0.458	0.208	0.056	0.011	0.006	0.003
	144	D	0.000	0.000	0.011	0.172	0.448	0.281	0.066	0.013	0.005	0.003
	144	S	0.000	0.003	0.040	0.336	0.462	0.120	0.020	0.013	0.000	0.007
	144	A	0.027	0.375	0.276	0.236	0.083	0.000	0.003	0.000	0.000	0.000
	178	C	0.000	0.000	0.003	0.157	0.345	0.252	0.096	0.058	0.035	0.055
	178	D	0.000	0.000	0.007	0.146	0.337	0.219	0.128	0.062	0.056	0.045
	178	S	0.000	0.003	0.019	0.250	0.437	0.181	0.075	0.009	0.009	0.015

REACTION TIME DISTRIBUTIONS IN RECALL 1 TABLE 46 P.2

S	SOA	CC	150	200	250	300	350	400	450	500	550	600+
AA	75	C	0.002	0.014	0.034	0.096	0.206	0.192	0.220	0.110	0.035	0.043
	75	U	0.002	0.002	0.074	0.107	0.137	0.226	0.235	0.133	0.058	0.026
	75	S	0.010	0.038	0.111	0.116	0.238	0.207	0.114	0.033	0.023	0.011
	109	C	0.000	0.014	0.082	0.196	0.314	0.198	0.133	0.036	0.019	0.007
	109	U	0.000	0.010	0.064	0.168	0.325	0.204	0.160	0.046	0.021	0.003
	109	S	0.000	0.022	0.199	0.259	0.271	0.131	0.075	0.034	0.005	0.004
BB	75	C	0.000	0.010	0.113	0.454	0.309	0.085	0.014	0.009	0.000	0.000
	75	U	0.000	0.011	0.075	0.474	0.349	0.059	0.021	0.007	0.000	0.007
	75	S	0.002	0.125	0.361	0.359	0.106	0.038	0.014	0.002	0.002	0.010
	109	C	0.000	0.005	0.145	0.490	0.281	0.049	0.015	0.000	0.012	0.002
	109	U	0.002	0.009	0.128	0.464	0.298	0.070	0.022	0.004	0.000	0.002
	109	S	0.000	0.157	0.486	0.254	0.092	0.017	0.005	0.005	0.002	0.000
AA	109	C	0.000	0.000	0.049	0.299	0.474	0.145	0.029	0.003	0.000	0.000
	109	U	0.000	0.000	0.018	0.251	0.528	0.159	0.038	0.006	0.000	0.000
	109	S	0.000	0.004	0.090	0.533	0.324	0.037	0.012	0.000	0.000	0.000
	144	C	0.000	0.003	0.003	0.140	0.312	0.203	0.106	0.086	0.086	0.060
	144	U	0.000	0.000	0.013	0.127	0.370	0.162	0.075	0.078	0.084	0.090
	144	S	0.003	0.000	0.054	0.302	0.254	0.108	0.083	0.105	0.038	0.054

TABLE 47 p.1

REACTION TIME MEANS

PANEL A: MEANS, NOT CORRECTED FOR SESSION (All the data).

S	SOA	RECALL 4				RECALL 1			
		C	U	S	Mean	C	U	S	Mean
AR	75	496	510	453	486	473	482	424	460
	109	436	434	392	421	436	444	406	429
	144	511	545	464	507				
	214	509	539	462	503				
	Mean	488	507	442	479	454	463	415	444
GL	75	367	371	324	354	391	401	360	384
	109	385	393	340	372	389	391	345	375
	144	393	406	346	382				
	214	392	401	352	382				
	Mean	384	393	340	373	390	396	353	380
AK	109	458	466	428	451	413	420	389	407
	144	432	438	414	428	489	483	455	476
	178	469	472	430	457				
	Mean	453	459	424	445	451	452	422	442

PANEL B: MAIN EFFECTS, NOT CORRECTED FOR SESSION (All the data)

S	MAIN EFFECT OF LETTER= E(Letter). RECALL 4			RECALL 1		
	C	U	S	C	U	S
AR	9	28	-37	10	19	-29
GL	11	21	-33	10	16	-27
AK	8	14	-21	9	10	-20

	MAIN EFFECT OF SOA= E(SOA).						
	75	109	144	178/214	75	109	144
AR	7	-58	28	24	16	-15	
GL	-19	-1	9	9	4	-5	
AK		6	-17	12		-35	34

	GRAND MEAN = G.M.	
AR	479	444
GL	373	380
AK	445	442

TABLE 47 p.2

PANEL C: MEANS, CORRECTED FOR SESSION.

S	SOA	RECALL 4				RECALL 1			
		C	U	S	Mean	C	U	S	Mean
AR	75	496	510	453	486	473	482	424	460
	109	489	492	440	474	470	474	442	462
	144	511	545	464	507				
	214	509	539	462	503				
	Mean	501	522	455	493	472	478	433	461
GL	75	367	371	324	354	391	401	360	384
	109	385	393	340	372	389	391	345	375
	144	393	406	346	382				
	214	392	401	352	382				
	Mean	384	393	340	373	390	396	353	380
AK	109	410	437	380	409	413	420	389	407
	144	432	438	414	428	430	442	400	424
	178	432	449	416	432				
	Mean	425	441	403	423	422	431	395	416

PANEL D: MAIN EFFECTS, CORRECTED FOR SESSION.

	MAIN EFFECT OF LETTER					
	C	U	S	C	U	S
AR	**9**	**29**	**-38**	11	17	-28
GL	**12**	21	-33	**11**	16	-27
AK	2	18	-20	**6**	15	-21
	MAIN EFFECT OF SOA					
	75	109	144	178/214	75	109	144
AR	-7	**-19**	**15**	**11**	-1	1	
GL	-19	-1	**10**	**10**	**5**	-5	
AK		-14	**5**	**9**		-9	**9**

NORMAL FIT TO RT DATA RECALL 4 AND 1. TABLE 48

75 MSEC. BINS. D = DATA MEAN - FITTED MEAN. Chi^2 for least squares fit.

PANEL A: RECALL 4.

CONDITION		C			U			S			A		
S	SOA	D	CHI^2	df	D	CHI^2	df	D	CHI^2	df	D	CHI^2	df
AR	75	2	2.18	3	1	13.	2	2	14.9	4	1	2.45	5
	109	1	17.4	5	1	7.0	5	2	14.1	4	0	0.07	3
	144	2	3.0	5	2	24.9	4	1	1.80	4	2	18.4	5
	214	2	18.4	5	2	22.4	5	2	22.4	5			
GL	75	1	0.53	2	1	0.45	2	2	0.49	2	2	0.01	2
	109	1	0.31	2	2	0.25	4	1	0.24	3	0	0.01	2
	144	2	0.25	2	1	2.04	2	1	0.12	3			
	214	0	0.10	2	2	1.28	3	2	0.42	3			
AK	109	2	58.3	5	2	44.2	5	2	35.3	1	2	0.20	3
	144	2	0.61	3	2	1.29	3	2	0.32	2	2	0.98	3
	178	2	25.9	4	2	23.8	4	1	1.11	3			
PANEL B: RECALL 1.													
AR	75	2	2.94	6	1	6.40	6	2	11.2	5			
	109	1	11.0	5	0	5.06	5	1	19.5	5			
GL	75	1	0.09	2	1	0.58	2	2	13.2	3			
	109	0	0.62	2	1	0.81	2	2	4.65	1			
AK	109	1	0.13	3	2	0.19	2	2	0.35	2			
	144	2	69.7	6	2	60.9	6	2	73.3	5			

$\overline{RT}|i$ * SUBJECT: A.R. CONDITION: RECALL 1 TABLE 49 p.1

CONDITION		i							
SOA	CC	1	2	3	4	5	6	7	N**
75	C	549 ɣ	443	513	462	446	488	495	521
		5	9	42	115	132	69	34	22
	U	544	530	482	483	472	465	513	515
		4	7	36	111	128	83	42	19
	S	454	466	447	420	380	411	532	439
		4	18	97	188	58	17	4	10
	A	293	290	293	294	289	304	315	314
		16	22	22	83	105	99	53	26
109	C	0	439	431	433	463	470	520	427
		0	9	191	161	33	15	1	4
	U	446	445	438	443	449	481	458	531
		2	9	115	205	37	13	4	3
	S	325	433	407	387	451	454	367	374
		1	36	274	84	8	4	1	5
	A	326	298	308	313	328	320	336	308
		15	32	135	146	63	6	3	11

* $RT|i$ = Mean RT, conditional on R(i), where i is a Positive Set position.

** Responses from the Negative set of stimulus positions.

ɣ Table entries are the mean conditioned RT above, and the number of trials in which R(i) occured below; this is the number of trials over which $\overline{RT}|i$ is averaged.

$\overline{RT}|i$ *. SUBJECT: G.L. CONDITION: RECALL 1 TABLE 49 p.2

CONDITION		i							
SOA	CC	1	2	3	4	5	6	7	N**
75	C	394 ✓	444	406	377	380	389	418	405
		17	5	13	78	115	107	61	38
	U	416	466	393	386	386	407	422	409
		7	10	15	58	138	129	54	28
	S	337	336	363	352	372	352	383	350
		10	3	21	157	112	64	29	20
109	C	420	412	375	388	394	407	450	396
		9	3	104	193	51	23	7	16
	U	397	386	382	387	401	447	419	413
		7	7	143	195	57	15	6	16
	S	354	342	337	355	398	384	337	343
		13	18	245	82	19	4	2	18

* $\overline{RT}|i$ = Mean RT, conditional on R(i), where i is a Positive set position.

** Responses from the Negative set of stimulus positions.

✓ Table entries are the mean conditioned RT above, and the number of trials in which R(i) occured below; this is the number of trials over which $\overline{RT}|i$ is averaged.

$\overline{RT}$ i* SUBJECT: A.K. CONDITION: RECALL 1 TABLE 49 p.3

CONDITION		i							
SOA	CC	1	2	3	4	5	6	7	N*
109	C	425	396	405	439	461	0	0	438
		5	94	149	81	9	0	0	6
	U	410	406	413	442	444	462	418	434
		1	96	138	82	6	7	1	8
	S	366	379	392	414	435	503	0	389
		12	103	80	33	2	2	0	12
144	C	627	451	452	483	557	695	699	571
		13	27	158	60	20	16	2	5
	U	518	431	445	507	595	643	569	624
		12	25	173	48	26	13	3	8
	S	446	407	417	496	614	574	784	495
		21	46	150	54	22	11	2	9

* Defined on page 1 of Table.

$\overline{RT}|e$*. SUBJECT: A.R. CONDITION: RECALL 4. TABLE 49 p.4

CONDITION		e						
SOA	CC	1 **	2	3	4	5	6	7
75	C	491	503	497	488	501	571	0
		63	90	129	101	30	1	0
	U	525	506	489	506	531	583	0
		60	85	103	112	54	13	0
	S	449	446	458	456	437	562	0
		57	124	171	52	4	2	0
	A	448	423	397	392	396	379	0
		89	57	97	64	56	32	0
109	C	451	447	426	452	500	0	0
		24	59	246	79	4	0	0
	U	435	447	428	436	461	0	0
		25	49	197	112	4	0	0
	S	391	420	380	354	0		
		26	120	256	9	0		
	A	306	303	315	334	336		
		98	135	135	35	3		
144	C	498	483	528	530	683	843	0
		26	35	222	104	10	2	0
	U	592	528	511	542	666	708	0
		25	27	162	132	38	4	0
	S	448	449	466	475	0		
		32	52	316	31	0		
214	C	479	470	505	563	811	571	0
		42	72	222	53	7	1	0
	U	525	505	512	587	815	828	1149
		59	56	187	85	8	1	2
	S	425	448	465	540	0		
		42	55	298	21	0		

* $\overline{RT}|e$ = Mean RT, conditional on e = EP = Min(R), where e is a Positive Set position.

** Table entries are the mean conditioned RT above, and the number of trials in which e=EP occured below; this is the number of trials over which $\overline{RT}|e$ is averaged.

RTie.* SUBJECT: G.L. CONDITION: RECALL 4 TABLE 49 p.5.

CONDITION		e						
SOA	CC	1	2	3	4	5	6	7
75	C	374 *	376	364	361	362	374	0
		95	82	73	117	74	7	0
	U	381	370	362	365	380	379	0
		96	75	69	111	49	11	0
	S	327	327	321	321	329	0	
		86	77	92	143	23	0	
	A	260	253	253	266	277	214	0
		99	114	100	101	25	1	0
109	C	387	404	375	394	412	567	0
		54	50	223	91	6	2	0
	U	404	402	386	396	461	0	
		44	52	244	77	5	0	
	S	340	327	340	375	0		
		52	63	269	24	0		
	A	269	263	265	262	279	0	
		58	81	128	103	35	0	
144	C	399	379	398	429	418	0	
		52	93	145	9	1	0	
	U	407	392	412	425	0		
		56	90	174	14	0		
	S	345	339	363	367	342	0	
		58	190	70	2	1	0	
214	C	390	389	392	495	0		
		50	48	229	4	0		
	U	399	412	399	439	0		
		33	41	213	2	0		
	S	343	351	355	0			
		46	53	206	0			

* Defined on page 4 of Table.

$\overline{RT}|e^*$ SUBJECT: A.K. CONDITION RECALL 4 TABLE 49 p.6.

CONDITION		e						
		1	2	3	4	5	6	7
109	C	472*	450	437	473	533	573	0
		56	93	97	59	16	1	0
	U	524	463	442	459	540	0	
		38	76	101	57	11	0	
	S	424	398	445	486	622	560	0
		57	125	111	23	2	3	0
	A	316	316	316	315	330	309	0
		39	38	101	64	59	7	0
144	C	431	418	424	445	582	0	
		26	35	193	77	7	0	
	U	463	430	426	453	501	0	
		27	37	211	91	11	0	
	S	416	402	409	456	384	0	
		23	55	188	34	1	0	
	A	314	322	321	355	410	0	
		34	126	120	19	2	0	
178	C	471	457	441	452	556	615	0
		30	20	111	103	36	13	0
	U	495	499	426	456	550	598	665
		20	25	82	114	33	12	2
	S	428	424	407	453	478	465	0
		25	36	140	91	21	7	0

* Defined on page 4 of Table.

MEAN RT AND POSITION ESTIMATE IN RECALL 1 TABLE 50

S	CONDITION SOA	CC		POSITION ESTIMATE 1	2	3	4	CORRELATION r	AND SIGNIFICANCE T_r	*=p .05 (2-tail)
AR	75	C	X	469	470	471	497	.056	1.1	
		U		471	476	473	536	.146	3.1	*
		S		446	415	424	461	.059	1.2	
	109	C		433	434	440	466	.063	1.3	
		U		439	438	460	468			
		S		403	405	408	418	.032	0.7	
GL	75	C		353	380	394	397	.151	3.0	*
		U		404	383	400	420	.142	2.9	*
		S		298	350	361	379	.163	3.2	*
	109	C		347	382	390	401	.154	3.1	*
		U		377	383	397	403	.166	3.5	*
		S		326	336	357	380	.308	6.5	*
AK	109	C		393	404	429	447	.416	8.4	*
		U		412	413	428	450	.247	4.7	*
		S		381	389	403	441	.317	5.2	*
	144	C		474	459	507	642	.318	5.8	*
		U		470	462	507	630	.367	6.9	*
		S		442	433	500	610	.291	5.4	*

X Table entries are the mean RT, conditioned on the position estimate.

MEAN RTs, CORRECTED FOR ORDER, BY SOA AND CC. TABLE 51

MEANS

S		RECALL 4					RECALL 1		
	CC	C	U	S			C	U	S
AR		501	522	456			472	478	433
GL		384	393	341			390	396	353
AK		425	441	403			422	420	389
	SOA	75	109	144	178	214	75	109	144
AR		486	474	507		507	460	462	
GL		354	373	382		382	384	375	
AK			409	428	432			407	424

ANALYSIS OF VARIANCE

S	Recall	Effect	SS	df	MS	F	Omega^2
AR	4	CC	3750000	2	1875000	251 *	.09
		SOA	853000	3	284300	10.2*	.02
		CCxSOA	168000	6	28000	3.75*	.003
		Error	35780000	4788	7474		
		Total	40551000				
	1	CC	947000	2	475300	77.0*	.06
		SOA	3270	1	3270	0.1	.000
		CCxSOA	76130	2	38070	6.2 *	.004
		Error	14706000	2394	6143		
		Total	15732400				
GL	4	CC	2520000	2	1260000	498 *	.16
		SOA	612000	3	204000	55.2*	.04
		CCxSOA	22200	6	3700	1.5	.00
		Error	12090000	4788	2526		
		Total	15244200				
	1	CC	889000	2	445000	111 *	.08
		SOA	48600	1	48600	5.7	.004
		CCxSOA	17200	2	8600	2.1	.001
		Error	9590000	2394	4006		
		Total	10544800				
AK	4	CC	653000	2	327000	136 *	.09
		SOA	277000	2	139000	6.05	.04
		CCxSOA	91700	4	22933	9.6 *	.011
		Error	6459000	2691	2400		
		Total	7480700				
	1	CC	430000	2	215000	102 *	.10
		SOA	125000	1	125000	27.5*	.03
		CCxSOA	9100	2	4550	2.16	.00
		Error	3781000	1794	2108		
		Total	4345100				

TAU: QUAD TESTS. TABLE 52

CONDITION			NUMBER OF TESTS	NUMBER OF VIOLATIONS	PROPORTION OF VIOLATIONS	MEAN SIZE χ
AR	75	C	70	0	.000	-
		U	61	1	.016	.267
		S	66	0	.000	-
		A	49	0	.000	-
	109	C	70	2	.029	.318
		U	65	1	.014	.241
		S	65	1	.015	.440
		A	78	4	.051 *	.335
	144	C	74	0	.000	-
		U	82	8	.098 *	.497
		S	76	0	.000	-
	214	C	64	5	.078 *	.635
		U	72	11	.153 *	.517
		S	71	3	.042	.375
GL	75	C	59	0	.000	-
		U	60	2	.033	.364
		S	63	0	.000	-
		A	64	0	.000	-
	109	C	72	2	.028	.909
		U	70	0	.000	-
		S	72	2	.028	.278
		A	80	3	.037	.293
	144	C	59	3	.051 *	.395
		U	56	1	.018	.356
		S	51	1	.020	.556
	214	C	74	12	.162 *	.458
		U	67	6	.090 *	.549
		S	62	6	.097 *	.626
AK	109	C	84	2	.024	.316
		U	67	0	.000	-
		S	80	1	.012	.400
		A	65	0	.000	-
	144	C	60	1	.017	.548
		U	74	3	.041	.440
		S	54	1	.019	.369
		A	70	0	.000	-
	178	C	76	9	.118 *	.547
		U	56	4	.071 *	.519
		S	60	1	.017	.347

χ Mean absolute value of the differences $Tau_{ik}-Tau_{jl}$ which are in violation.

* 5% or more violate the 95% confidence interval.

TAU: TRIPLE TESTS. TABLE 53

CONDITION			NUMBER OF TESTS	NUMBER OF VIOLATIONS	PROPORTION OF VIOLATIONS	MEAN SIZE ✗
AR	75	C	35	0	.000	-
		U	35	0	.000	-
		S	55	2	.036	.520
		A	70	0	.000	-
	109	C	50	0	.000	-
		U	45	0	.000	-
		S	65	0	.000	-
		A	50	1	.015	.552
	144	C	50	0	.000	-
		U	50	0	.000	-
		S	55	0	.000	-
	214	C	50	2	.040	.537
		U	50	4	.080 *	.700
		S	50	0	.000	-
GL	75	C	25	2	.080 *	1.605
		U	25	3	.120 *	1.868
		S	30	0	.000	-
		A	30	0	.000	-
	109	C	50	0	.000	-
		U	50	0	.000	-
		S	60	0	.000	-
		A	40	1	.025	1.814
	144	C	65	0	.000	-
		U	65	1	.015	.630
		S	80	0	.000	-
	214	C	50	0	.000	-
		U	55	0	.000	-
		S	60	1	.017	1.082
AK	109	C	50	1	.020	.485
		U	50	0	.000	-
		S	70	1	.014	.692
		A	40	1	.025	.858
	144	C	50	1	.020	.612
		U	50	3	.060 *	.735
		S	50	0	.000	-
		A	75	0	.000	-
	178	C	55	5	.091 *	1.862
		U	50	2	.040	.944
		S	50	0	.000	-

✗ Mean absolute value of the differences Tau_{ik}-Tau_{jl} which are in violation.

* 5% or more violate the 95% confidence interval.

TAU: SUMMARY OF QUAD AND TRIPLE TESTS. TABLE 54

CONDITION	TOTAL NUMBER OF TESTS		TOTAL NUMBER OF VIOLATIONS		PROPORTION OF VIOLATIONS	
	QUAD	TRIPLE	QUAD	TRIPLE	QUAD	TRIPLE
PANEL A; BY SUBJECT						
AR	963	710	36	9	.037	.013
GL	909	685	38	8	.042	.012
AK	746	590	22	14	.029	.024
PANEL B; BY SOA						
75 *	492	305	3	7	.006	.023
109	868	620	18	5	.021	.008
144	656	590	18	5	.027	.008
178 & 214	602	470	57	14	.095	.030
TOTAL	2618	1985	96	31	.037	.016

* There are less tests at 75 msec because AK did not contribute data.

TABLE 55

TEST OF THE STRENGTH COMPONENT OF THE GENERAL MODEL FOR TAU.

CONDITION		AR		GL		AK	
		P_1	P_2	P_1	P_2	P_1	P_2
75	C	.93	.80	.96	.89		
	U	.96	.91	.83	.74		
	S	.98	.94	.95	.89		
	A	.80	.69	.94	.83		
109	C	.93	.83	.96	.86	.95	.80
	U	.97	.91	.96	.83	.96	.91
	S	.99	.94	.97	.83	.97	.86
	A	.97	.94	.98	.89	.88	.80
144	C	.94	.86	.96	.89	.92	.86
	U	.95	.83	.93	.79	.94	.89
	S	.91	.71	.89	.77	.93	.80
	A					.95	.89
214 /178	C	.92	.80	.95	.86	.90	.74
	U	.97	.91	.77	.69	.87	.74
	S	.85	.74	.71	.63	.94	.86
Grand Mean		.93	.84	.91	.81	.93	.83
Mean Across Letters C,U,S.							
75		.96	.88	.91	.84		
109		.96	.89	.96	.84	.96	.86
144		.93	.80	.93	.82	.93	.85
178/214		.91	.82	.81	.73	.90	.78

Let X= 1 if $(Tau_{ij} < Tau_{kl}$ & $P_i - P_j < P_k - P_l \mid i-j=k-1)$

Let Y= 1 if $(P_i - P_j < P_k - P_l \mid i-j=k-1)$

otherwise 0.

Then $$P_1 = \frac{\Sigma (X) \cdot |(P_i - P_j) - (P_k - P_l)|}{\Sigma (Y) \cdot |(P_i - P_j) - (P_k - P_l)|}$$

$$P_2 = \frac{\Sigma (X)}{\Sigma (Y)}$$

TEST OF ORDER COMPONENT OF GENERAL MODEL FOR TAU. TABLE 56

TABLE OF VIOLATIONS OF MONOTONICITY OF TAU_{ij} $(\pm CI)$ with i-j , for $i > j$ and $|P_i - P_j| \leq e \leq .24$.

CONDITION		AR			GL			AK		
		N	e	V	N	e	V	N	e	V
75	C	4	.1	0	5	.1	0			
	U	6	.1	0	6	.1	0			
	S	4	.15	0	8	.2	1			
	A	5	.05	0	7	.15	1			
109	C	5	.17	1	6	.2	0	7	.2	0
	U	5	.15	0	6	.2	0	7	.2	0
	S	4	.15	0	5	.2	0	6	.15	0
	A	6	.15	0	7	.2	1	6	.15	1
144	C	5	.1	0	5	.15	0	4	.24	0
	U	6	.2	1	5	.15	0	6	.22	1
	S	4	.15	0	7	.15	0	4	.20	0
	A							5	.10	0
178 /214	C	7	.2	0	4	.2	0	6	.2	0
	U	6	.2	1	6	.2	0	5	.2	0
	S	6	.2	0	6	.15	0	6	.2	0
Mean		5.2	.14	.21	5.9	.17	.21	4.4	.19	.14
p(V)				.04			.04			.03

N = The number of comparisons in which $|P_i - P_j| \leq e$ and $i > j$. The maximum value for N is $21 = \sum_{i=1}^{6} (i)$.

V = The number of comparisons of i-j with Tau_{ij} that violate monotonicity, **minimized by** allowing Tau_{ij} to vary by one CI (Confidence interval) = $\pm$ 2(S.D. of Tau_{ij}). $P(V) = (\Sigma V)/(\Sigma N)$.

Every obtained violation included an i value at the ends of the window (positions 1,2,6,7), where guessing is greatest and Tau_{ij} is most likely to have been corrupted towards zero by guessing (one exception: AK condition 144 letter U).

TABLE OF ERROR IN PREDICTION OF TAU_{ij} FROM TAU_i-TAU_j. TABLE 57

S	CC	75		109		144		178/214	
		$\bar{e}$	n	$\bar{e}$	n	$\bar{e}$	n	$\bar{e}$	n
AR	C	.081	0	.174	0	.202	0	.242	8
	U	.072	0	.129	0	.265	2	.230	6
	S	.112	0	.132	2	.174	2	.189	4
	A	.062	0	.125	2				
GL	C	.085	0	.187	4	.179	2	.217	6
	U	.142	0	.149	0	.123	4	.202	6
	S	.101	0	.129	2	.134	2	.196	6
	A	.060	0	.116	2				
AK	C			.134	4	.187	2	.321	10
	U			.143	0	.221	2	.247	2
	S			.153	2	.161	2	.147	0
	A			.125	0	.226	4		
Mean		..089	0	.141	1.5	.187	2.2	.221	5.33
Mean/Maximum		.044	0	.071	..036	.093	.052	.111	.127

$$\bar{e} = \frac{\sum\sum_{ij} (|e_{ij}|)}{\text{N of cases} = 7 \times (7-1) = 42}$$

n = N of cases in which e_{ij} is greater than two standard errors of the difference SE_d. $(SE_d)^2 = \text{Var}(Tau_{ij}) + \text{Var}(Tau_i - Tau_j)$.

$$e_{ij} = \left| |Tau_{ij}| - |Tau_i - Tau_j| \right|$$

The Maximum values of e_{ij} and of n are 2 and 42 respectively.

TAU$_i$ IN RECALL 4

TABLE 58

Tabulation of $Tau_i = (\sum_j^{nj} Tau_{ij})/nj$

S	CONDITION		1	2	3	4	5	6	7
AR	75	C	-.309	-.158	.156	.289	.251	-.016	-.214
		U	-.245	-.242	.031	.266	.304	.065	-.178
		S	-.307	.090	.347	.334	.116	-.216	-.364
		A	.249	.049	.179	.062	-.034	-.147	-.357
	109	C	-.300	.061	.471	.400	.004	-.194	-.443
		U	-.301	-.157	.426	.524	.056	-.168	-.380
		S	-.090	.223	.608	.331	-.229	-.326	-.516
		A	.030	.013	.391	.341	-.004	-.295	-.476
	144	C	-.350	-.454	.558	.543	.081	-.143	-.235
		U	-.325	-.553	.323	.566	.194	-.019	-.187
		S	-.294	.043	.711	.322	-.128	-.247	-.407
	214	C	-.087	-.323	.498	.449	-.001	-.073	-.463
		U	-.299	-.050	.333	.429	.123	-.077	-.459
		S	-.052	-.196	.686	.412	-.029	-.348	-.473
GL	75	C	-.237	-.383	-.243	.223	.333	.262	.045
		U	-.290	-.208	-.285	.135	.354	.231	.063
		S	-.262	-.295	-.062	.404	.219	.038	-.042
		A	-.158	-.014	-.024	.239	.179	-.048	-.173
	109	C	-.268	-.396	.431	.435	.181	-.068	-.313
		U	-.323	-.263	.462	.435	.104	-.106	-.309
		S	.089	.025	.519	.253	-.010	-.286	-.591
		A	-.387	-.132	.168	.358	.221	.052	-.306
	144	C	..065	.154	.540	.367	-.086	-.362	-.679
		U	.065	.242	.528	.253	-.167	-.400	-.522
		S	.282	.502	.351	.143	-.232	-.497	-.549
	214	C	-.001	.038	.619	.376	-.077	-.307	-.649
		U	.143	.108	.453	.327	-.146	-.385	-.500
		S	-.045	.455	.533	.124	-.300	-.479	-.288
AK	109	C	-.379	-.064	.452	.363	.142	-.124	-.388
		U	-.336	-.226	.396	.418	.111	-.111	-.252
		S	-.427	.326	.473	.305	-.048	-.210	-.418
		A	-.528	-.092	.304	.289	.284	-.011	-.247
	144	C	-.458	.124	.523	.518	.154	-.331	-.529
		U	-.585	-.135	.446	.558	.243	-.157	-.370
		S	-.036	.037	.593	.411	-.079	-.290	-.636
		A	-.419	.551	.406	.233	-.006	-.287	-.477
	144	C	-.191	-.309	.375	.416	.093	-.177	-.207
		U	-.299	-.091	.464	.373	.159	-.156	-.451
		S	-.259	-.120	.576	.398	.055	-.160	-.489

CORRELATION OF TAU_i WITH P_i IN RECALL 4 TABLE 59

$$Tau_i = \frac{1}{7} \sum_{i=1}^{7} Tau_{ij}$$

CONDITION S	SOA	CORRELATION r_{Tau_i, P_i} C	U	S	A	PARTIAL CORRELATION $r_{Tau_i, P_i \mid i}$ C	U	S	A
AR	75	.831	.776	.849	.664	.987	.962	.949	.728
	109	.626	.705	.571	.785	.913	.948	.943	.953
	144	.781	.774	.605		.923	.912	.843	
	214	.754	.900	.680		.884	.922	.863	
GL	75	.927	.953	.915	.797	.898	.915	.965	.942
	109	.881	.863	.938	.126	.967	.963	.990	.037
	144	.688	.535	.562		.977	.893	.912	
	214	.605	.380	.168		.963	.894	.865	
AK	109	.825	.861	.851	.477	.942	.934	.931	.642
	144	.724	.893	.664	.681	.890	.941	.972	.770
	178	.578	.334	.558		.781	.740	.885	

LINEAR REGRESSION OF TAU_i ON P_i AND i. TABLE 60

$$\hat{Tau}_i = \underline{a}\cdot(P_i - P_o) + \underline{d.b}\cdot(i-4), \text{ where } P_o = \frac{1}{7}\sum_1 P_i .$$

S	SOA	a					d.b				
		C	U	S	Mean C,U,S	A	C	U	S	Mean C,U,S	A
AR	75	.936	.788	1.008	.911	1.711	.037	.032	.058	.042	.061
	109	.669	.781	.730	.727	.907	.096	.086	.140	.107	.083
	144	.957	.901	.703	.854		.074	.058	.102	.078	
	214	.752	.844	.662	.759		.077	.081	.107	.088	
	Mean	.829	.829	.781	.813		.071	.064	.102	.079	
GL	75	1.065	1.031	.965	1.020	.626	.013	.009	.021	.014	.030
	109	1.055	.954	.615	.875	.142	.057	.060	.136	.084	.015
	144	.943	.653	.863	.820		.138	.139	.155	.144	
	214	.711	.442	.178	.443		.145	.162	.127	.145	
	Mean	.944	.770	.665	.790		.088	.093	.110	.097	
AK	109	1.237	1.093	1.456	1.262	.629	.065	.047	.068	.060	.028
	144	.943	1.243	.880	1.022	.934	.105	.053	.133	.097	.053
	178	.603	.396	.768	.589		.054	.071	.100	.075	
	Mean	.928	.911	1.035	.958		.075	.057	.100	.077	

AVERAGE ERROR OF PREDICTION OF TAU_i FROM LINEAR REGRESSION. TABLE 61

Table entries are $\frac{1}{7}\sum_i \left(|\widehat{Tau}_i - Tau_i|\right)$

S	SOA	C	U	S	Mean
AR	75	.084	.109	.075	.089
	109	.133	.129	.102	.121
	144	.151	.167	.206	.176
	214	.116	.105	.165	.129
GL	75	.075	.068	.038	.067
	109	.081	.082	.068	.077
	144	.046	.095	.088	.076
	214	.084	.113	.231	.143
AK	109	.079	.084	.080	.081
	144	.127	.113	.099	.113
	178	.169	.226	.161	.185

TAU(I,J) TABLE 62 P. 1

CONDITION		1	2	3	4	5	6	7
AA	15 C	Ø.ØØØ	Ø.2ØØ	Ø.636	Ø.442	Ø.474	Ø.333	Ø.Ø77
		-Ø.2ØØ	Ø.ØØØ	Ø.Ø91	Ø.565	Ø.475	Ø.143	Ø.Ø29
		-Ø.636	-Ø.Ø91	Ø.ØØØ	Ø.Ø6Ø	-Ø.Ø23	-Ø.Ø42	-Ø.358
		-Ø.442	-Ø.565	-Ø.Ø6Ø	Ø.ØØØ	-Ø.138	-Ø.362	-Ø.456
		-Ø.474	-Ø.475	Ø.Ø23	Ø.138	Ø.ØØØ	-Ø.39Ø	-Ø.581
		-Ø.333	-Ø.143	Ø.Ø42	Ø.362	Ø.39Ø	Ø.ØØØ	-Ø.2Ø8
		-Ø.Ø77	-Ø.Ø29	Ø.358	Ø.456	Ø.581	Ø.2Ø8	Ø.ØØØ
		-Ø.3Ø9	-Ø.158	Ø.156	Ø.289	Ø.251	-Ø.Ø16	-Ø.214
	15 D	Ø.ØØØ	-Ø.111	Ø.273	Ø.467	Ø.647	Ø.379	Ø.Ø59
		Ø.111	Ø.ØØØ	Ø.212	Ø.531	Ø.661	Ø.297	-Ø.116
		-Ø.273	-Ø.212	Ø.ØØØ	Ø.Ø62	Ø.213	Ø.233	-Ø.241
		-Ø.467	-Ø.531	-Ø.Ø62	Ø.ØØØ	-Ø.117	-Ø.269	-Ø.415
		-Ø.647	-Ø.661	-Ø.213	Ø.117	Ø.ØØØ	-Ø.33Ø	-Ø.391
		-Ø.379	-Ø.297	-Ø.233	Ø.269	Ø.33Ø	Ø.ØØØ	-Ø.143
		-Ø.Ø59	Ø.116	Ø.241	Ø.415	Ø.391	Ø.143	Ø.ØØØ
		-Ø.245	-Ø.242	Ø.Ø31	Ø.266	Ø.3Ø4	Ø.Ø65	-Ø.178
	15 S	Ø.ØØØ	Ø.556	Ø.579	Ø.571	Ø.588	Ø.ØØØ	-Ø.143
		-Ø.556	Ø.ØØØ	Ø.187	Ø.413	Ø.ØØØ	-Ø.135	-Ø.538
		-Ø.579	-Ø.187	Ø.ØØØ	-Ø.2Ø3	-Ø.373	-Ø.458	-Ø.63Ø
		-Ø.571	-Ø.413	Ø.2Ø3	Ø.ØØØ	-Ø.319	-Ø.654	-Ø.583
		-Ø.588	Ø.ØØØ	Ø.373	Ø.319	Ø.ØØØ	-Ø.5Ø7	-Ø.4Ø7
		Ø.ØØØ	Ø.135	Ø.458	Ø.654	Ø.5Ø7	Ø.ØØØ	-Ø.245
		Ø.143	Ø.538	Ø.63Ø	Ø.583	Ø.4Ø7	Ø.245	Ø.ØØØ
		-Ø.3Ø7	Ø.Ø9Ø	Ø.347	Ø.334	Ø.116	-Ø.216	-Ø.364
	75 A	Ø.ØØØ	-Ø.174	-Ø.124	-Ø.28Ø	-Ø.325	-Ø.333	-Ø.5Ø9
		Ø.174	Ø.ØØØ	Ø.129	-Ø.Ø95	Ø.Ø22	-Ø.158	-Ø.415
		Ø.124	-Ø.129	Ø.ØØØ	-Ø.184	-Ø.281	-Ø.284	-Ø.619
		Ø.23Ø	Ø.Ø95	Ø.184	Ø.ØØØ	-Ø.151	-Ø.372	-Ø.468
		Ø.325	-Ø.Ø22	Ø.281	Ø.151	Ø.ØØØ	-Ø.Ø54	-Ø.44Ø
		Ø.333	Ø.158	Ø.234	Ø.372	Ø.Ø54	Ø.ØØØ	-Ø.17Ø
		Ø.5Ø9	Ø.415	Ø.619	Ø.468	Ø.44Ø	Ø.17Ø	Ø.ØØØ
		Ø.249	Ø.Ø49	Ø.196	Ø.Ø62	-Ø.Ø34	-Ø.147	-Ø.374

TAUCI.JD TABLE 62 P. 2

CONDITION	1	2	3	4	5	6	7
109 C	0.000	0.333	0.667	0.600	0.500	0.667	-0.667
	-0.333	0.000	0.309	0.149	-0.154	-0.091	-0.308
	-0.667	-0.309	0.000	-0.179	-0.622	-0.695	-0.823
	-0.600	-0.149	0.179	0.000	-0.629	-0.821	-0.783
	-0.500	0.154	0.622	0.629	0.000	-0.470	-0.465
	-0.667	0.091	0.695	0.821	0.470	0.000	-0.053
	0.667	0.308	0.823	0.783	0.465	0.053	0.000
	-0.300	0.061	0.471	0.401	0.004	-0.194	-0.442
109 D	0.000	-0.333	0.750	0.800	0.286	0.750	-0.143
	0.333	0.000	0.655	0.511	0.086	-0.286	-0.200
	-0.750	-0.655	0.000	-0.027	-0.368	-0.569	-0.612
	-0.800	-0.511	0.027	0.000	-0.690	-0.804	-0.893
	-0.286	-0.086	0.368	0.690	0.000	-0.478	-0.597
	-0.750	0.286	0.569	0.804	0.478	0.000	-0.213
	0.143	0.200	0.612	0.893	0.597	0.213	0.000
	-0.301	-0.157	0.426	0.525	0.055	-0.168	-0.380
109 S	0.000	0.200	0.760	0.867	-0.273	-0.143	-0.778
	-0.200	0.000	0.306	-0.024	-0.364	-0.535	-0.745
	-0.760	-0.306	0.000	-0.645	-0.803	-0.852	-0.892
	-0.867	0.024	0.645	0.000	-0.745	-0.690	-0.683
	0.273	0.364	0.803	0.745	0.000	-0.263	-0.316
	0.143	0.535	0.852	0.690	0.263	0.000	-0.200
	0.778	0.745	0.892	0.683	0.316	0.200	0.000
	-0.090	0.223	0.608	0.331	-0.229	-0.326	-0.516
109 A	0.000	0.130	0.449	0.309	-0.098	-0.222	-0.778
	-0.130	0.000	0.248	0.141	0.045	-0.176	-0.217
	-0.449	-0.248	0.000	-0.215	-0.472	-0.699	-0.667
	-0.309	-0.141	0.215	0.000	-0.600	-0.758	-0.795
	0.098	-0.045	0.472	0.600	0.000	-0.423	-0.672
	0.222	0.176	0.699	0.758	0.423	0.000	-0.231
	0.778	0.217	0.667	0.795	0.672	0.231	0.000
	0.030	0.013	0.393	0.341	-0.004	-0.293	-0.480

TAUCI, D TABLE 62 P. 3

CONDITION	1	2	3	4	5	6	7
144 C	0.000	-1.000	0.857	0.826	0.600	0.500	0.667
	1.000	0.000	0.909	0.867	0.200	0.125	0.077
	-0.857	-0.909	0.000	-0.169	-0.572	-0.685	-0.714
	-0.826	-0.867	0.169	0.000	-0.668	-0.749	-0.859
	-0.600	-0.200	0.572	0.668	0.000	-0.449	-0.561
	-0.500	-0.125	0.685	0.749	0.449	0.000	-0.255
	-0.667	-0.077	0.714	0.859	0.561	0.255	0.000
	-0.350	-0.454	0.558	0.543	0.081	-0.143	-0.235
144 U	0.000	-1.000	0.400	0.750	0.857	0.714	0.556
	1.000	0.000	0.600	0.818	0.474	0.833	0.143
	-0.400	-0.600	0.000	0.017	-0.320	-0.556	-0.402
	-0.750	-0.818	-0.017	0.000	-0.696	-0.799	-0.884
	-0.857	-0.474	0.320	0.696	0.000	-0.496	-0.549
	-0.714	-0.833	0.556	0.799	0.496	0.000	-0.171
	-0.556	-0.143	0.402	0.884	0.549	0.171	0.000
	-0.325	-0.553	0.323	0.566	0.194	-0.019	-0.187
144 S	0.000	1.000	0.931	0.462	0.176	0.636	-0.250
	-1.000	0.000	0.647	0.286	-0.111	-0.520	-0.500
	-0.931	-0.647	0.000	-0.713	-0.826	-0.878	-0.984
	-0.462	-0.286	0.713	0.000	-0.632	-0.773	-0.814
	-0.176	0.111	0.826	0.632	0.000	-0.287	-0.207
	-0.636	0.520	0.878	0.773	0.287	0.000	-0.091
	0.250	0.500	0.984	0.814	0.207	0.091	0.000
	-0.422	0.171	0.711	0.322	-0.128	-0.247	-0.407

TAU(I,J)

TABLE 62 P. 4

CONDITION	1	2	3	4	5	6	7
214 C	0.000	-0.200	0.226	0.128	0.059	0.455	0.000
	0.200	0.000	0.821	0.634	0.302	0.636	-0.333
	-0.226	-0.821	0.000	-0.411	-0.669	-0.654	-0.707
	-0.128	-0.634	0.411	0.000	-0.908	-0.935	-0.948
	-0.059	-0.302	0.669	0.908	0.000	-0.574	-0.694
	-0.455	-0.636	0.654	0.935	0.574	0.000	-0.560
	0.000	0.333	0.707	0.948	0.694	0.560	0.000
	-0.095	-0.323	0.498	0.449	0.007	-0.073	-0.463
214 D	0.000	0.333	0.278	0.429	0.409	0.500	0.143
	-0.333	0.000	0.450	0.356	0.333	0.545	-1.000
	-0.278	-0.450	0.000	-0.217	-0.441	-0.410	-0.533
	-0.429	-0.356	0.217	0.000	-0.830	-0.896	-0.711
	-0.409	-0.333	0.441	0.830	0.000	-0.673	-0.720
	-0.500	-0.545	0.410	0.896	0.673	0.000	-0.393
	-0.143	1.000	0.533	0.711	0.720	0.393	0.000
	-0.299	-0.050	0.333	0.429	0.123	-0.077	-0.459
214 J	0.000	0.333	0.744	0.450	0.267	-0.429	-1.000
	-0.333	0.000	0.789	0.368	0.217	0.333	0.000
	-0.744	-0.789	0.000	-0.683	-0.831	-0.855	-0.902
	-0.450	-0.368	0.683	0.000	-0.881	-0.955	-0.915
	-0.267	-0.217	0.831	0.881	0.000	-0.478	-0.550
	0.429	-0.333	0.855	0.955	0.478	0.000	0.053
	1.000	0.000	0.902	0.915	0.550	-0.053	0.000
	-0.052	-0.196	0.686	0.412	-0.029	-0.348	-0.474

TAU(I,J) TABLE 62 P. 5

CONDITION		1	2	3	4	5	6	7
GL	75 C	Ø.ØØØ	-Ø.158	-Ø.25Ø	Ø.455	Ø.464	Ø.767	Ø.379
		Ø.158	Ø.ØØØ	Ø.Ø53	Ø.542	Ø.831	Ø.6ØØ	Ø.5ØØ
		Ø.25Ø	-Ø.Ø53	Ø.ØØØ	Ø.317	Ø.564	Ø.38Ø	Ø.24Ø
		-Ø.455	-Ø.542	-Ø.317	Ø.ØØØ	Ø.Ø92	-Ø.136	-Ø.2ØØ
		-Ø.464	-Ø.831	-Ø.564	-Ø.Ø92	Ø.ØØØ	-Ø.12Ø	-Ø.261
		-Ø.767	-Ø.6ØØ	-Ø.38Ø	Ø.136	Ø.12Ø	Ø.ØØØ	-Ø.34Ø
		-Ø.379	-Ø.5ØØ	-Ø.24Ø	Ø.2ØØ	Ø.261	Ø.34Ø	Ø.ØØØ
		-Ø.237	-Ø.383	-Ø.243	Ø.222	Ø.333	Ø.261	Ø.Ø46
	75 U	Ø.ØØØ	Ø.333	-Ø.Ø77	Ø.277	Ø.516	Ø.492	Ø.489
		-Ø.333	Ø.ØØØ	-Ø.474	Ø.576	Ø.796	Ø.619	Ø.273
		Ø.Ø77	Ø.474	Ø.ØØØ	Ø.Ø7Ø	Ø.397	Ø.552	Ø.424
		-Ø.277	-Ø.576	-Ø.Ø7Ø	Ø.ØØØ	Ø.15Ø	Ø.Ø43	-Ø.217
		-Ø.516	-Ø.796	-Ø.397	-Ø.15Ø	Ø.ØØØ	-Ø.25Ø	-Ø.367
		-Ø.492	-Ø.619	-Ø.552	-Ø.Ø43	Ø.25Ø	Ø.ØØØ	-Ø.162
		-Ø.489	-Ø.273	-Ø.424	Ø.217	Ø.367	Ø.162	Ø.ØØØ
		-Ø.29Ø	-Ø.2Ø8	-Ø.285	Ø.135	Ø.354	Ø.231	Ø.Ø63
	75 S	Ø.ØØØ	Ø.ØØØ	Ø.28Ø	Ø.529	Ø.423	Ø.235	Ø.368
		Ø.ØØØ	Ø.ØØØ	Ø.2ØØ	Ø.7Ø5	Ø.355	Ø.489	Ø.317
		-Ø.28Ø	-Ø.2ØØ	Ø.ØØØ	Ø.3Ø5	Ø.25Ø	Ø.169	Ø.187
		-Ø.529	-Ø.7Ø5	-Ø.3Ø5	Ø.ØØØ	-Ø.2Ø6	-Ø.56Ø	-Ø.52Ø
		-Ø.423	-Ø.355	-Ø.25Ø	Ø.2Ø6	Ø.ØØØ	-Ø.34Ø	-Ø.373
		-Ø.235	-Ø.489	-Ø.169	Ø.56Ø	Ø.34Ø	Ø.ØØØ	-Ø.271
		-Ø.368	-Ø.317	-Ø.187	Ø.52Ø	Ø.373	Ø.271	Ø.ØØØ
		-Ø.262	-Ø.295	-Ø.Ø62	Ø.4Ø4	Ø.219	Ø.Ø38	-Ø.Ø42
	75 A	Ø.ØØØ	Ø.Ø71	Ø.212	Ø.333	Ø.284	Ø.243	-Ø.Ø34
		-Ø.Ø71	Ø.ØØØ	-Ø.Ø91	Ø.3Ø2	Ø.2ØØ	-Ø.1ØØ	-Ø.143
		-Ø.212	Ø.Ø91	Ø.ØØØ	Ø.157	Ø.217	-Ø.Ø14	-Ø.Ø71
		-Ø.333	-Ø.3Ø2	-Ø.157	Ø.ØØØ	-Ø.148	-Ø.387	-Ø.346
		-Ø.284	-Ø.2ØØ	-Ø.217	Ø.148	Ø.ØØØ	-Ø.216	-Ø.482
		-Ø.243	Ø.1ØØ	Ø.Ø14	Ø.387	Ø.216	Ø.ØØØ	-Ø.137
		Ø.Ø34	Ø.143	Ø.Ø71	Ø.346	Ø.482	Ø.137	Ø.ØØØ
		-Ø.153	-Ø.Ø14	-Ø.Ø24	Ø.239	Ø.179	-Ø.Ø48	-Ø.173

TAUCI,D TABLE 62 P. 6

CONDITION	1	2	3	4	5	6	7
109 C	0.000	-1.000	0.769	0.682	0.750	0.500	0.176
	1.000	0.000	0.333	0.556	0.500	0.385	0.000
	-0.769	-0.333	0.000	-0.160	-0.429	-0.586	-0.737
	-0.682	-0.556	0.160	0.000	-0.504	-0.723	-0.737
	-0.750	-0.500	0.429	0.504	0.000	-0.434	-0.516
	-0.500	-0.385	0.586	0.723	0.434	0.000	-0.380
	-0.176	0.000	0.737	0.737	0.516	0.380	0.000
	-0.263	-0.396	0.431	0.434	0.181	-0.068	-0.313
109 J	0.000	0.000	0.583	0.556	0.290	0.500	0.333
	0.000	0.000	0.548	0.556	0.442	0.294	0.000
	-0.583	-0.548	0.000	-0.137	-0.495	-0.651	-0.820
	-0.556	-0.556	0.137	0.000	-0.538	-0.690	-0.844
	-0.290	-0.442	0.495	0.538	0.000	-0.500	-0.526
	-0.500	-0.294	0.651	0.690	0.500	0.000	-0.306
	-0.333	0.000	0.820	0.844	0.526	0.306	0.000
	-0.323	-0.263	0.462	0.435	0.104	-0.106	-0.309
109 S	0.000	0.000	0.511	0.314	-0.200	-0.250	-1.000
	0.000	0.000	0.300	0.154	-0.027	-0.100	-0.500
	-0.511	-0.300	0.000	-0.510	-0.671	-0.775	-0.865
	-0.314	-0.154	0.510	0.000	-0.369	-0.627	-0.818
	0.200	0.027	0.671	0.369	0.000	-0.528	-0.671
	0.250	0.100	0.775	0.627	0.528	0.000	-0.280
	1.000	0.500	0.865	0.818	0.671	0.280	0.000
	0.089	0.025	0.519	0.253	-0.010	-0.286	-0.591
109 H	0.000	0.250	0.111	0.829	0.500	0.800	0.222
	-0.250	0.000	0.208	0.460	0.382	0.292	-0.167
	-0.111	-0.208	0.000	0.070	-0.078	-0.173	-0.673
	-0.829	-0.460	-0.070	0.000	-0.263	-0.434	-0.640
	-0.500	-0.382	0.078	0.263	0.000	-0.437	-0.568
	-0.800	-0.292	0.173	0.434	0.437	0.000	-0.319
	-0.222	0.167	0.673	0.640	0.568	0.319	0.000
	-0.387	-0.132	0.168	0.385	0.221	0.052	-0.307

TAUCI.D

TABLE 62 P. 7

CONDITION	1	2	3	4	5	6	7
144 C	0.000	0.000	0.404	0.512	-0.037	-0.333	-1.000
	0.000	0.000	0.253	0.089	-0.263	-0.692	-0.467
	-0.404	-0.253	0.000	-0.462	-0.809	-0.910	-0.939
	-0.512	-0.089	0.462	0.000	-0.727	-0.873	-0.833
	0.037	0.263	0.809	0.727	0.000	-0.377	-0.860
	0.333	0.692	0.910	0.873	0.377	0.000	-0.652
	1.000	0.467	0.939	0.833	0.860	0.652	0.000
	0.065	0.154	0.540	0.368	-0.085	-0.362	-0.679
144 U	0.000	-0.143	0.333	0.250	-0.200	-0.200	-0.500
	0.143	0.000	0.085	-0.241	-0.345	-0.556	-0.778
	-0.333	-0.085	0.000	-0.528	-0.862	-0.917	-0.969
	-0.250	0.241	0.528	0.000	-0.689	-0.798	-0.806
	0.200	0.345	0.862	0.689	0.000	-0.378	-0.550
	0.200	0.556	0.917	0.798	0.378	0.000	-0.048
	0.500	0.778	0.969	0.806	0.550	0.048	0.000
	0.066	0.242	0.528	0.254	-0.167	-0.400	-0.522
144 S	0.000	0.118	-0.211	-0.182	-0.238	-0.714	-0.750
	-0.118	0.000	-0.319	-0.605	-0.798	-0.906	-0.767
	0.211	0.319	0.000	-0.410	-0.741	-0.923	-0.913
	0.182	0.605	0.410	0.000	-0.674	-0.794	-0.729
	0.238	0.798	0.741	0.674	0.000	-0.269	-0.556
	0.714	0.906	0.923	0.794	0.269	0.000	-0.125
	0.750	0.767	0.913	0.729	0.556	0.125	0.000
	0.282	0.502	0.351	0.143	-0.232	-0.497	-0.549

TAUCI.D TABLE 62 P. 8

CONDITION	1	2	3	4	5	6	7
214 C	0.000	0.200	0.429	0.200	-0.176	-0.263	-0.385
	-0.200	0.000	0.373	0.294	0.000	-0.067	-0.667
	-0.429	-0.373	0.000	-0.650	-0.930	-0.981	-0.972
	-0.200	-0.294	0.650	0.000	-0.897	-0.971	-0.923
	0.176	0.000	0.930	0.897	0.000	-0.682	-0.784
	0.263	0.067	0.981	0.971	0.682	0.000	-0.812
	0.385	0.667	0.972	0.923	0.784	0.812	0.000
	-0.001	0.033	0.619	0.376	-0.077	-0.307	-0.649
214 U	0.000	0.333	0.241	0.083	-0.385	-0.273	-1.000
	-0.333	0.000	0.268	0.171	-0.167	-0.263	-0.429
	-0.241	-0.268	0.000	-0.641	-0.921	-1.000	-1.000
	-0.083	-0.171	0.641	0.000	-0.838	-0.906	-0.934
	0.385	0.167	0.921	0.838	0.000	-0.712	-0.576
	0.273	0.263	1.000	0.906	0.712	0.000	-0.462
	1.000	0.429	1.000	0.934	0.576	0.462	0.000
	0.143	0.108	0.582	0.327	-0.146	-0.385	-0.629
214 S	0.000	0.200	0.391	-0.111	-0.500	0.000	0.333
	-0.200	0.000	-0.115	-0.592	-0.611	-1.000	-0.667
	-0.391	0.115	0.000	-0.790	-0.974	-0.979	-0.714
	0.111	0.592	0.790	0.000	-0.815	-0.954	-0.590
	0.500	0.611	0.974	0.815	0.000	-0.641	-0.158
	0.000	1.000	0.979	0.954	0.641	0.000	-0.222
	-0.333	0.667	0.714	0.590	0.158	0.222	0.000
	-0.045	0.455	0.533	0.124	-0.300	-0.479	-0.288

TAU(I,J

TABLE 62 P. 9

CONDITION	1	2	3	4	5	6	7
AK 109 C	0.000	0.385	0.625	0.714	0.655	0.474	-0.200
	-0.385	0.000	0.333	0.325	0.283	0.111	-0.217
	-0.625	-0.333	0.000	-0.341	-0.582	-0.494	-0.786
	-0.714	-0.325	0.341	0.000	-0.425	-0.693	-0.724
	-0.655	-0.283	0.582	0.425	0.000	-0.455	-0.605
	-0.474	-0.111	0.494	0.693	0.455	0.000	-0.187
	0.200	0.217	0.786	0.724	0.605	0.187	0.000
	-0.379	-0.064	0.452	0.363	0.141	-0.124	-0.389
109 B	0.000	0.000	0.455	0.571	0.444	0.500	0.385
	0.000	0.000	0.472	0.594	0.349	0.280	-0.111
	-0.455	-0.472	0.000	-0.125	-0.434	-0.746	-0.542
	-0.571	-0.594	0.125	0.000	-0.500	-0.667	-0.718
	-0.444	-0.349	0.434	0.500	0.000	-0.358	-0.562
	-0.500	-0.280	0.746	0.667	0.358	0.000	-0.216
	-0.385	0.111	0.542	0.718	0.562	0.216	0.000
	-0.336	-0.226	0.396	0.418	0.111	-0.111	-0.252
109 S	0.000	0.636	0.632	0.744	0.300	0.385	0.294
	-0.636	0.000	0.009	-0.154	-0.485	-0.378	-0.636
	-0.632	-0.009	0.000	-0.508	-0.639	-0.720	-0.803
	-0.744	0.154	0.508	0.000	-0.507	-0.680	-0.865
	-0.300	0.485	0.639	0.507	0.000	-0.408	-0.585
	-0.385	0.378	0.720	0.680	0.408	0.000	-0.333
	-0.294	0.636	0.803	0.865	0.585	0.333	0.000
	-0.427	0.326	0.473	0.305	-0.048	-0.210	-0.418
109 A	0.000	0.333	0.556	1.000	0.615	0.760	0.429
	-0.333	0.000	0.500	0.263	0.429	0.120	-0.333
	-0.556	-0.500	0.000	-0.111	-0.091	-0.294	-0.576
	-1.000	-0.263	0.111	0.000	-0.140	-0.383	-0.351
	-0.615	-0.429	0.091	0.140	0.000	-0.497	-0.676
	-0.760	-0.120	0.294	0.383	0.497	0.000	-0.219
	-0.429	0.333	0.576	0.351	0.676	0.219	0.000
	-0.528	-0.092	0.304	0.289	0.284	-0.011	-0.247

TAU(I,J) TABLE 62 P.10

CONDITION	1	2	3	4	5	6	7
144 C	0.000	0.200	0.733	0.760	0.750	0.333	-0.500
	-0.200	0.000	0.235	0.600	0.500	-0.600	-0.600
	-0.733	-0.235	0.000	-0.300	-0.652	-0.850	-0.793
	-0.760	-0.600	0.300	0.000	-0.783	-0.883	-0.842
	-0.750	-0.500	0.652	0.783	0.000	-0.548	-0.731
	-0.333	0.600	0.850	0.883	0.548	0.000	-0.240
	0.500	0.600	0.793	0.842	0.731	0.240	0.000
	-0.325	0.009	0.509	0.510	0.156	-0.330	-0.529
144 U	0.000	1.000	0.765	0.826	0.538	0.500	0.600
	-1.000	0.000	0.333	0.647	0.333	0.333	-0.200
	-0.765	-0.333	0.000	-0.152	-0.429	-0.663	-0.815
	-0.826	-0.647	0.152	0.000	-0.731	-0.908	-0.961
	-0.538	-0.333	0.429	0.731	0.000	-0.681	-0.846
	-0.500	-0.333	0.663	0.908	0.681	0.000	-0.368
	-0.600	0.200	0.815	0.961	0.846	0.368	0.000
	-0.604	-0.135	0.451	0.560	0.249	-0.150	-0.370
144 S	0.000	0.333	0.500	0.647	-0.111	0.000	-0.667
	-0.333	0.000	0.451	0.455	-0.071	-0.091	-1.000
	-0.500	-0.451	0.000	-0.576	-0.834	-0.929	-0.933
	-0.647	-0.455	0.576	0.000	-0.639	-0.820	-0.938
	0.111	0.071	0.834	0.639	0.000	-0.467	-0.633
	0.000	0.091	0.929	0.820	0.467	0.000	-0.280
	0.667	1.000	0.933	0.938	0.633	0.280	0.000
	-0.100	0.084	0.603	0.418	-0.079	-0.290	-0.636
144 A	0.000	0.733	0.630	0.462	0.444	-0.333	1.000
	-0.733	0.000	-0.442	-0.400	-0.676	-0.714	-0.889
	-0.630	0.442	0.000	-0.313	-0.629	-0.793	-0.917
	-0.462	0.400	0.313	0.000	-0.412	-0.604	-0.867
	-0.444	0.676	0.629	0.412	0.000	-0.564	-0.667
	0.333	0.714	0.793	0.604	0.564	0.000	-1.000
	-1.000	0.889	0.917	0.867	0.667	1.000	0.000
	-0.419	0.551	0.406	0.233	-0.006	-0.287	-0.477

TAU(I,J) TABLE 62 P.11

CONDITION	1	2	3	4	5	6	7
178 C	0.000	-1.000	0.556	0.619	0.333	0.400	0.429
	1.000	0.000	0.111	0.143	0.000	-0.091	1.000
	-0.556	-0.111	0.000	-0.132	-0.435	-0.627	-0.765
	-0.619	-0.143	0.132	0.000	-0.641	-0.762	-0.877
	-0.333	0.000	0.435	0.641	0.000	-0.622	-0.773
	-0.400	0.091	0.627	0.762	0.622	0.000	-0.462
	-0.429	-1.000	0.765	0.877	0.773	0.462	0.000
	-0.191	-0.309	0.375	0.416	0.093	-0.177	-0.207
178 U	0.000	1.000	0.429	0.333	0.467	-0.250	0.111
	-1.000	0.000	0.600	0.222	0.125	0.778	-0.091
	-0.429	-0.600	0.000	-0.227	-0.391	-0.771	-0.829
	-0.333	-0.222	0.227	0.000	-0.651	-0.807	-0.827
	-0.467	-0.125	0.391	0.651	0.000	-0.693	-0.867
	0.250	-0.778	0.771	0.807	0.693	0.000	-0.654
	-0.111	0.091	0.829	0.827	0.867	0.654	0.000
	-0.299	-0.091	0.464	0.373	0.158	-0.156	-0.451
178 S	0.000	-0.200	0.833	0.647	0.286	0.250	0.000
	0.200	0.000	0.429	0.437	-0.091	0.200	-0.333
	-0.833	-0.429	0.000	-0.517	-0.687	-0.733	-0.833
	-0.647	-0.437	0.517	0.000	-0.552	-0.776	-0.890
	-0.286	0.091	0.687	0.552	0.000	-0.537	-0.890
	-0.250	-0.200	0.733	0.776	0.537	0.000	-0.477
	0.000	0.333	0.833	0.890	0.890	0.477	0.000
	-0.259	-0.120	0.576	0.398	0.055	-0.160	-0.489

LIST OF RESPONSES OF OVER 5% PROBABILITY

TABLE 63

S	CONDITION		RESPONSE	PROBABILITY
AR	109	U	4567	.059
		S	3456	.078
			3458	.058
	144	C	3457	.050
		U	4567	.052
			4576	.067
		S	3456	.128
			3457	.056
			3465	.109
	214	C	3456	.166
			3465	.053
			4567	.060
		U	3456	.126
			4563	.075
			4567	.068
		S	3456	.288
			3465	.123
GL	144	C	3457	.060
			3458	.080
		U	3456	.072
			3458	.066
		S	2345	.056
	214	C	3456	.353
			3465	.054
		U	3456	.308
			3457	.052
		S	3456	.348
			3465	.066
AK	144	C	3458	.104
		U	3458	.074
			4568	.050
		S	3458	.093
	178	C	4567	.051
			4568	.070
		U	4567	.097
			4568	.069
			4578	.052
		S	4568	.050
			4578	.050

TABLE 64

RUNS IN RECALL 4, AVERAGED OVER C, U, AND S.

PANEL A: ALL RESPONSES.

S	SOA	P(R=(n,n+2))	P(R=(n,n+3))	P(ALL OTHER RUNS)
AR	75	.054	.014	.330
	109	.142	.085	.400
	144	.134	.095	.462
	214	.255	.245	.331
GL	75	.050	.012	.353
	109	.122	.056	.400
	144	.183	.085	.377
	214	.103	.350	.360
AK	109	.111	.037	.393
	144	.192	.053	.433
	178	.154	.087	.393

PANEL B:RESPONSES OF OVER 5% PROBABILITY.

S	SOA	P(R=(n,..,n+3))	P(R)	P(R=(n,..,n+3))/P(R)
AR	75	.000	.000	-
	109	.046	.065	.708
	144	.060	.154	.390
	214	.236	.394	.738
GL	75	.000	.000	-
	109	.000	.000	-
	144	.043	.111	.387
	214	.336	.394	.853
AK	109	.000	.000	-
	144	.000	.107	.000
	178	.066	.146	.452
Mean		.072	.118	.610

FIT OF MODEL 1.1 TO RECALL 4 DATA. TABLE 65

S	SOA	CC	m	q	f_1	f_2	f_3	f_4	$d(f_I)$	RMS x100	RMS(q=0) x100
AR	75	C	5	.02	.195	.231	.344	.229	270	.434	.435
		U	5	.00	.196	.229	.279	.296	276	.560	.560
		S	5	.02	.174	.336	.439	.051	253	.679	.686
	109	C	5	.06	.071	.159	.695	.074	302	1.415	1.548
		U	4	.08	.065	.128	.514	.292	331	1.502	1.760
		S	5	.12	.070	.308	.622	.000	278	2.143	2.601
	144	C	4	.04	.067	.090	.574	.269	294	1.777	1.810
		U	4	.06	.072	.078	.468	.382	310	2.014	2.101
		S	4	.14	.074	.121	.733	.072	260	3.353	4.755
	214	C	4	.26	.108	.185	.571	.136	157	1.943	6.197
		U	4	.22	.152	.145	.483	.220	165	2.224	4.534
		S	4	.38	.101	.132	.716	.050	153	4.048	14.37
GL	75	C	5	.02	.301	.187	.186	.325	265	.514	.519
		U	5	.00	.321	.167	.189	.324	264	.512	.512
		S	5	.04	.249	.164	.227	.360	277	.537	.593
	109	C	5	.02	.157	.107	.623	.113	293	1.076	1.108
		U	4	.04	.106	.125	.585	.185	311	1.064	1.187
		S	5	.06	.144	.141	.714	.000	280	1.497	1.642
	144	C	5	.06	.201	.312	.487	.000	185	2.810	2.843
		U	4	.10	.168	.269	.521	.042	207	2.049	2.460
		S	5	.08	.219	.668	.114	.000	129	1.142	1.440
	214	C	4	.48	.151	.145	.692	.012	121	1.909	19.37
		U	4	.44	.114	.142	.737	.007	136	2.590	15.47
		S	4	.50	.151	.174	.675	.000	112	1.858	18.88
AK	109	C	5	.04	.220	.313	.307	.159	371	.787	.806
		U	5	.04	.168	.295	.375	.162	385	1.059	1.085
		S	5	.04	.223	.436	.330	.011	341	.617	.664
	144	C	5	.04	.095	.105	.680	.120	263	3.773	3.796
		U	5	.02	.089	.101	.673	.137	268	2.843	2.853
		S	5	.06	.092	.199	.708	.000	233	3.343	3.379
	178	C	5	.10	.130	.058	.468	.344	182	2.394	2.566
		U	5	.18	.092	.097	.358	.454	209	2.449	3.444
		S	5	.06	.101	.122	.535	.242	164	1.666	1.773

FIT OF MODEL 1.1 TO RECALL 4 DATA: q AND df_I TABLE 66

S	SOA	df_I C	df_I U	df_I S	df_I Mean	q^* C	q^* U	q^* S	q^* Mean
AR	75	270	276	253	266	.02	.00	.02	.01
	109	302	331	278	304	.06	.08	.12	.09
	144	294	310	260	288	.04	.06	.14	.08
	214	157	165	153	158	.26	.22	.38	.29
	Mean	256	271	236	254	.09	.09	.17	.12
GL	75	265	264	277	269	.02	.00	.04	.02
	109	293	311	280	295	.02	.04	.06	.04
	144	185	207	129	174	.06	.10	.08	.08
	214	121	136	112	123	.48	.44	.50	.47
	Mean	216	230	200	215	.15	.15	.17	.15
AK	109	371	385	341	366	.04	.04	.04	.04
	144	263	268	233	255	.04	.02	.06	.04
	178	182	209	164	185	.10	.18	.06	.11
	Mean	272	287	246	269	.06	.08	.05	.06

* q was fit it steps of .02

MEAN ABSOLUTE EFFECT ON df_I , IN MSEC.

S	CC EFFECT	SOA EFFECT
AR	12	48
GL	10	67
AK	15	65
Mean	12	60

P(R=(i,i+1,i+2,i+3,i+4)) IN RECALL 4, PREDICTED BY MODEL 1.1, TABLE 67 AND OBSERVED.

CONDITION		q	R = (1,2,3,4) O	E	(2,3,4,5) O	E	(3,4,5,6) O	E	(4,5,6,7) O	E
AR	75	.01	.000	.014	.003	.026	.007	.035	.006	.019
	109	.07	.000	.004	.002	.014	.053	.043	.030	.008
	144	.08	.000	.005	.000	.008	.063	.047	.034	.019
	214	.29	.000	.034	.005	.048	.197	.171	.047	.039
GL	75	.02	.000	.004	.000	.004	.000	.004	.013	.007
	109	.04	.000	.005	.004	.006	.041	.026	.013	.004
	144	.08	.002	.014	.036	.036	.050	.030	.003	.001
	214	.47	.002	.065	.009	.087	.347	.329	.002	.003
AK	109	.04	.000	.006	.010	.014	.018	.013	.001	.004
	144	.04	.000	.003	.003	.005	.033	.028	.022	.003
	178	.11	.000	.009	.003	.011	.028	.049	.057	.038

O = Observed probability, averaged over C, U, and S.

E = Expected probability = $q \cdot f_i$, from Model 1.1.

q = Probability of no permutation from Model 1.1 fit, to P(R=r).

f_i and q are averaged over C,U, and S.

LINEAR FIT TO P'_i IN RECALL 4. TABLE 68 p.1

PANEL A: FITS

CONDITION		A.H. T	A.H. d/h	A.H. 1-MSE	G.L. T	G.L. d/h	G.L. 1-MSE	A.K. T	A.K. d/h	A.K. 1-MSE
75	C	333	134	.997	387	134	.998			
	U	366	133	1.0	384	136	.998			
	S	271	133	.998	349	114	.998			
	A	147	135	.998	103	132	.996			
109	C	322	144	.997	346	166	.996	412	164	.997
	U	354	141	.997	343	152	.997	402	173	.995
	S	288	139	.997	302	159	.997	380	163	.998
	A	58	140	.999	145	168	.999	203	208	.996
144	C	334	171	.998	215	196	.998	260	231	.995
	U	373	186	.999	229	199	.998	275	220	.996
	S	271	165	.999	137	199	.999	234	244	.992
	A							81	189	1.0
178	C							273	304	.999
	U							299	310	.998
	S							228	291	.998
214	C	196	248	.999	173	249	.999			
	U	255	251	.999	173	252	.999			
	S	182	237	1.0	144	250	.999			

T = Switch time, in msec

h^{-1} = 1 / (Slope), in msec

$MSE = \sum_i (\hat{P}'_i - P'_i)^2 / \sum_i (\hat{P}'_i)^2$

$P'_i = \frac{1}{4}Cum(P'_i)$

$\hat{P}'_i = h(t_i - T)$, if $T-d \geq t_i < T+3d$.

d = Digit SOA.

LINEAR FIT TO P'_i IN RECALL 4. TABLE 68 p.2

PANEL B: MEANS

CONDITION	AR	GL MEAN	AK	AR	GL EFFECT(	AK MEAN-GM)
MEAN OF C,U,S.						
75	133	128		-39	-56	
109	141	160	167	-31	-24	-66
144	174	198	232	-2	14	-1
178/214	245	250	302	72	66	67
MEAN OF SOAs						
C	174	186	233	2	2	0
U	178	185	234	6	1	1
S	165	181	233	-8	-3	-1

PANEL C: T MEANS AND EFFECTS

CONDITION	AR	GL MEAN	AK	AR	GL EFFECT(=MEAN-GM)	AK
MEAN OF C,U,S.						
75	324	373		28	108	
109	321	330	398	25	65	-91
144	326	194	256	30	-71	-51
178/214	211	163	267	-83	-102	-40
MEAN OF SOAs						
C	296	280	315	1	15	8
U	337	282	326	42	17	19
S	253	233	281	-43	-32	-26

FIT OF MODELS 2 AND 3 TO TAU_{ij} IN RECALL 4. TABLE 69

Table entries are : $\frac{1}{2}\left(\frac{1}{42}\sum_i\sum_j |\widehat{Tau}_{ij}-Tau_{ij}|\right)$

CONDITION		MODEL 2				MODEL 3			
S	SOA	C	U	S	Mean	C	U	S	Mean
AR	75	.051	.048	.065	.055	.054	.054	.065	.058
	109	.081	.087	.086	.085	.076	.072	.057	.068
	144	.065	.104	.092	.087	.079	.126	.056	.087
	214	.099	.122	.108	.110	.093	.104	.082	.093
	Mean	.074	.090	.088	.084	.076	.089	.065	.077
GL	75	.051	.076	.049	.059	.045	.071	.104	.073
	109	.076	.059	.099	.078	.072	.064	.068	.068
	144	.084	.090	.093	.089	.070	.048	.039	.052
	214	.071	.131	.119	.107	.063	.084	.091	.079
	Mean	.071	.089	.090	.083	.063	.067	.076	.068
AK	109	.051	.057	.056	.055	.061	.072	.057	.063
	144	.097	.144	.114	.118	.077	.090	.076	.081
	178	.183	.176	.121	.160	.131	.130	.071	.111
	Mean	.110	.126	.097	.111	.090	.097	.068	.085

Statistics for sampling from the Normal Table 70

Panel A. Mean and variance for the standard normal as a function of the number n of sampling points.

n	D	Mean		Variance	
		Mean	s.d.	Mean	s.d.
4	1.5	-.08	.054	.95	.041
5	1.2	-.04	.031	.97	.024
6	1.0	-.04	.022	.97	.018
7	.86	-.01	.010	.97	.010
8	.75	-.04	.012	.97	.006
∞	0	0	0	1.00	0

Panel B. 95% Confidence Intervals* for variances as a function of the number m of data points

m	Lower Limit	Upper limit
400	$.878\ s^2$	$1.161\ s^2$
300	$.898\ s^2$	$1.128\ s^2$

*C.I.s obtained from .975 and .025 critical values of the Chi^2 distribution for 400 and 300 d.f.

Panel C. 95% Confidence Intervals equal to the sum of C.I.s in Panel B and twice the s.d.s of the variances in Panel A.

n	D	m=400		m=300	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
4	1.5	$.796\ s^2$	$1.243\ s^2$	$.816\ s^2$	$1.210\ s^2$
5	1.2	$.830\ s^2$	$1.209\ s^2$	$.850\ s^2$	$1.176\ s^2$
6	1.0	$.842\ s^2$	$1.197\ s^2$	$.862\ s^2$	$1.164\ s^2$
7	.86	$.858\ s^2$	$1.181\ s^2$	$.878\ s^2$	$1.148\ s^2$
8	.75	$.866\ s^2$	$1.173\ s^2$	$.886\ s^2$	$1.140\ s^2$
∞	0	$.878\ s^2$	$1.161\ s^2$	$.898\ s^2$	$1.128\ s^2$

MEAN NP PER DIGIT#, AVERAGED OVER C, U, AND S. TABLE 71

CONDITION		DIGIT											
S	SOA	0	1	2	3	4	5	6	7	8	9	MEAN	CHI^2
		PANEL A: RECALL 4											
AR	75	4.26	5.25	4.27	4.28	3.76	4.08	4.20	4.29	4.37	4.30	4.31	10.7
	109	4.30	3.51	4.23	4.41	4.50	4.46	4.38	4.06	4.20	4.33	4.24	11.8
	144	4.49	4.44	4.55	4.27	4.01	4.49	4.34	4.06	4.16	4.44	4.32	9.5
	214	4.10	4.59	4.49	4.29	4.03	4.14	4.33	4.22	4.41	4.69	4.33	12.0
GL	75	4.26	4.50	4.64	4.11	4.06	4.15	3.94	4.13	4.23	4.40	4.24	5.0
	109	4.50	2.08	4.18	4.51	4.41	4.53	5.19	4.62	4.32	4.60	4.30	39.2*
	144	4.53	5.44	4.00	4.43	4.49	4.32	4.67	4.72	4.14	4.73	4.55	15.9
	214	4.09	4.14	4.40	3.79	4.68	4.67	4.76	4.47	4.17	4.00	4.32	17.5*
AK	109	4.21	4.33	4.07	4.30	3.91	4.27	4.25	4.09	3.88	4.44	4.18	7.8
	144	4.35	3.88	4.24	4.46	4.07	4.13	4.25	4.52	4.02	4.39	4.23	7.5
	178	4.07	3.84	4.23	4.58	4.27	4.40	3.87	4.13	3.92	4.25	4.16	11.8
		PANEL B: RECALL 1											
AR	75	4.14	3.64	3.51	4.03	3.87	4.11	4.22	4.17	4.36	4.57	4.06	15.5
	109	4.08	4.15	3.87	4.60	4.37	4.46	4.95	4.24	4.14	4.17	4.30	22.1*
GL	75	4.04	4.17	3.89	3.85	4.18	3.83	3.35	4.19	4.21	4.09	3.98	15.4
	109	4.43	4.13	4.50	4.32	4.32	4.39	4.75	4.33	4.07	4.32	4.36	5.9
AK	109	4.92	3.59	4.31	4.43	4.43	4.61	4.47	4.77	4.43	4.58	4.45	11.7
	144	4.47	4.55	4.79	4.24	4.52	4.44	4.65	4.45	4.07	5.10	4.53	16.4

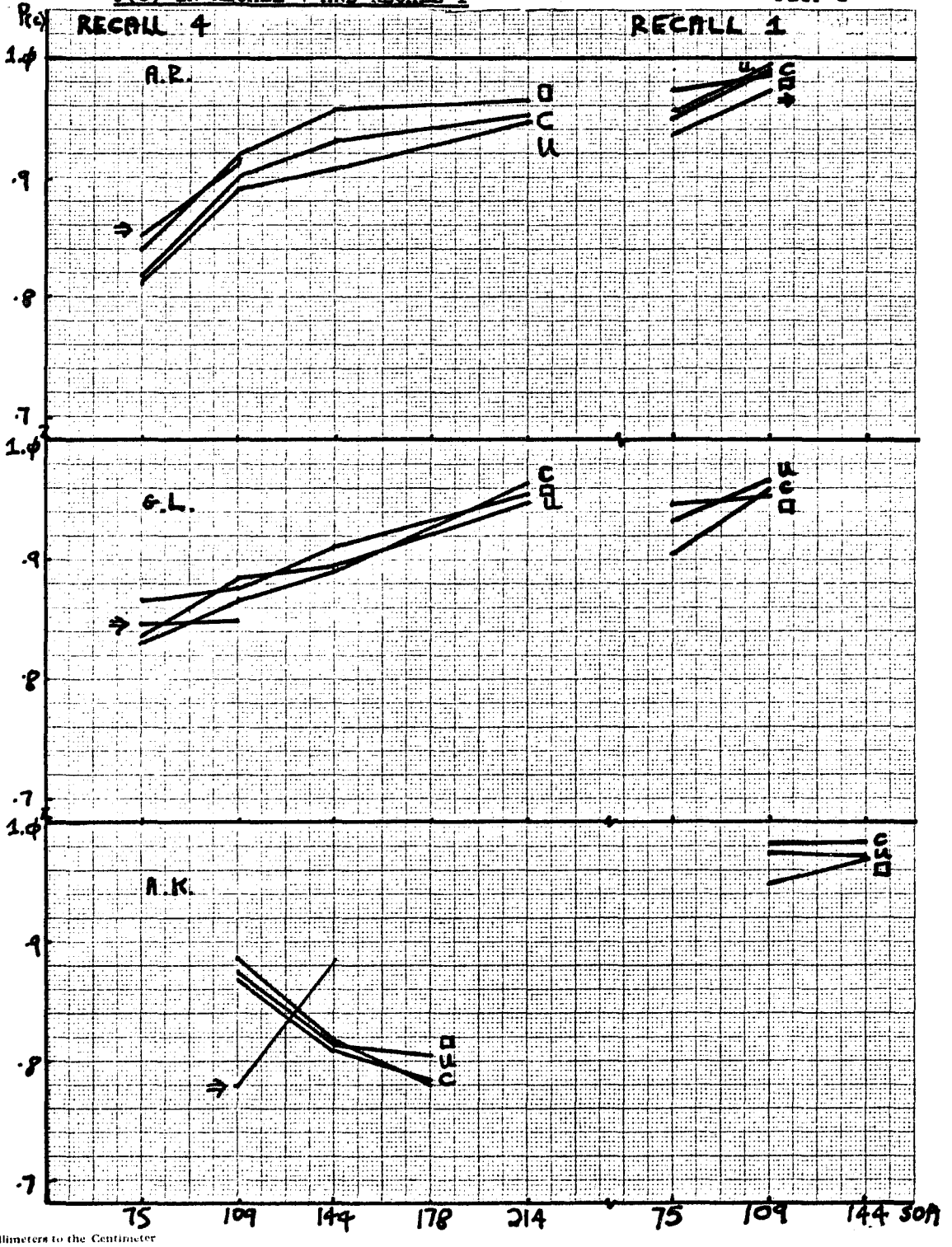
*Reject equality of row entries at .05 or better (Chi^2 with 9 d.f.).

\# $\overline{NP}_x$ = Mean NP per Digit x

$$= \sum_1 1 \cdot P(NP=1 \mid \text{Digit in } NP=x)$$

$\overline{NP}_x$ has been computed seperately for each condition of SOA, without regard for the CC. (One may compute $\overline{NP}_x$ for each condition of CC and SOA, and then average the resulting values over the CCs. Because the number of observations at each value of x are not the same over CCs, the two methods of finding $\overline{NP}_x$ produce slightly different results.)

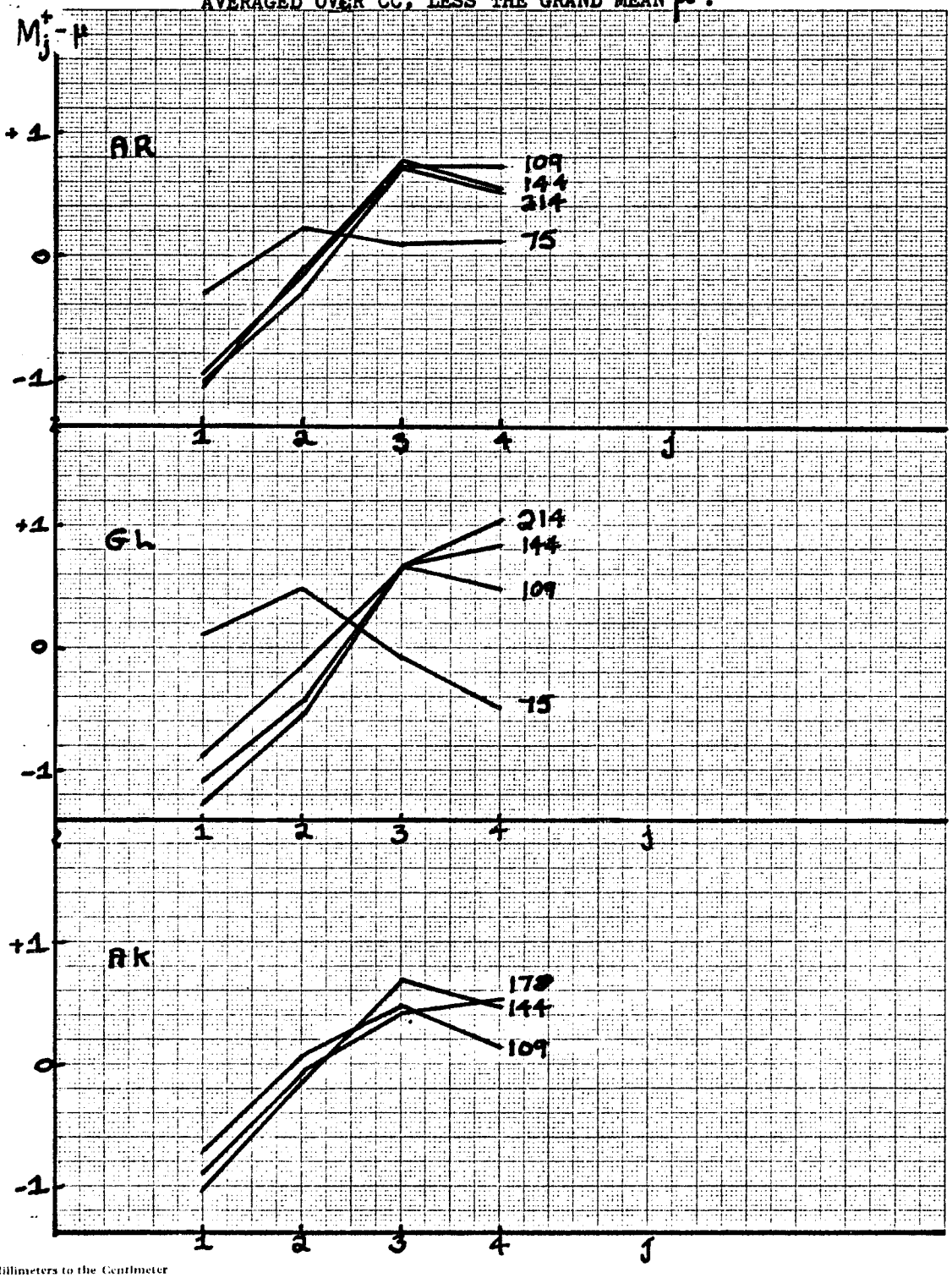
P(c) IN RECALL 4 AND RECALL 1 FIG. 1



10 Millimeters to the Centimeter

MEAN RESPONSE M_j^+ TO THE POSITIVE SET IN RECALL 4, AVERAGED OVER CC, LESS THE GRAND MEAN μ.

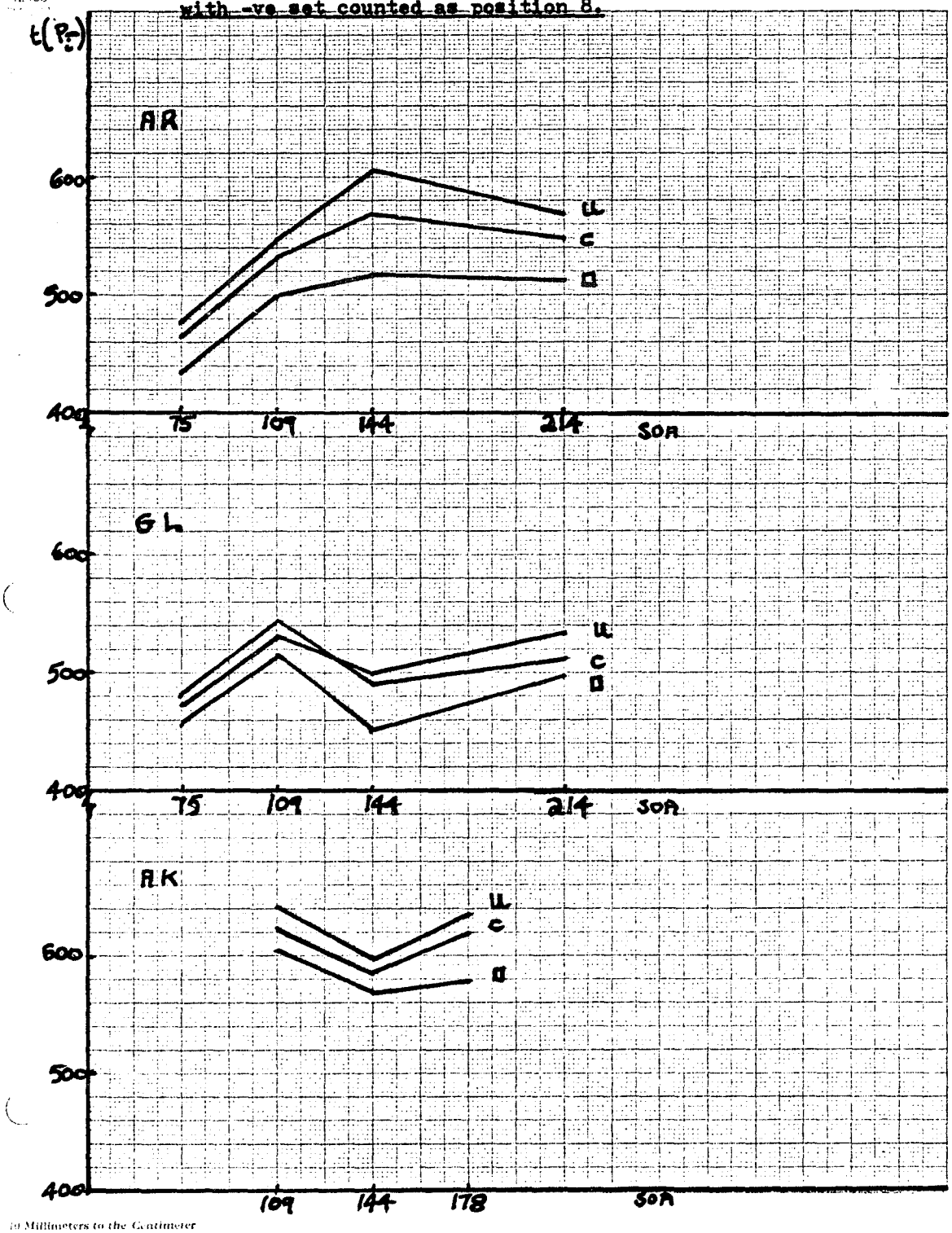
FIG. 2



10 Millimeters to the Centimeter

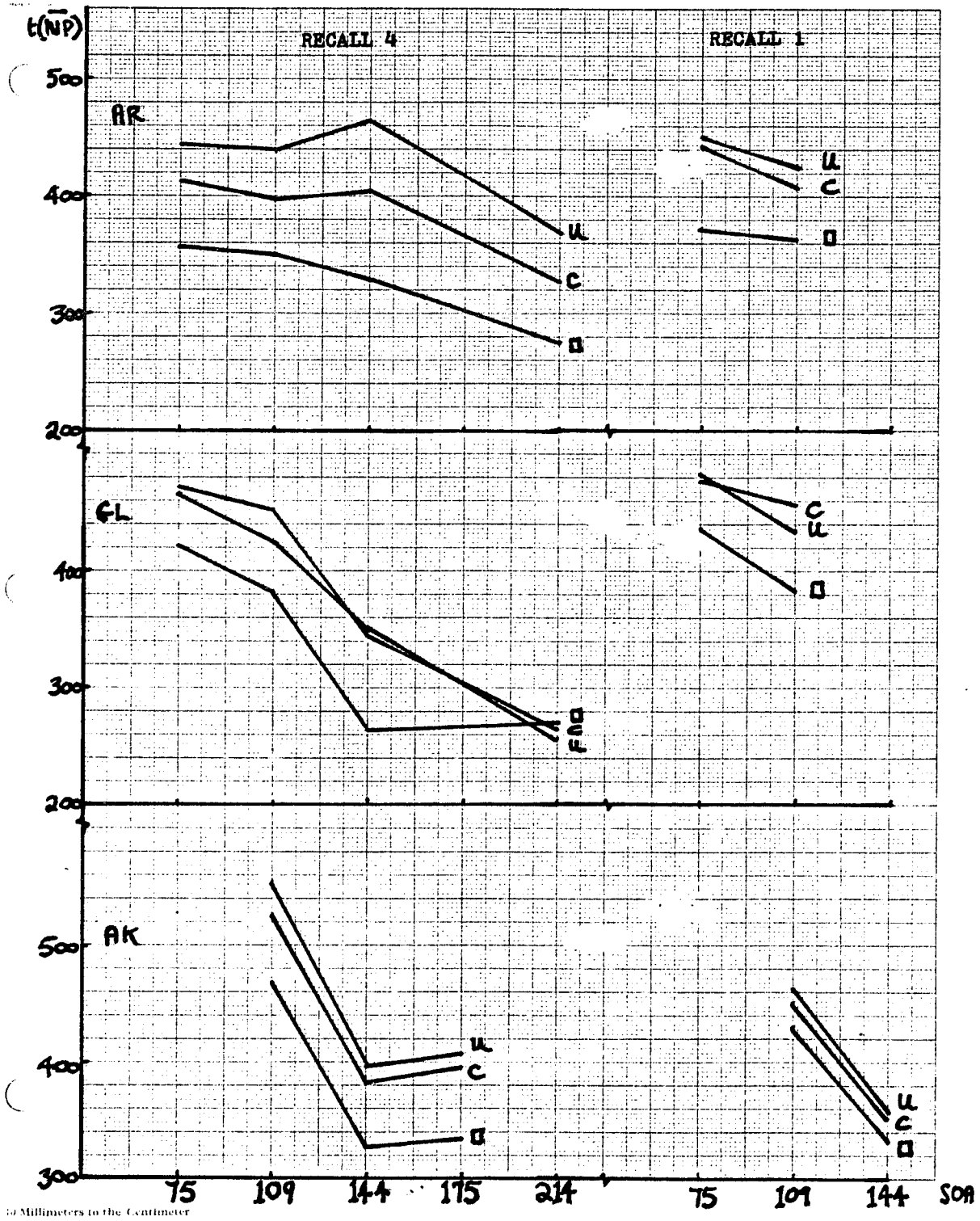
$t(P_T)$: MEAN RESPONSE IN RECALL 4 with -ve set counted as position 8.

FIG. 3

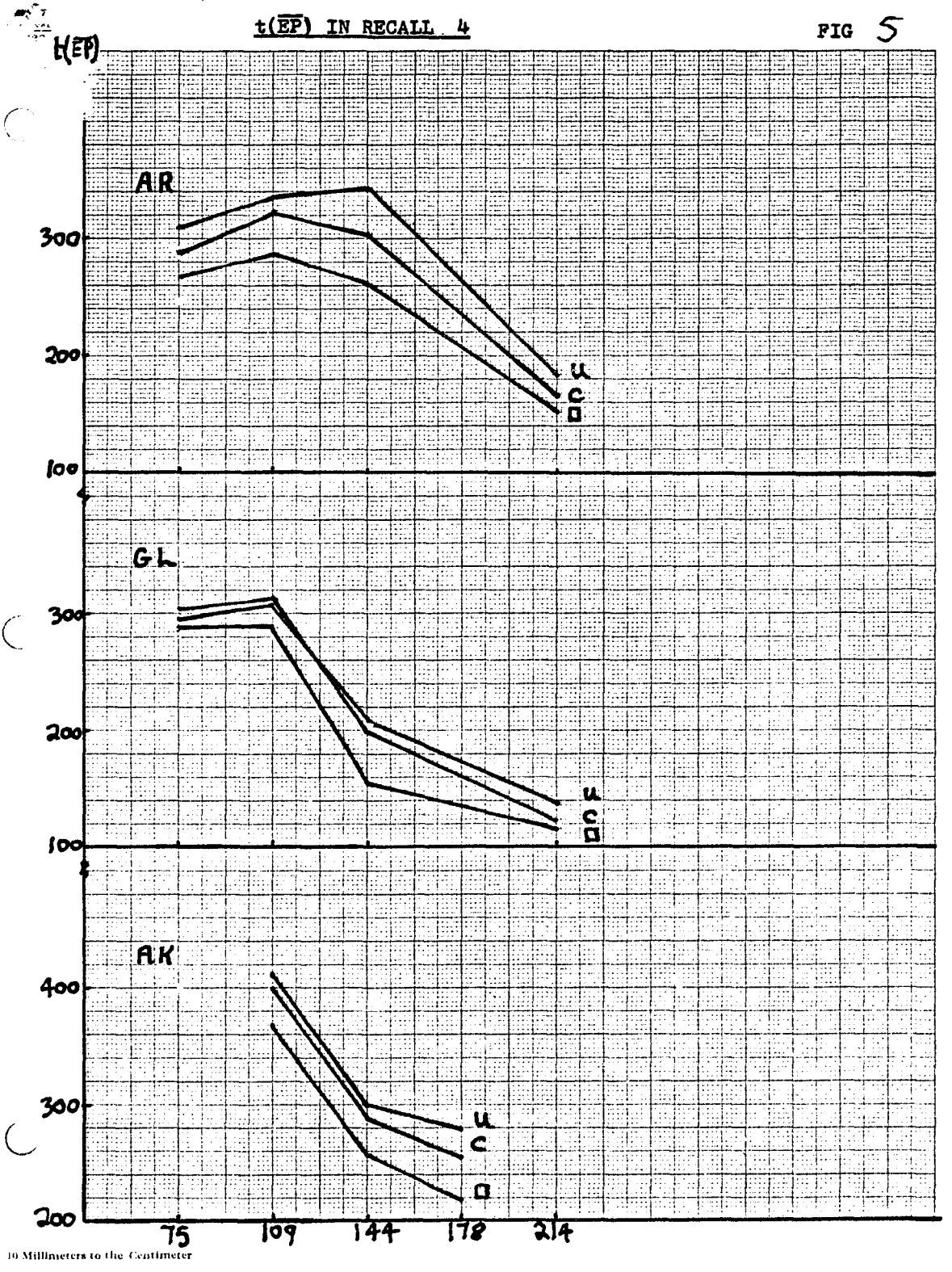


10 Millimeters to the Centimeter

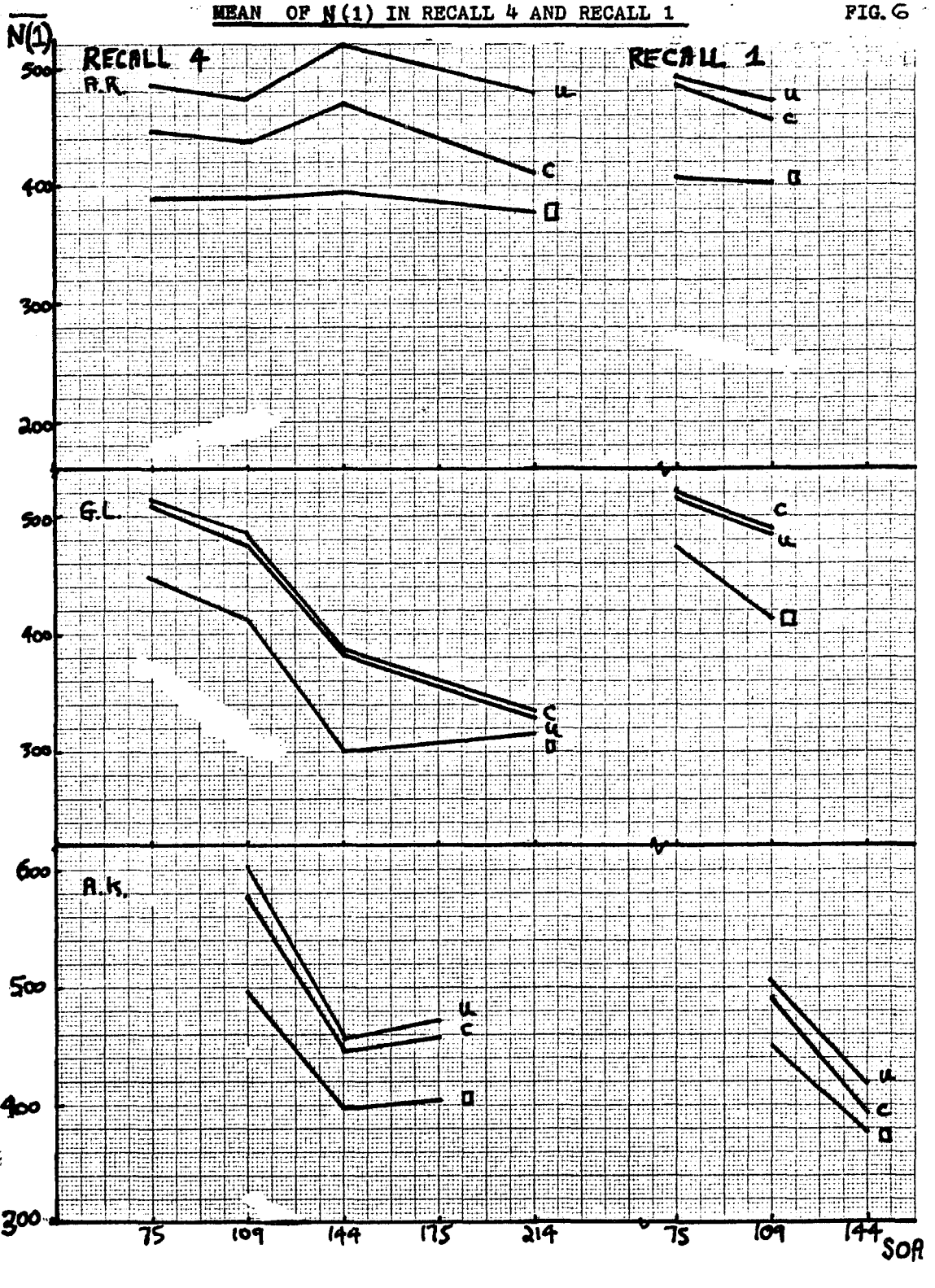
t(NP) IN RECALL 4 AND RECALL 1 FIG 4



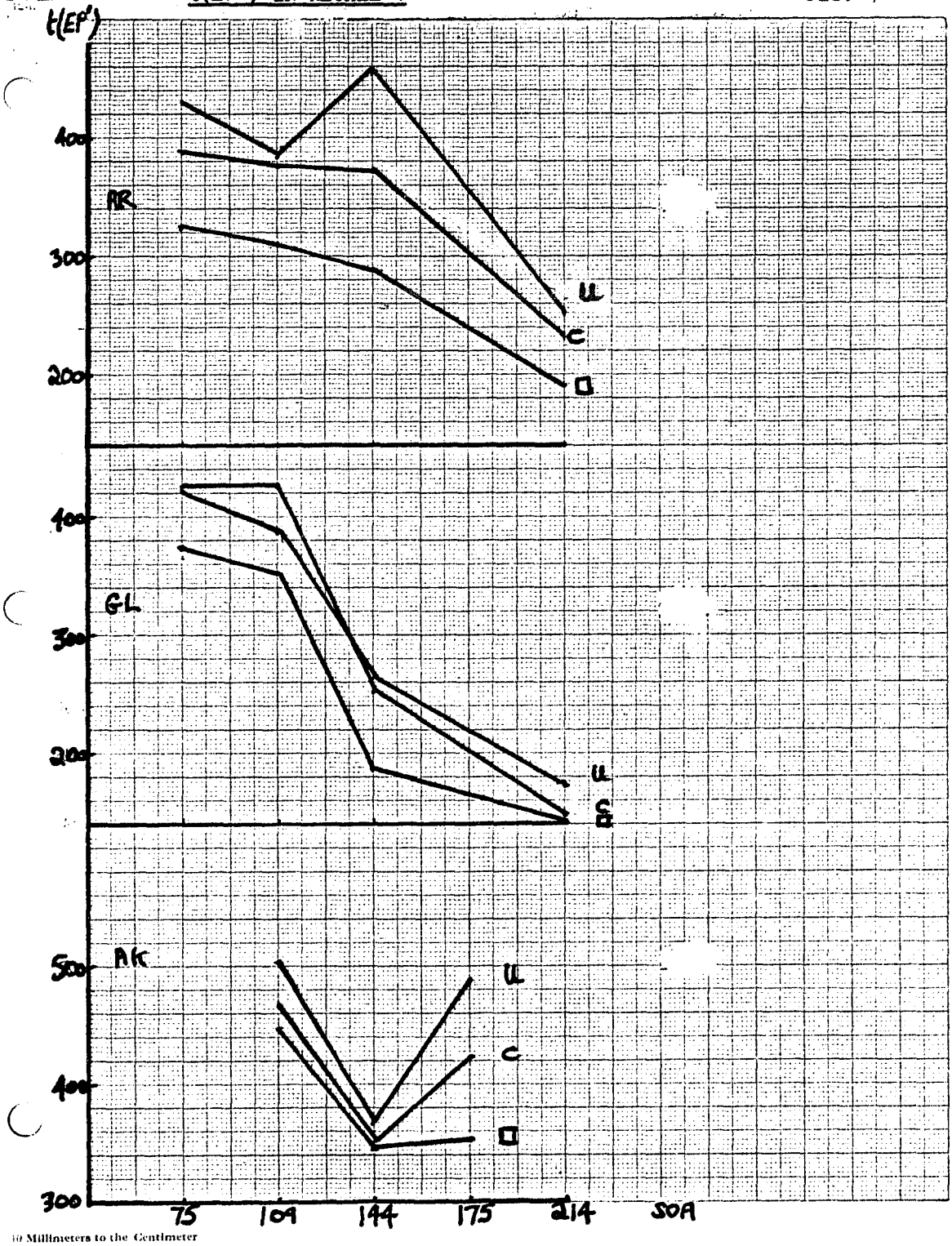
10 Millimeters to the Centimeter


t(EP) IN RECALL 4
FIG 5
t(EP)
AR
300
200
100
u
c
a
GL
300
200
100
u
c
a
AK
400
300
200
u
c
a
75
109
144
178
214
10 Millimeters to the Centimeter

MEAN OF N(1) IN RECALL 4 AND RECALL 1 FIG. 6

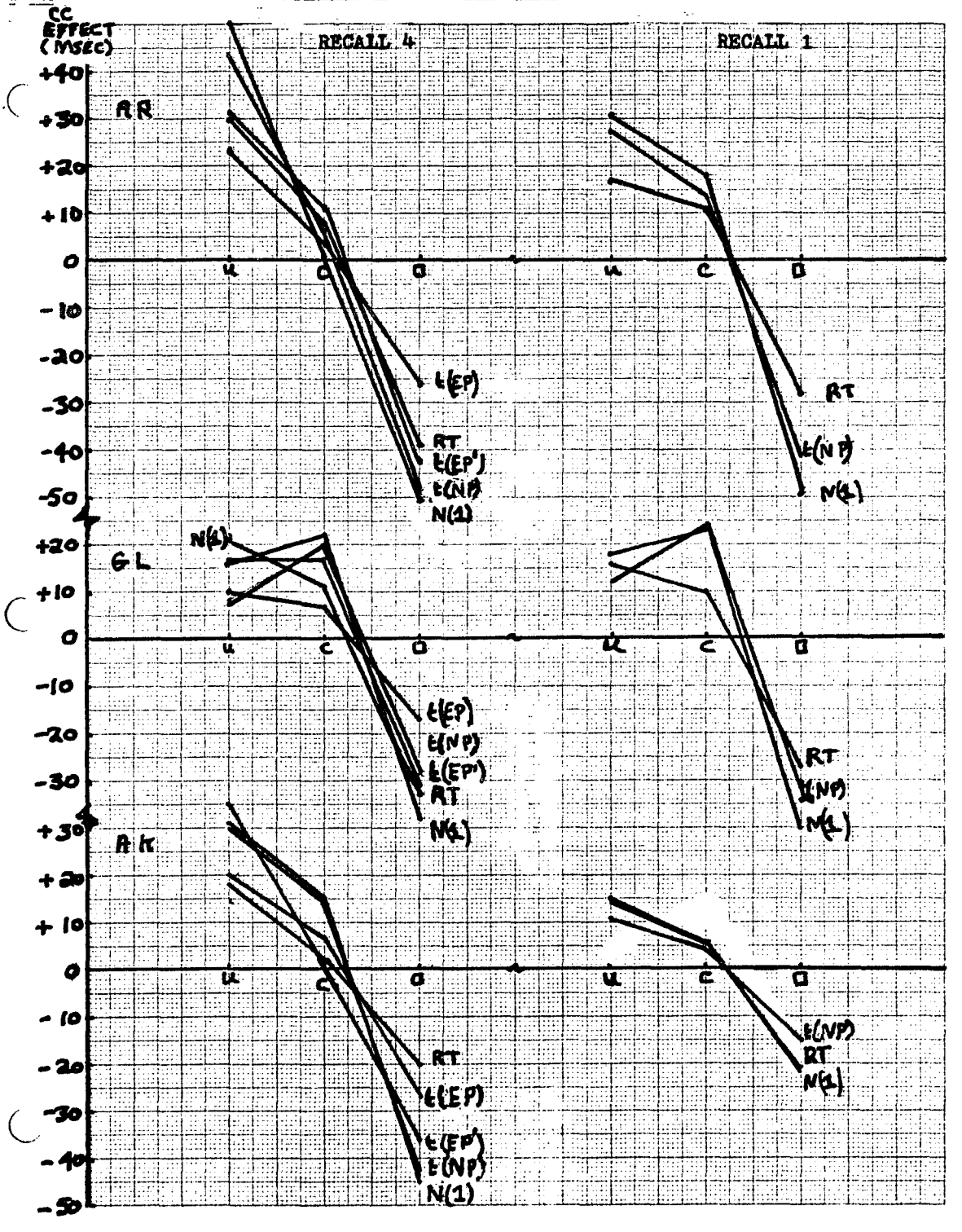


t($\overline{EF}$') IN RECALL 4 FIG. 7



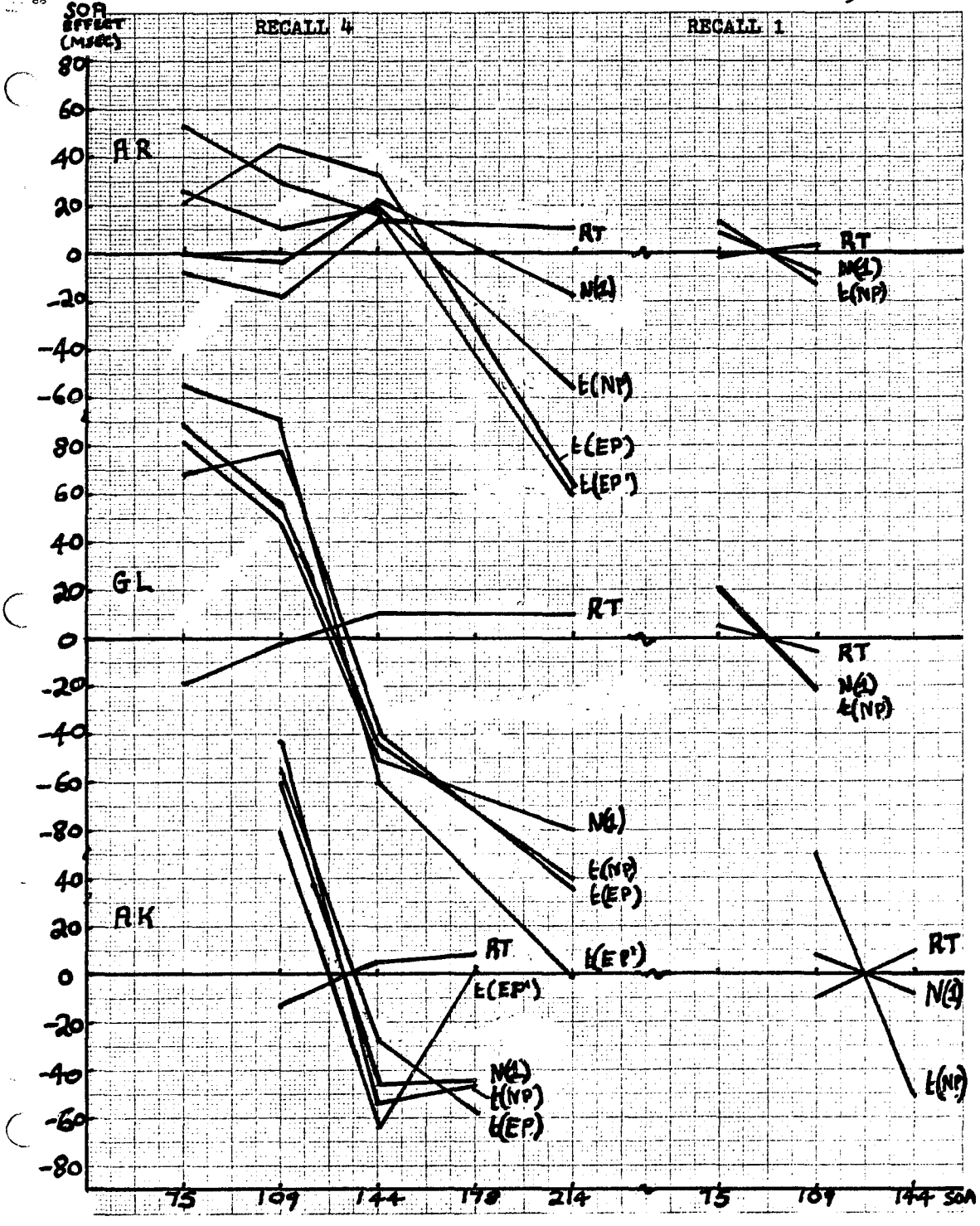
10 Millimeters to the Centimeter

CC EFFECT ON LATENCY MEASURES. FIG. 8



10 Millimeters to the Centimeter

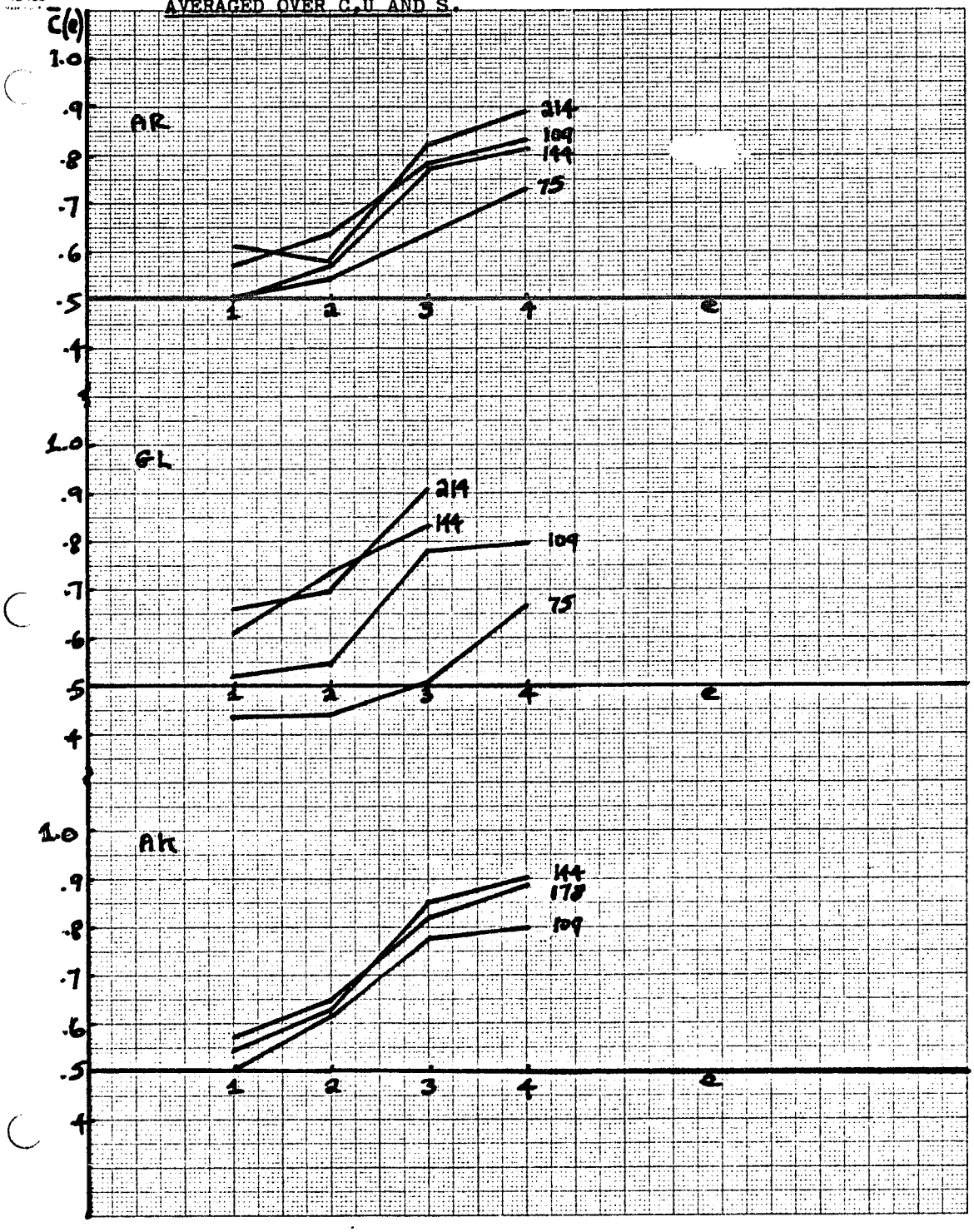
SOA EFFECT ON LATENCY MEASURES. FIG. 9



10 Millimeters to the Centimeter

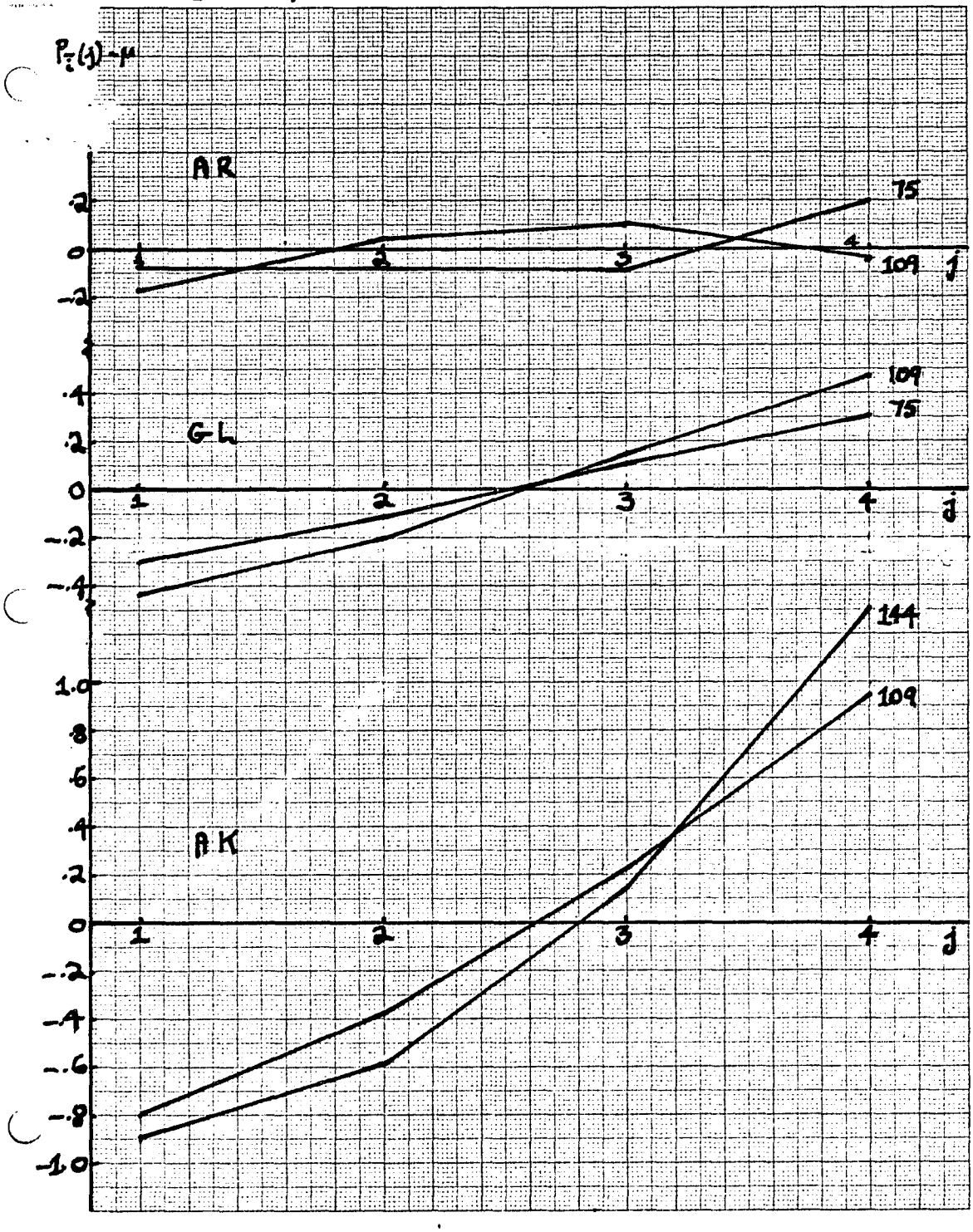
$\bar{C}(e)$ = MEAN CONCORDANCE | EP=e , IN RECALL 4, AVERAGED OVER C, U AND S.

FIG. 10



10 Millimeters to the Centimeter

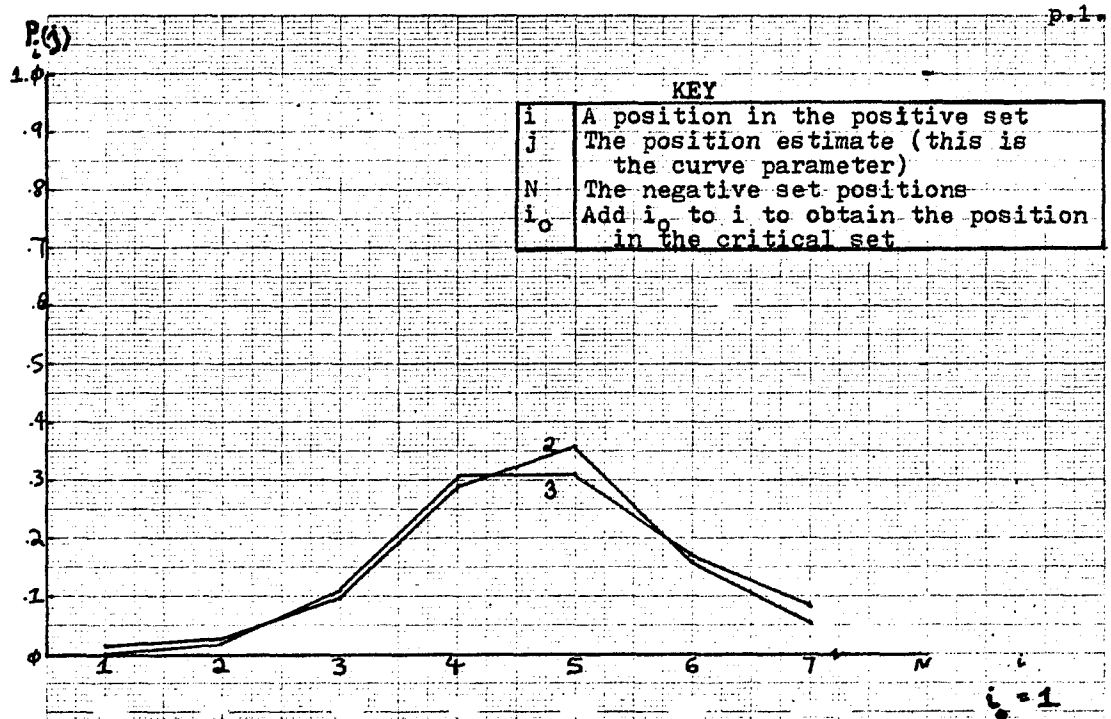
$P_I(j) - \mu$ IN RECALL 1 FIG. 11



10 Millimeters to the Centimeter

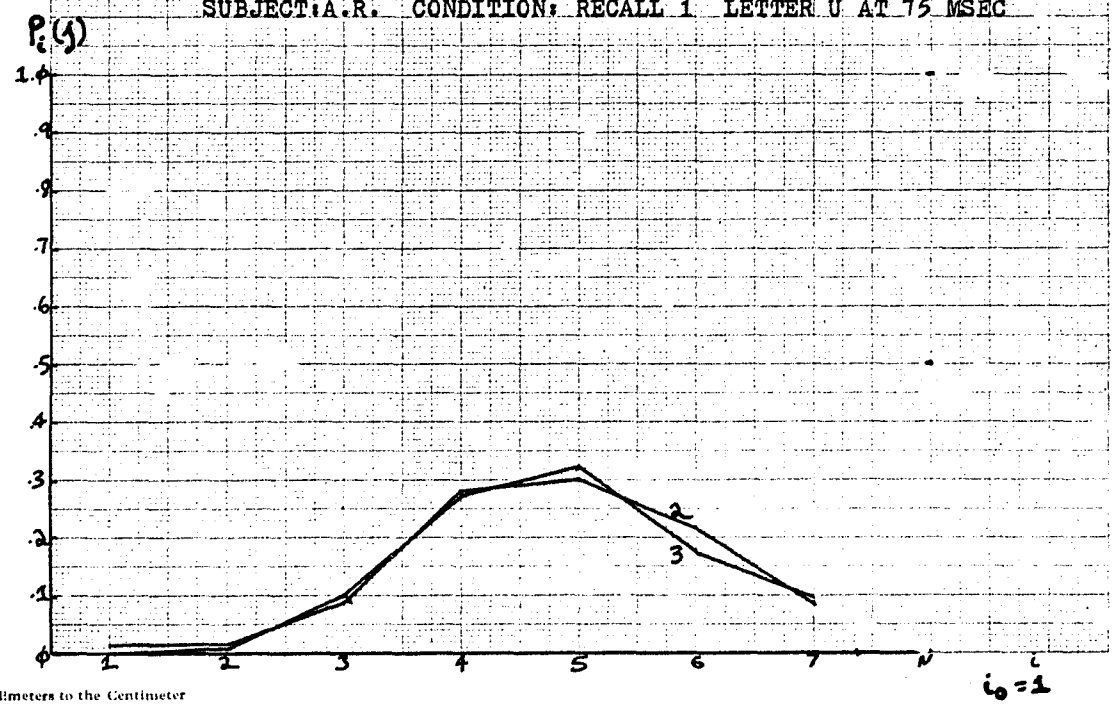
SUBJECT:A.R. CONDITION: RECALL 1 LETTER C AT 75 MSEC. FIG.12

p.1.



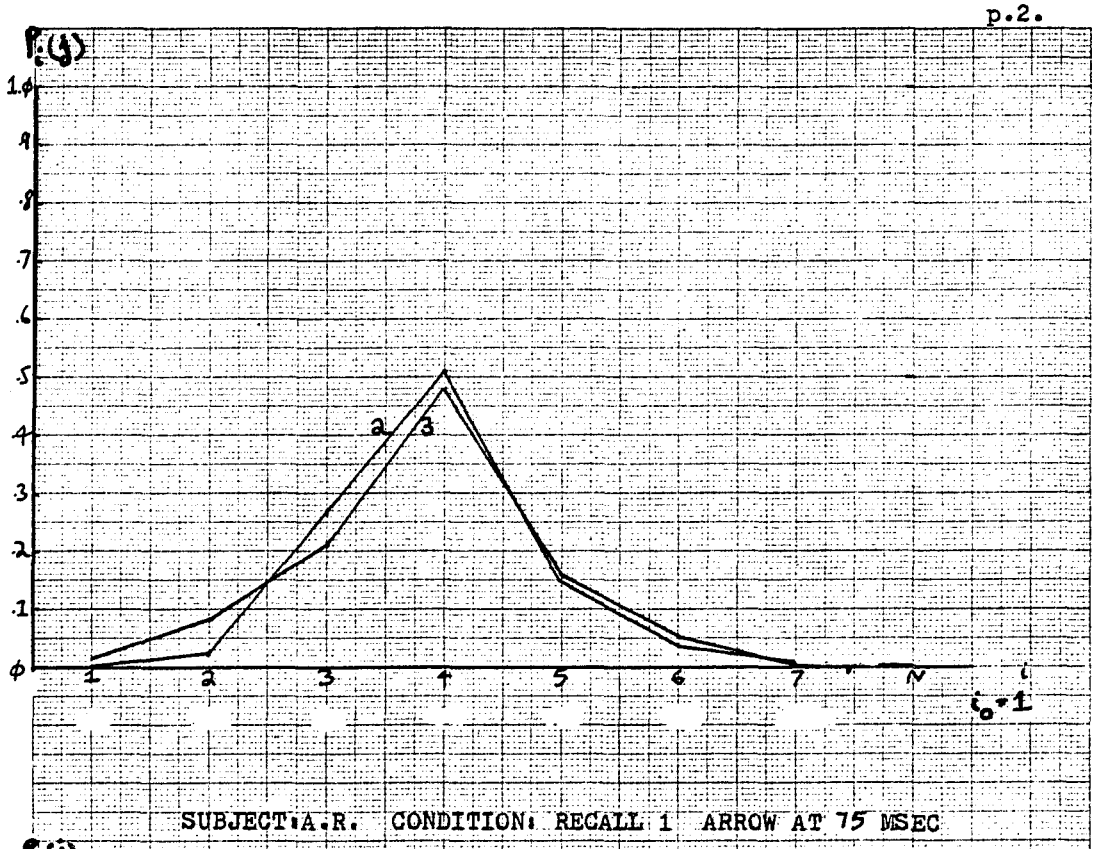
KEY	
i	A position in the positive set
j	The position estimate (this is the curve parameter)
N	The negative set positions
i_o	Add i_o to i to obtain the position in the critical set

SUBJECT:A.R. CONDITION: RECALL 1 LETTER U AT 75 MSEC

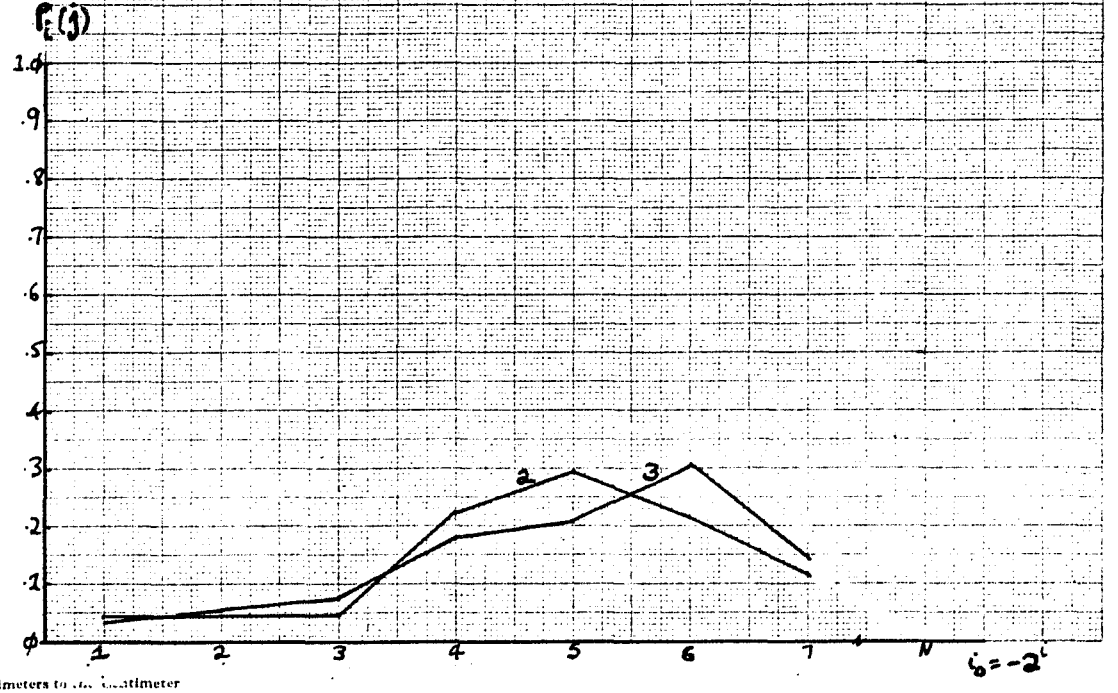


10 Millimeters to the Centimeter

SUBJECT:A.R. CONDITION: RECALL 1 SQUARE AT 75 MSEC. FIG.12. p.2.

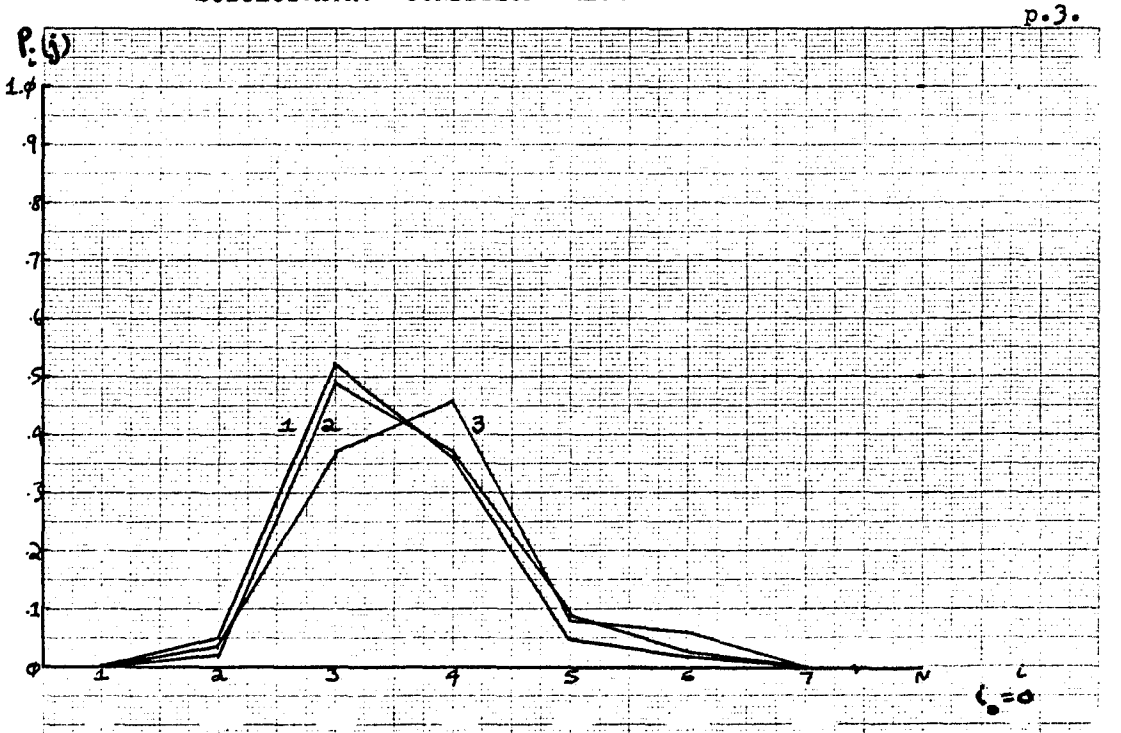


SUBJECT:A.R. CONDITION: RECALL 1 ARROW AT 75 MSEC

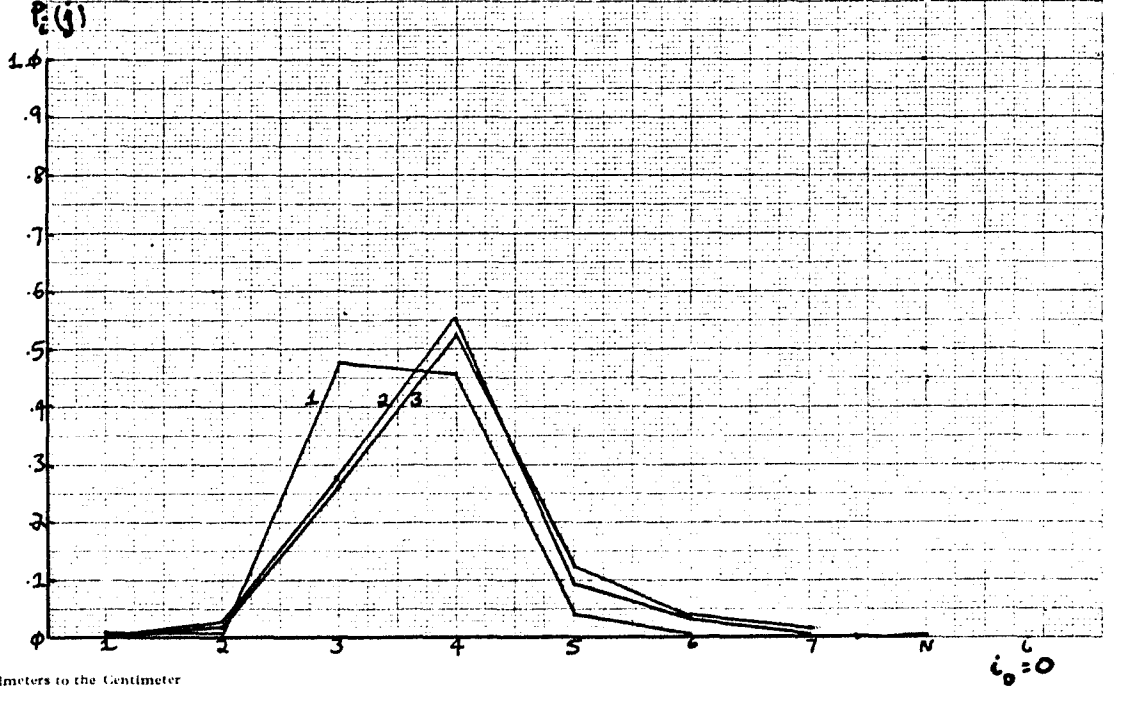


10 Millimeters to the Centimeter

SUBJECT:A.R. CONDITION: RECALL 1 LETTER C AT 109 MSEC. FIG.12.

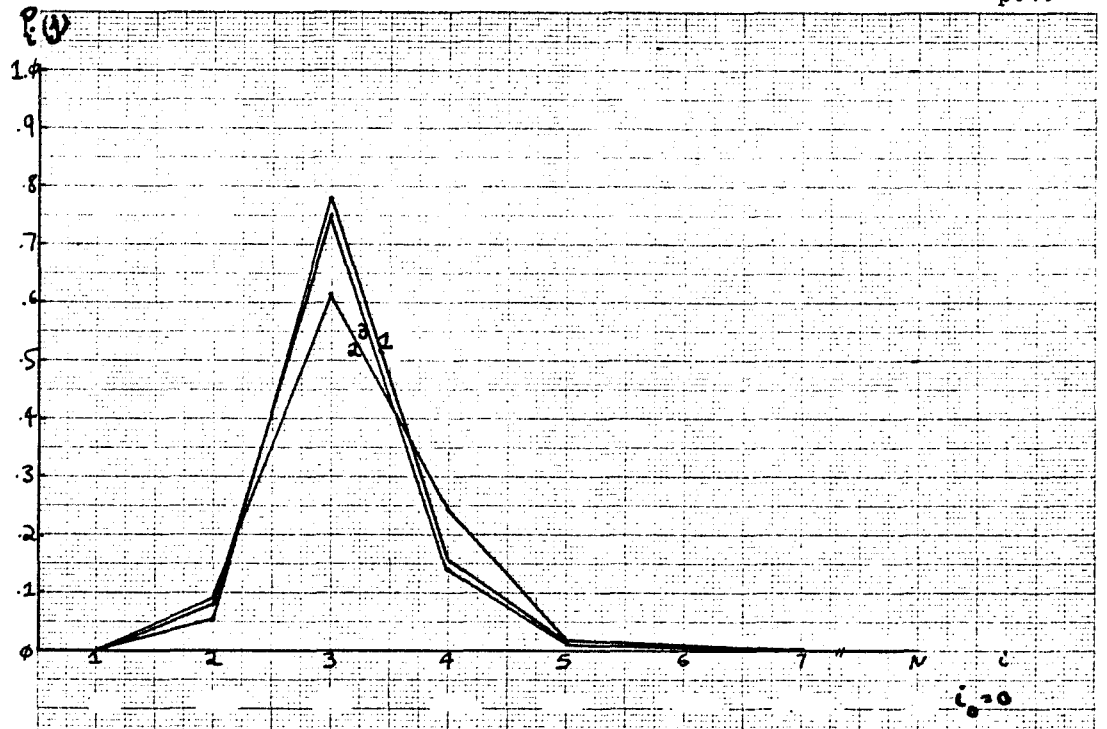


SUBJECT:A.R. CONDITION: RECALL 1 LETTER U AT 109 MSEC

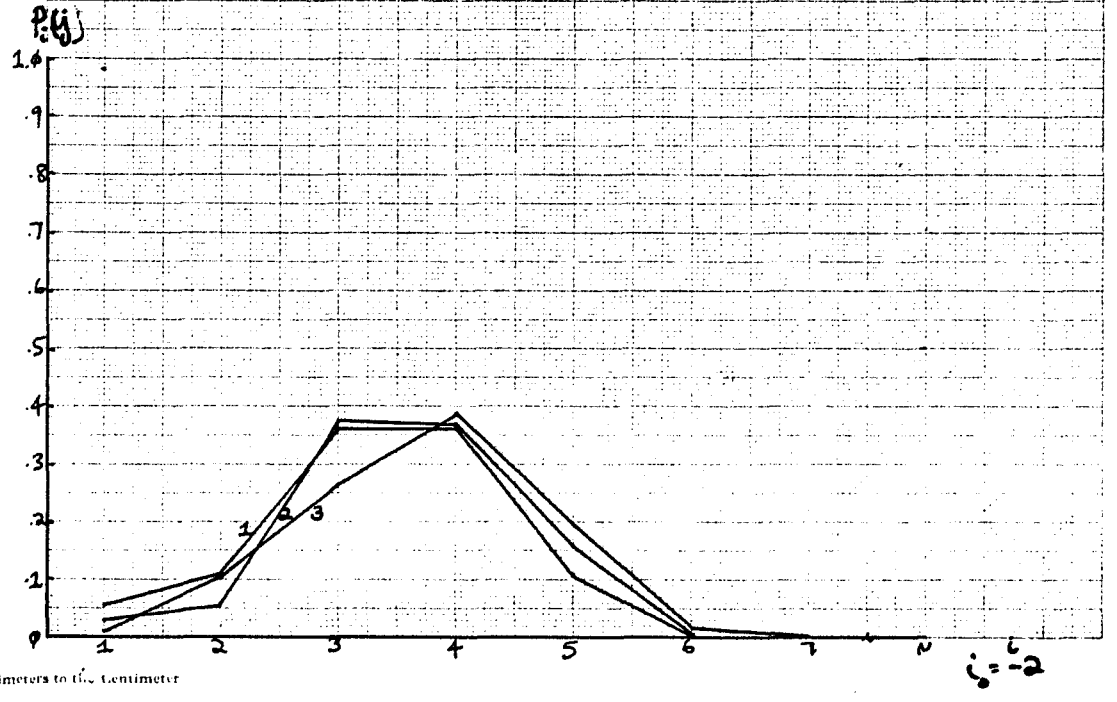


10 Millimeters to the Centimeter

SUBJECT:A.R. CONDITION: RECALL 1 SQUARE AT 109 MSEC. FIG. 12. p.4.

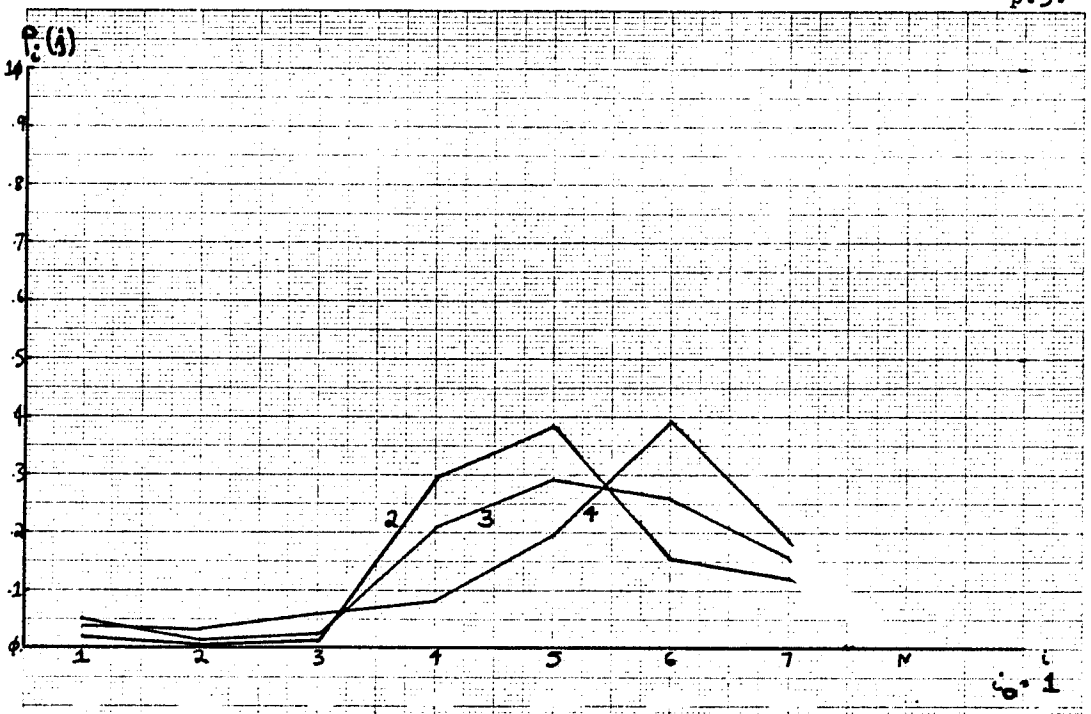


SUBJECT:A.R. CONDITION: RECALL 1 ARROW AT 109 MSEC

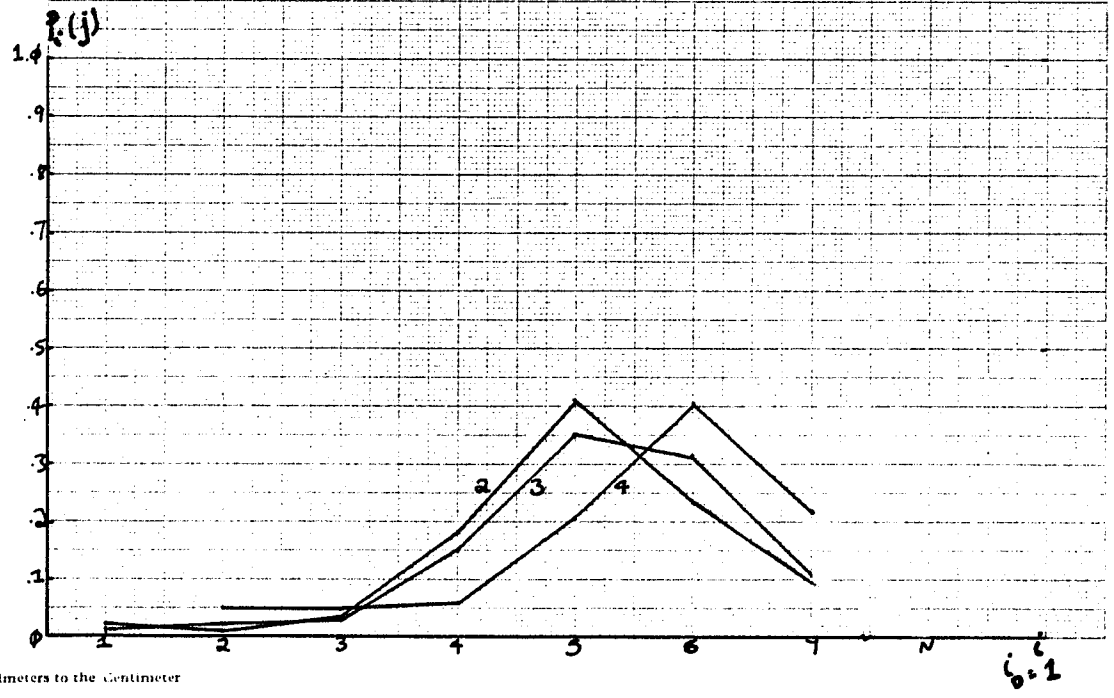


10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 LETTER C AT 75 MSEC. FIG.12.
p.5.

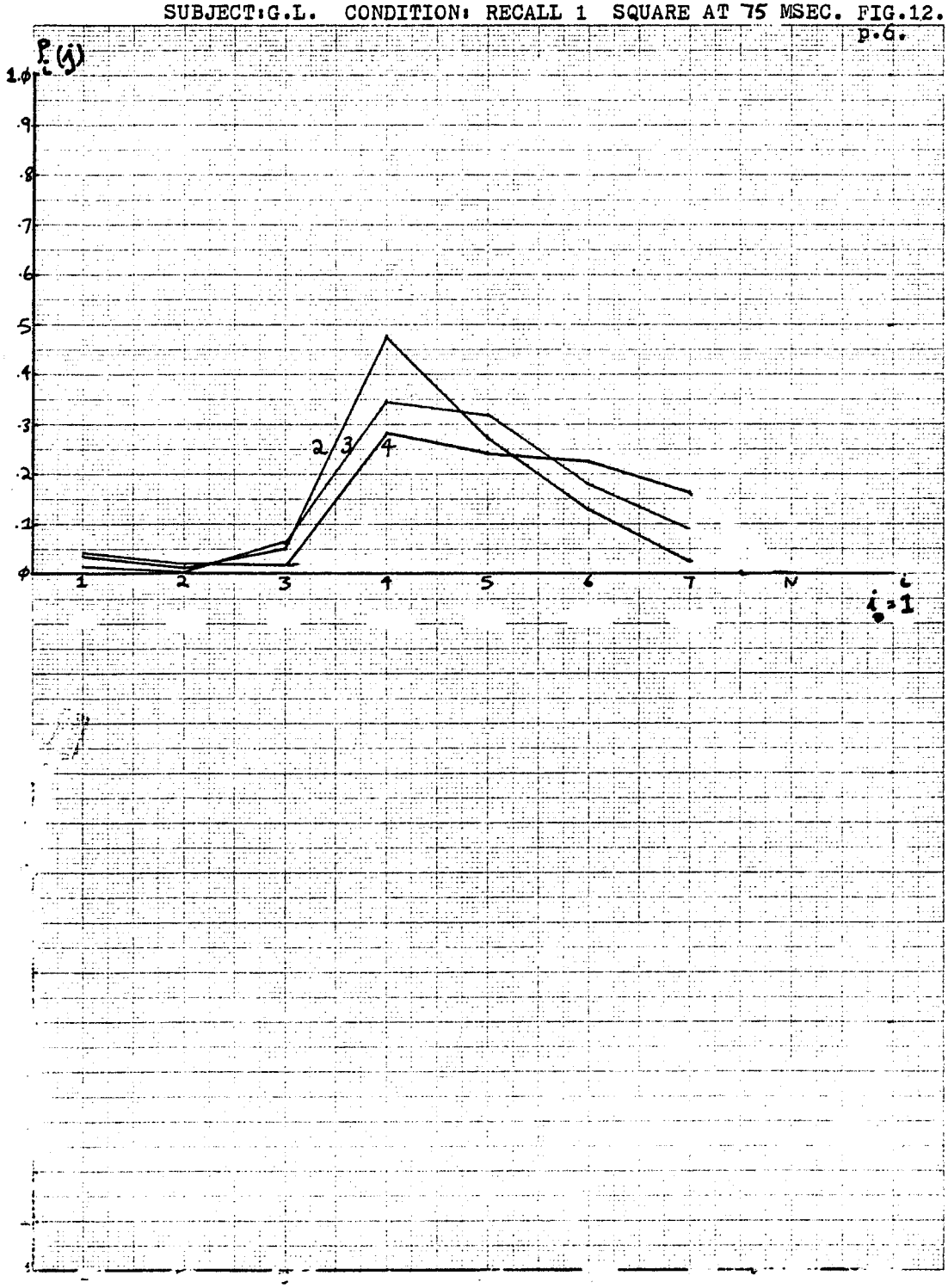


SUBJECT:G.L. CONDITION: RECALL 1 LETTER U AT 75 MSEC



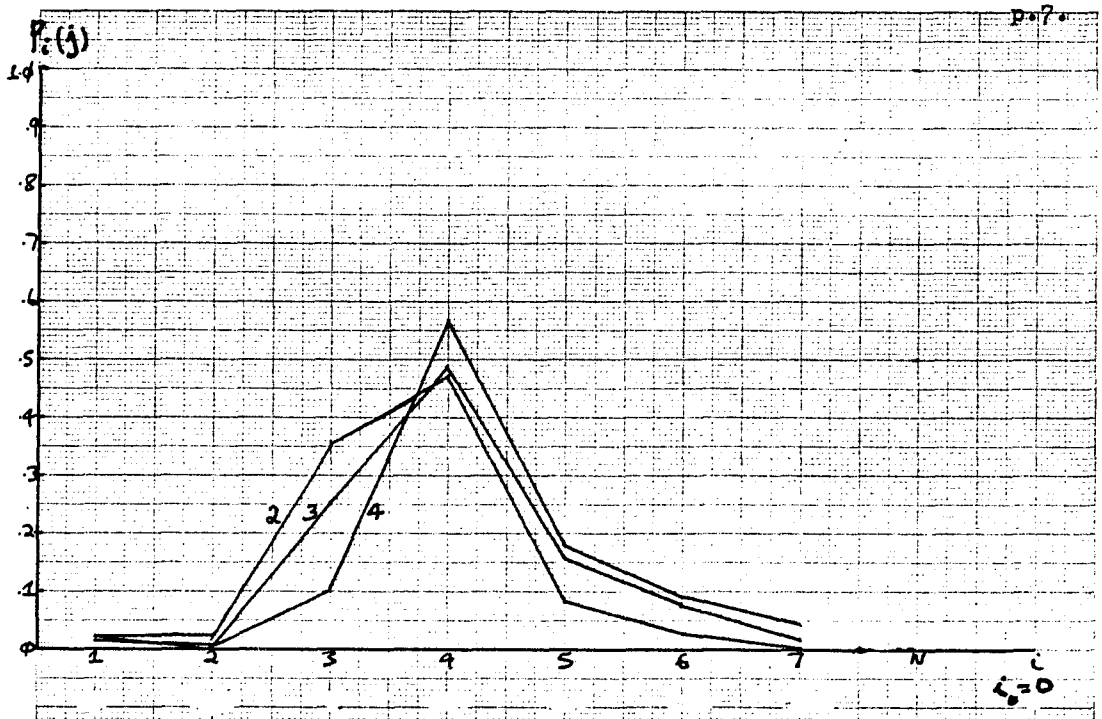
10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 SQUARE AT 75 MSEC. FIG.12.
p.6.

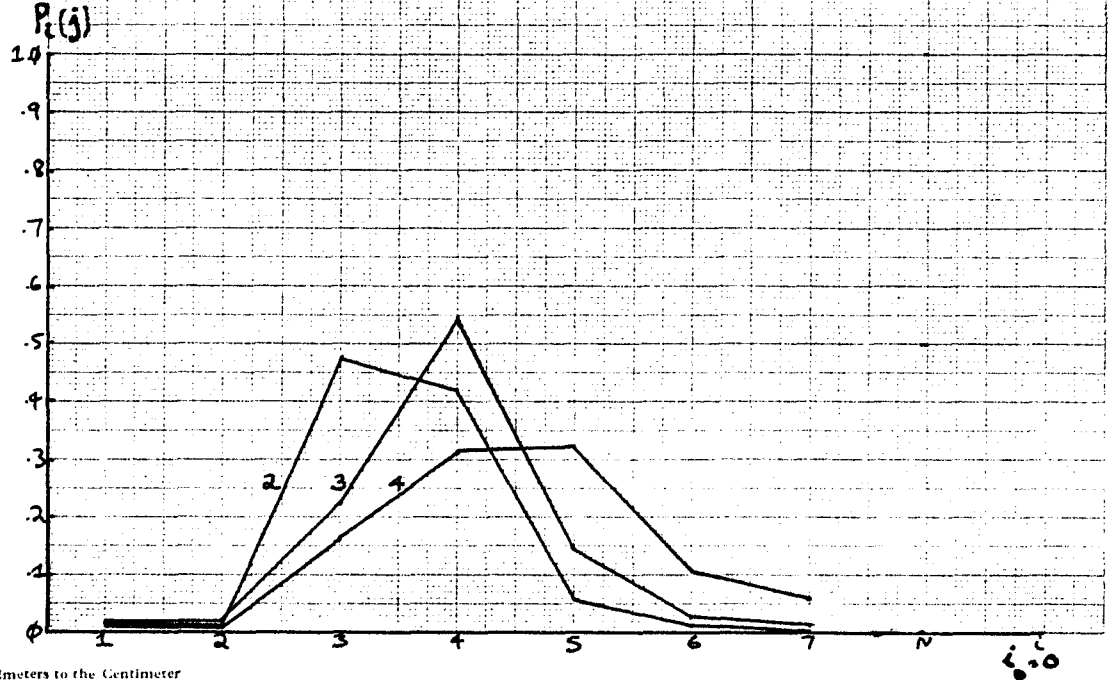


10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 LETTER C AT 109 MSEC. FIG.12.

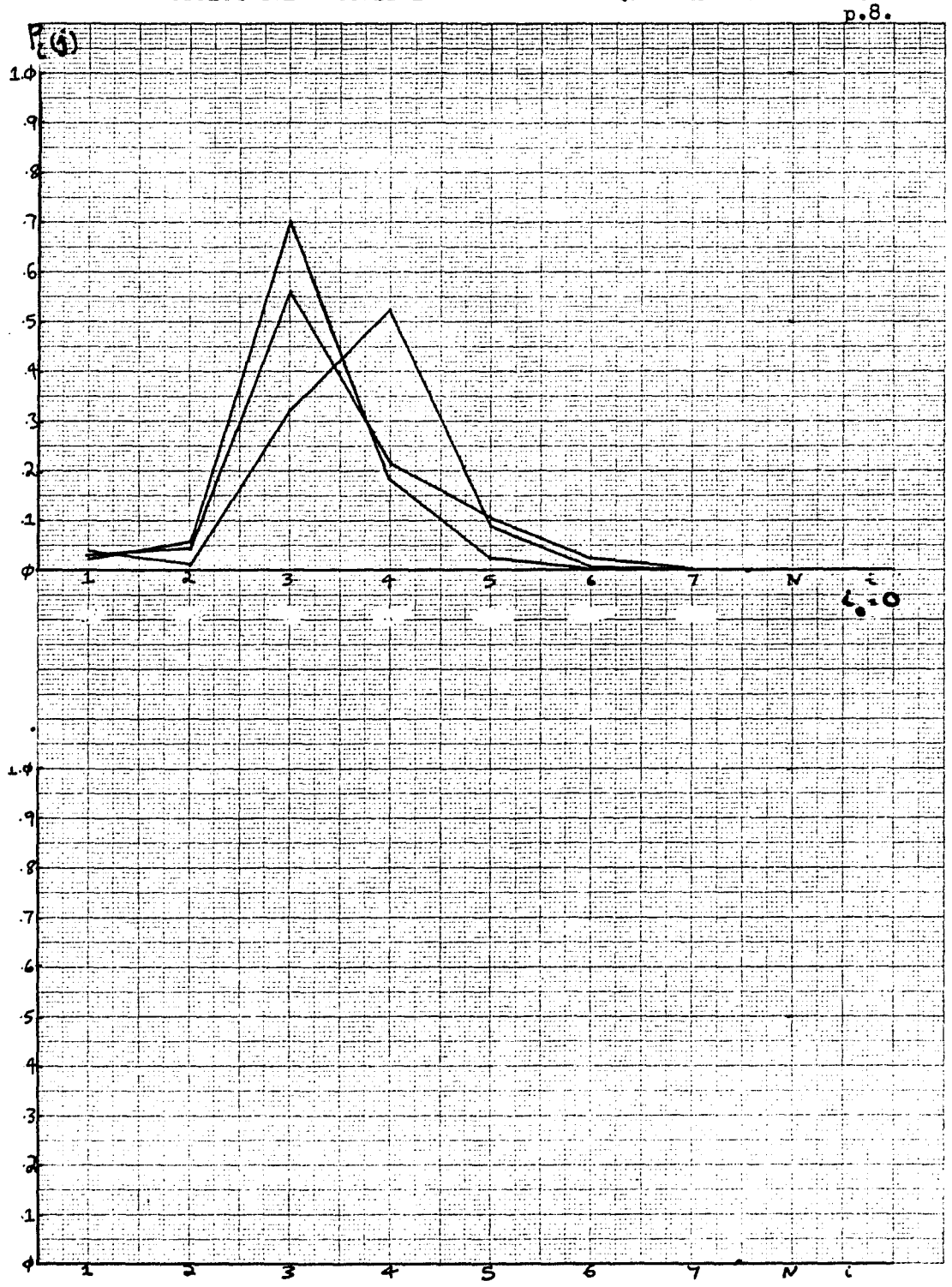


SUBJECT:G.L. CONDITION: RECALL 1 LETTER U AT 109 MSEC



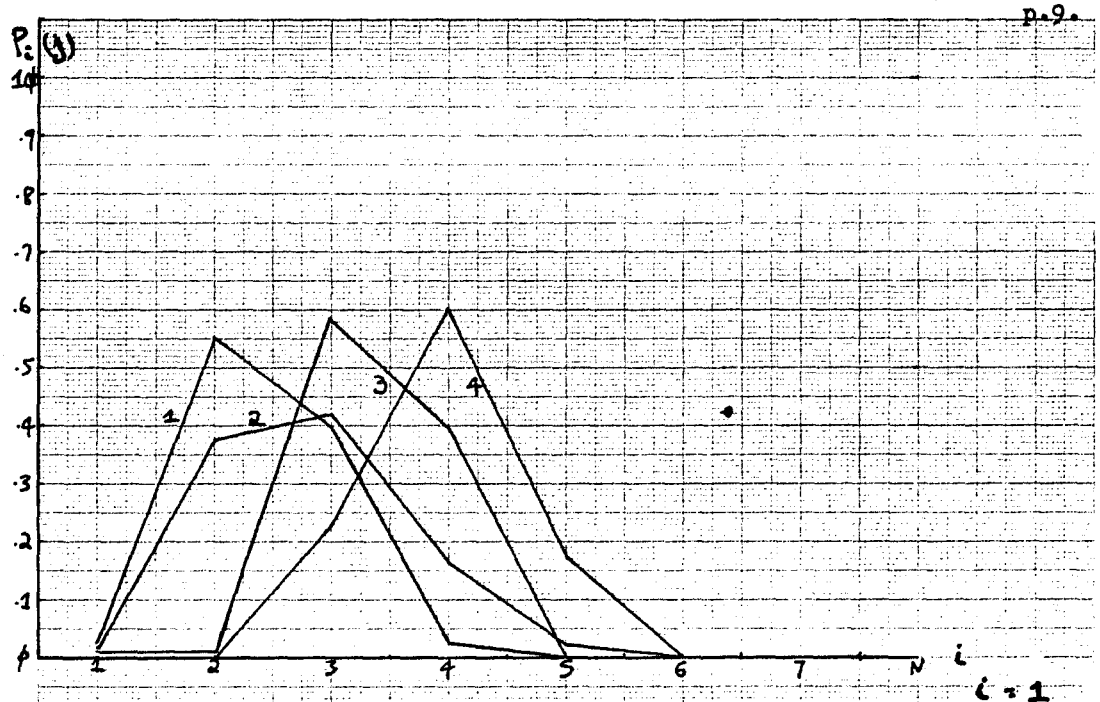
10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 SQUARE AT 109 MSEC. FIG.12.
p.8.

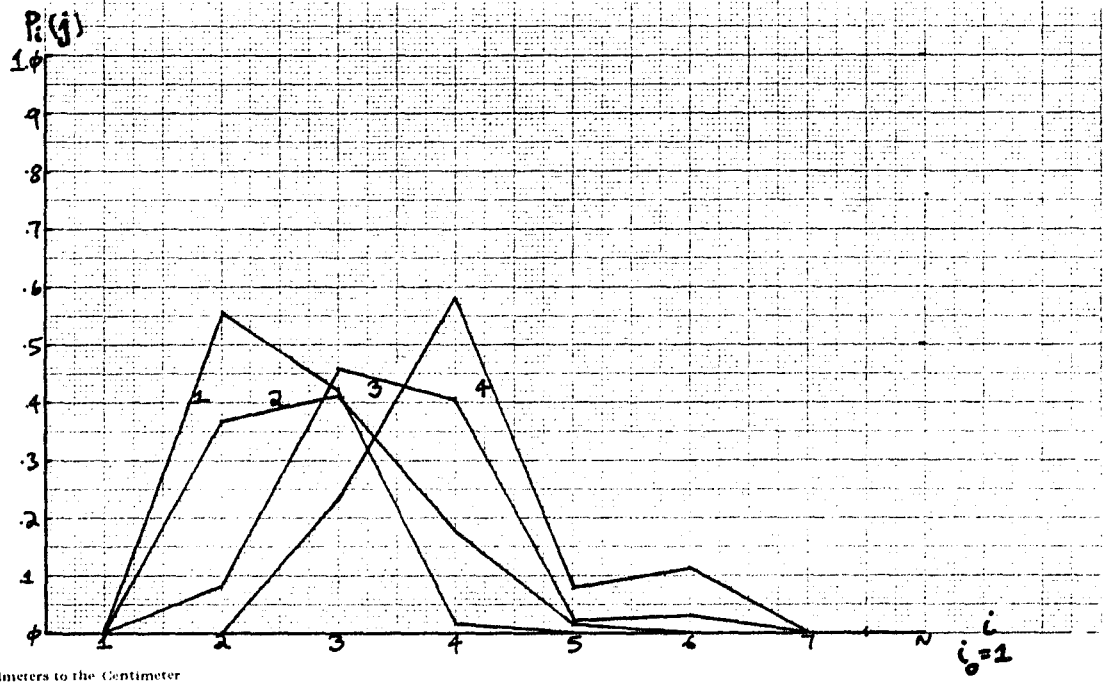


10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL 1 LETTER C AT 109MSEC. FIG. 12.

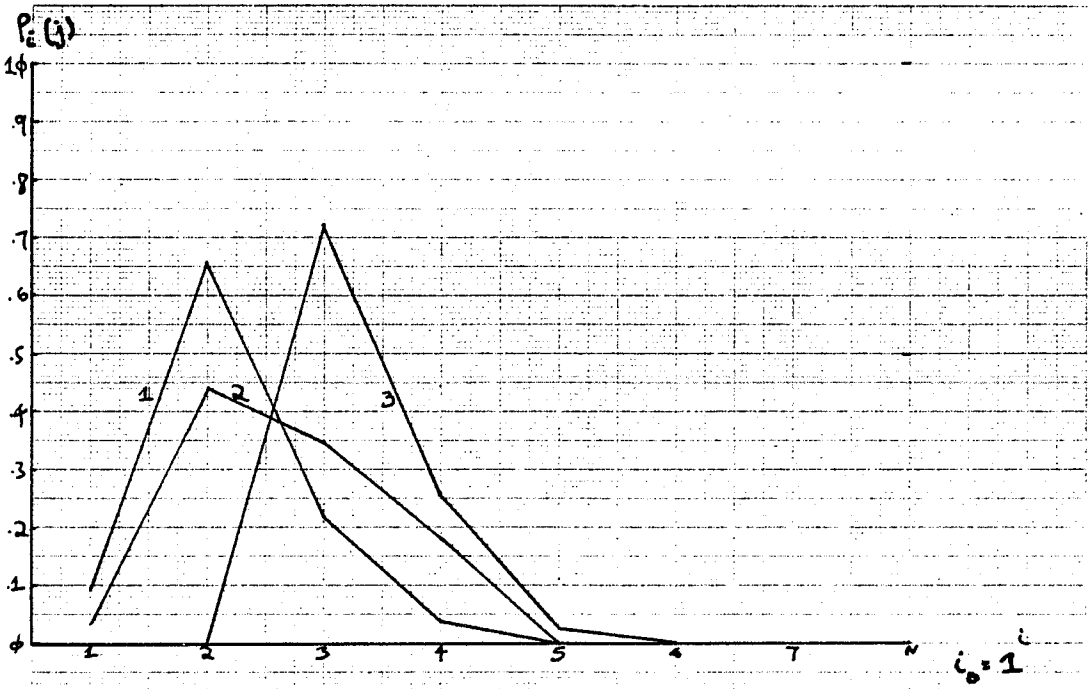


SUBJECT: A.K. CONDITION: RECALL 1 LETTER U AT 109 MSEC



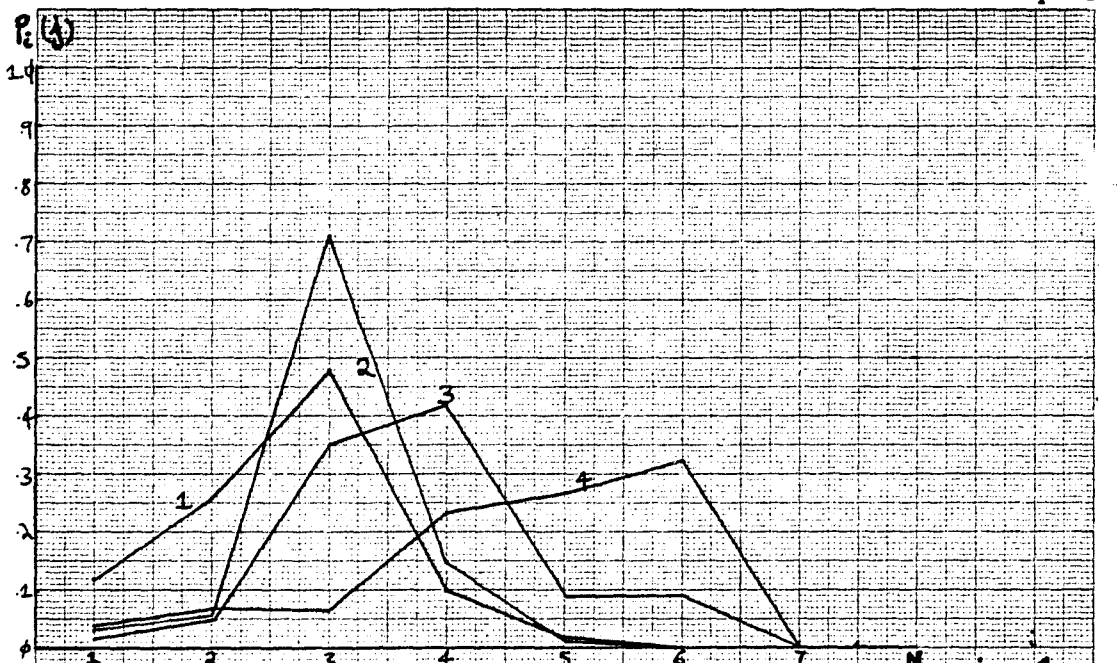
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL 1 SQUARE AT 109MSEC.FIG.12
p.10.

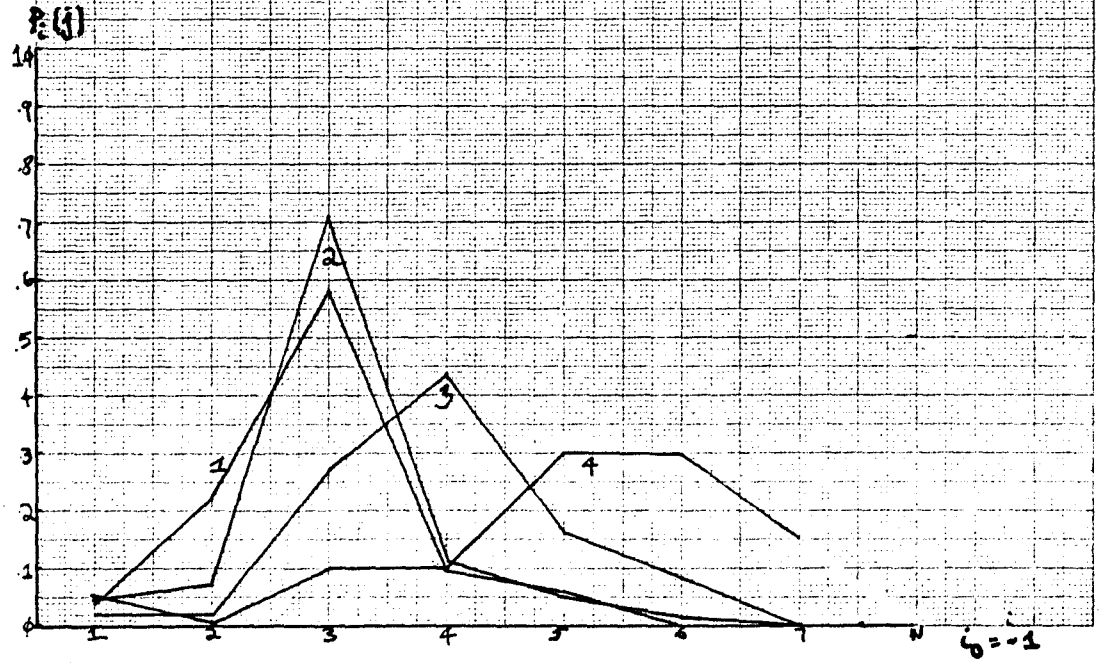


10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL 1 LETTER C AT 144 MSEC. FIG.12
p.11.

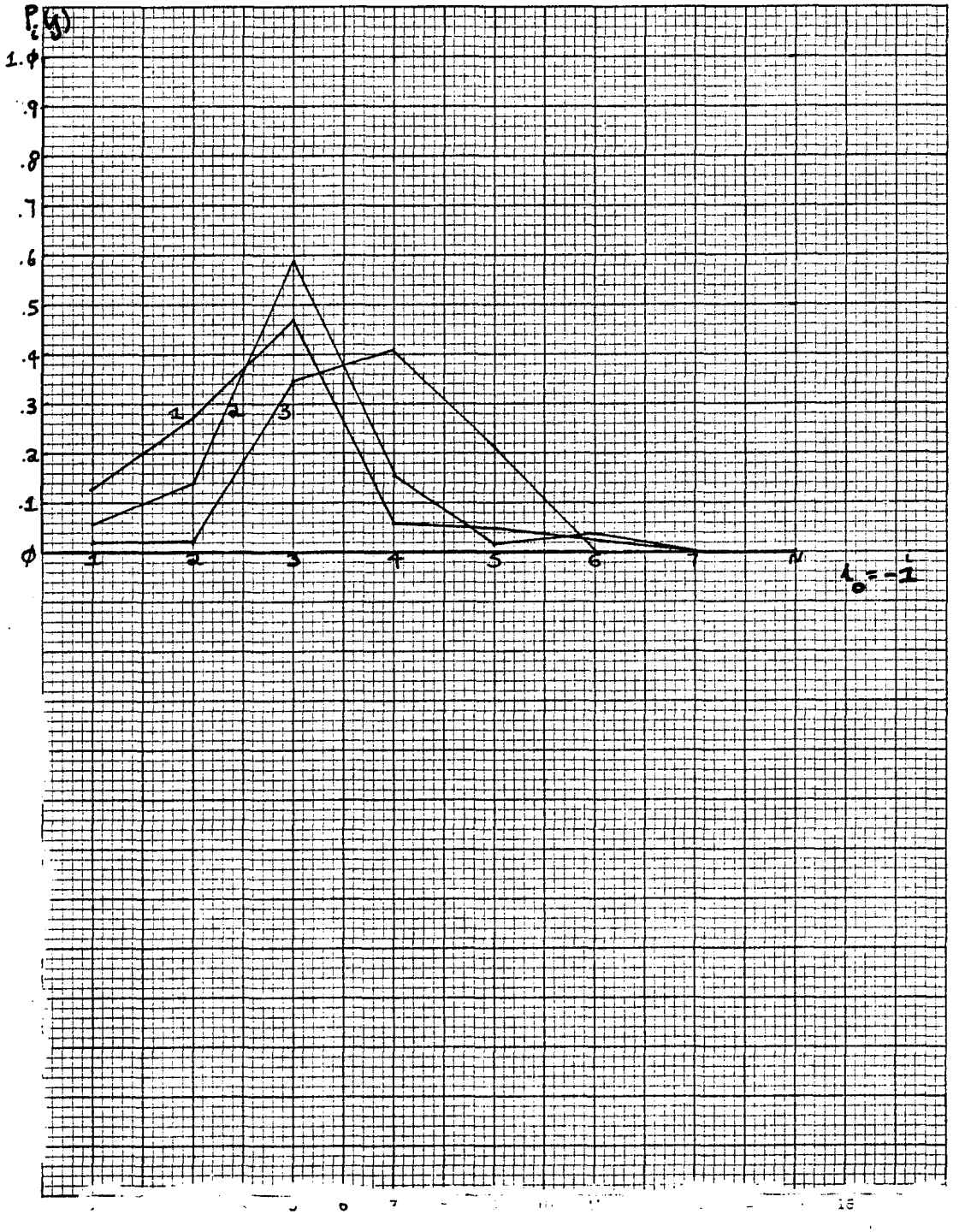


SUBJECT: A.K. CONDITION: RECALL 1 LETTER U AT 144 MSEC



10 Millimeters to the Centimeter

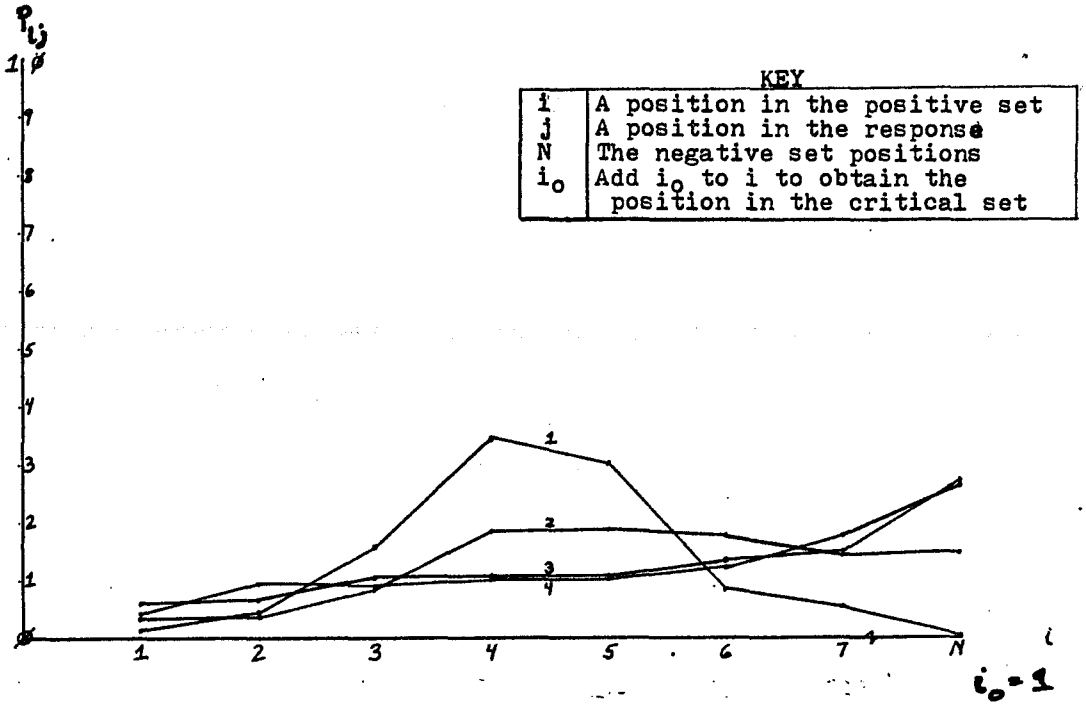
SUBJECT: A.K. CONDITION: RECALL 1 SQUARE AT 144 MSEC. FIG.12
p.12.



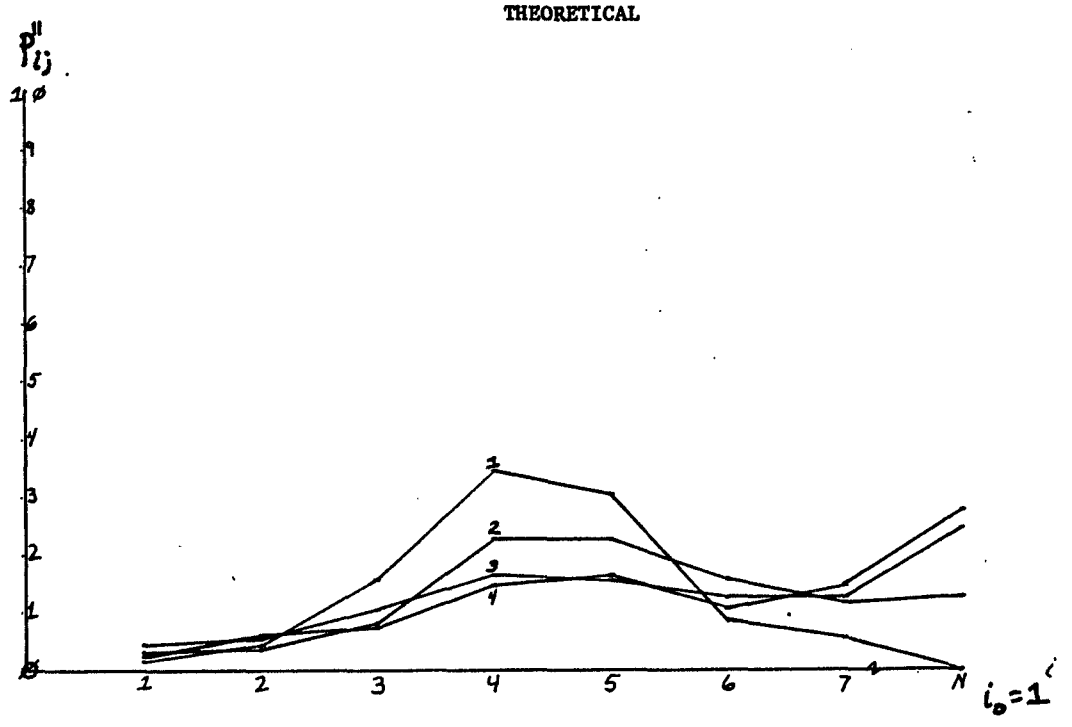
5 Squares to the Centimeter

SUBJECT A.R. CONDITION: RECALL LETTER C AT 75 MSEC. FIG.13.p.1.

DATA

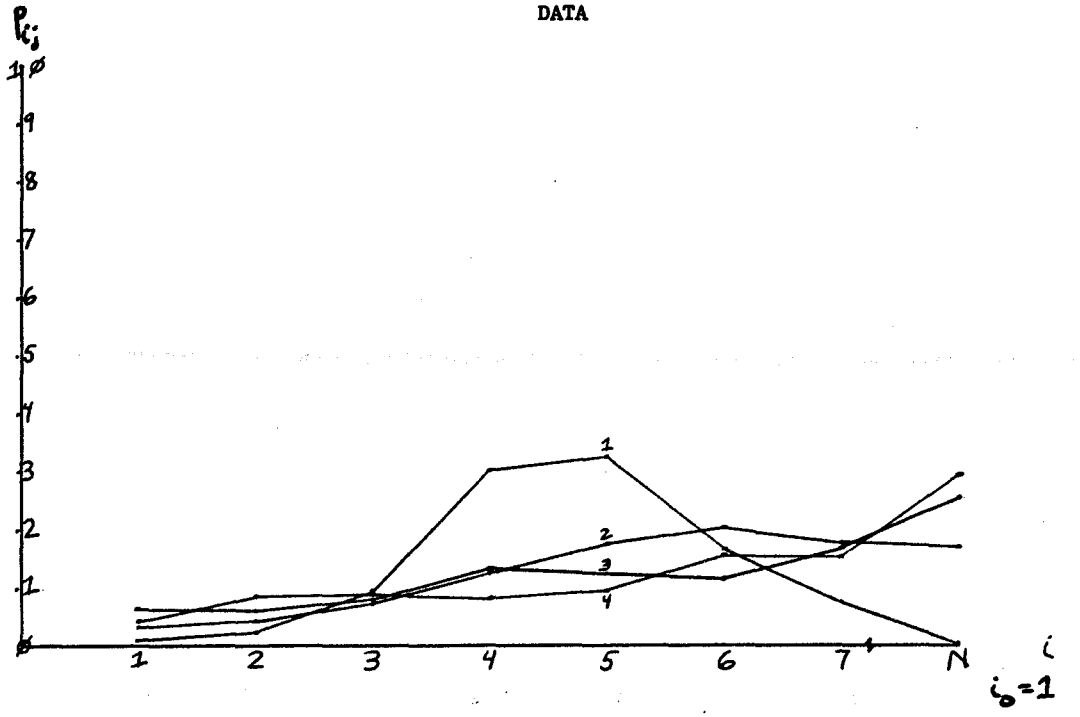


THEORETICAL

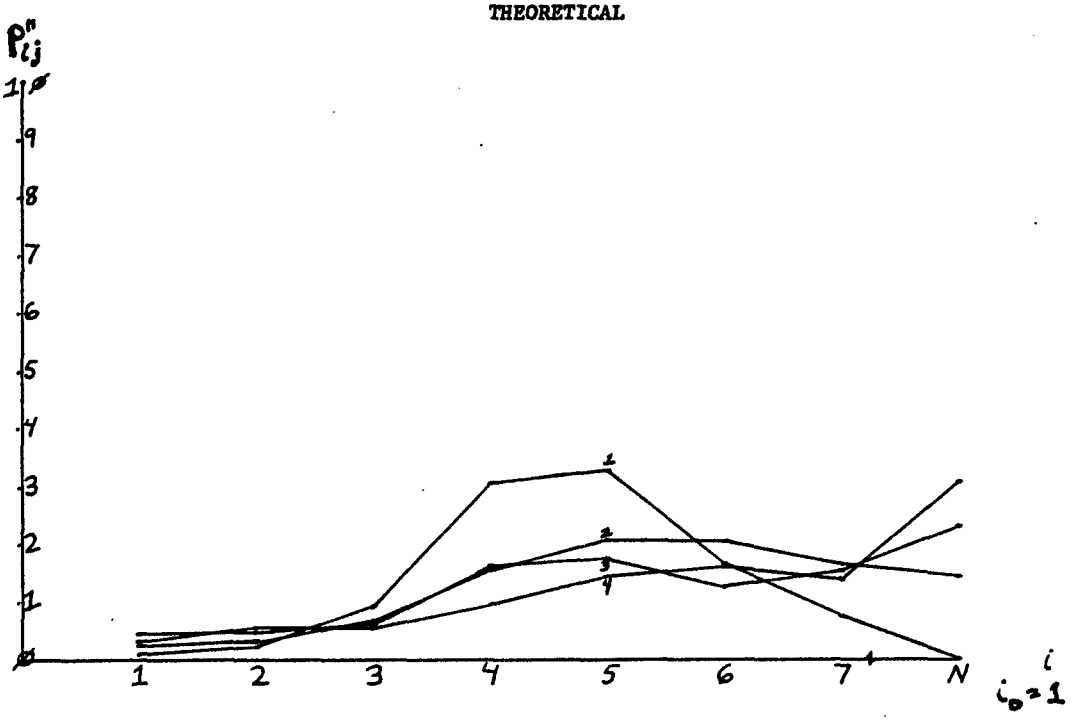


SUBJECT A.R. CONDITION: RECALL LETTER U AT 75 MSEC. FIG.13 p.2.

DATA

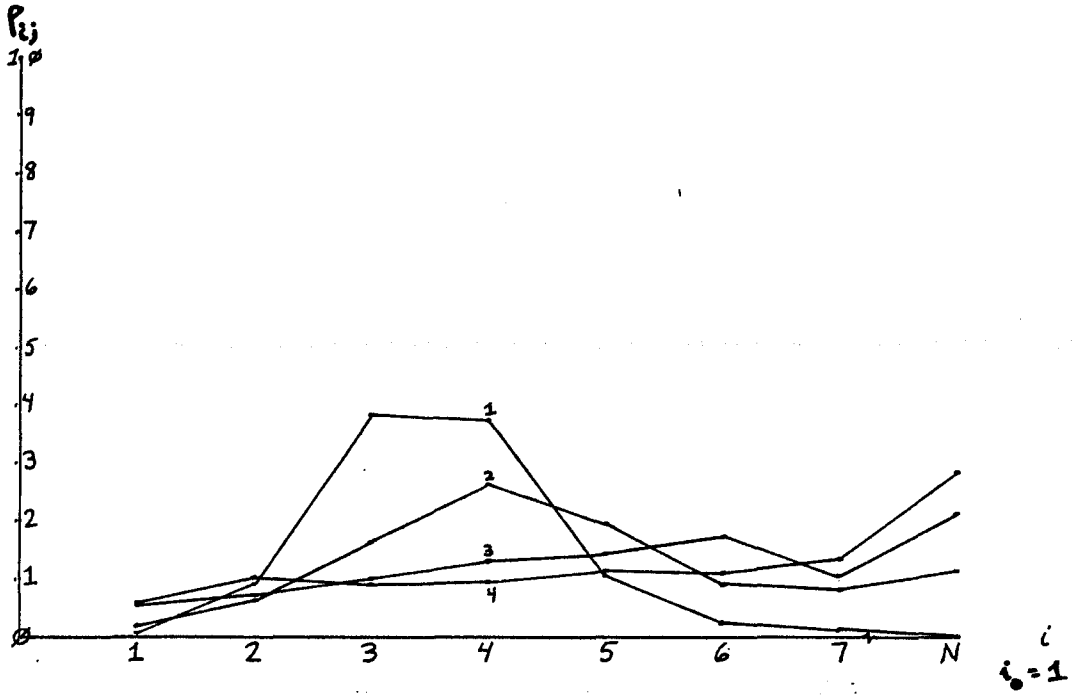


THEORETICAL

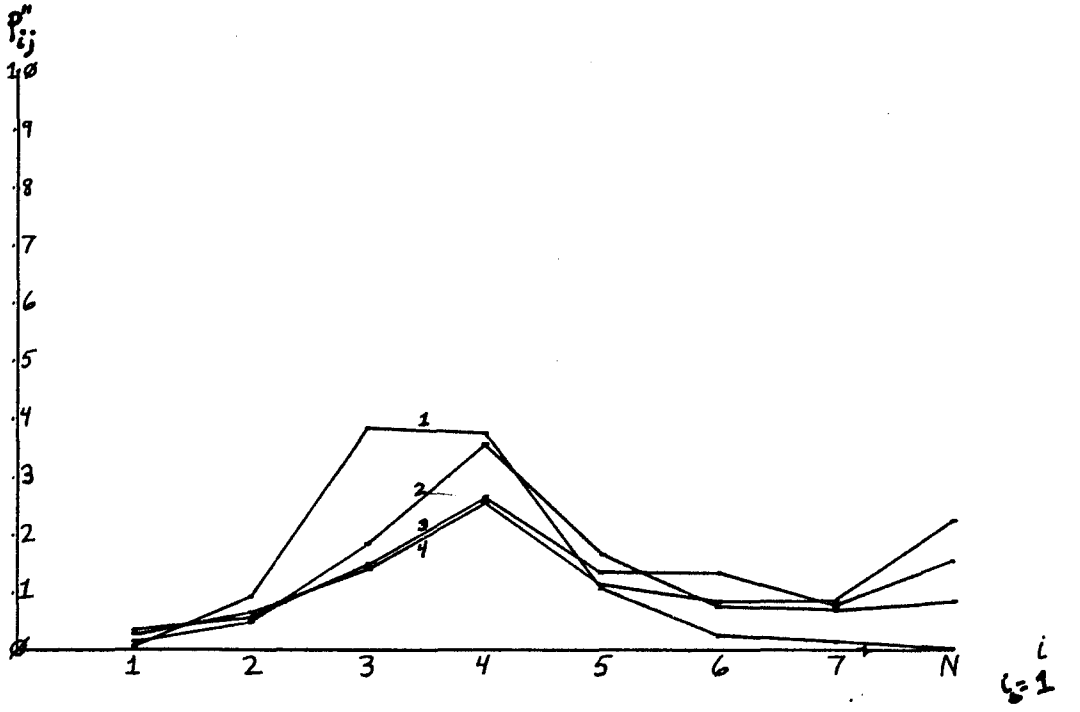


SUBJECT A.R. CONDITION: RECALL SQUARE AT 75 MSEC. FIG.13. p.3.

DATA

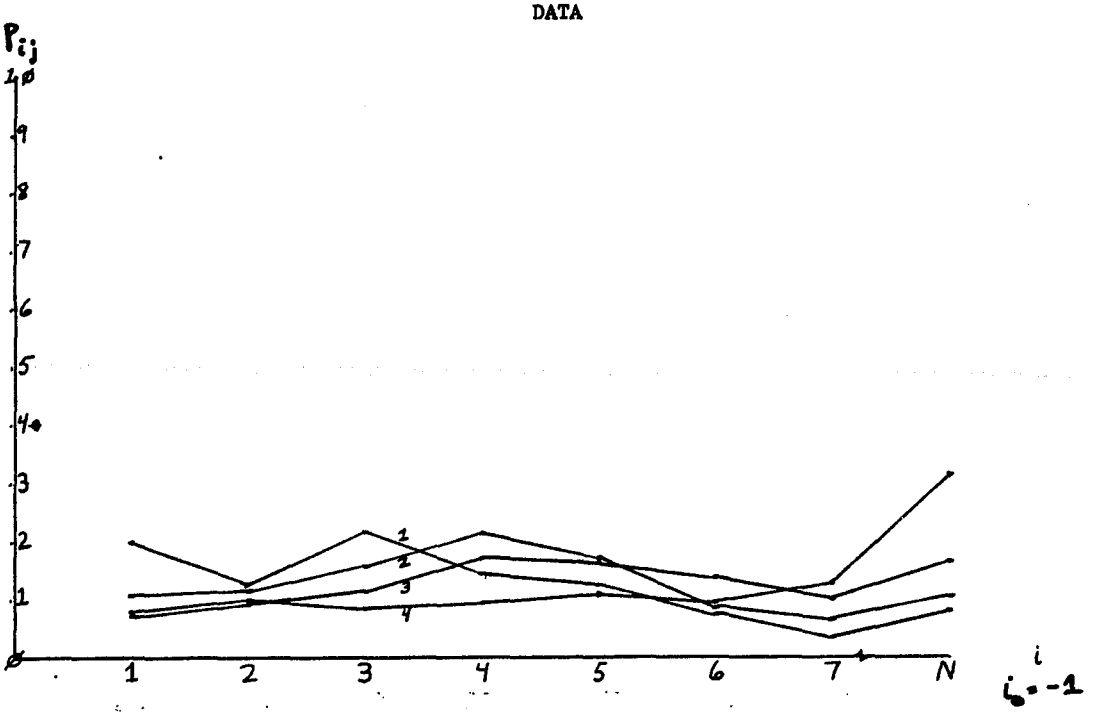


THEORETICAL

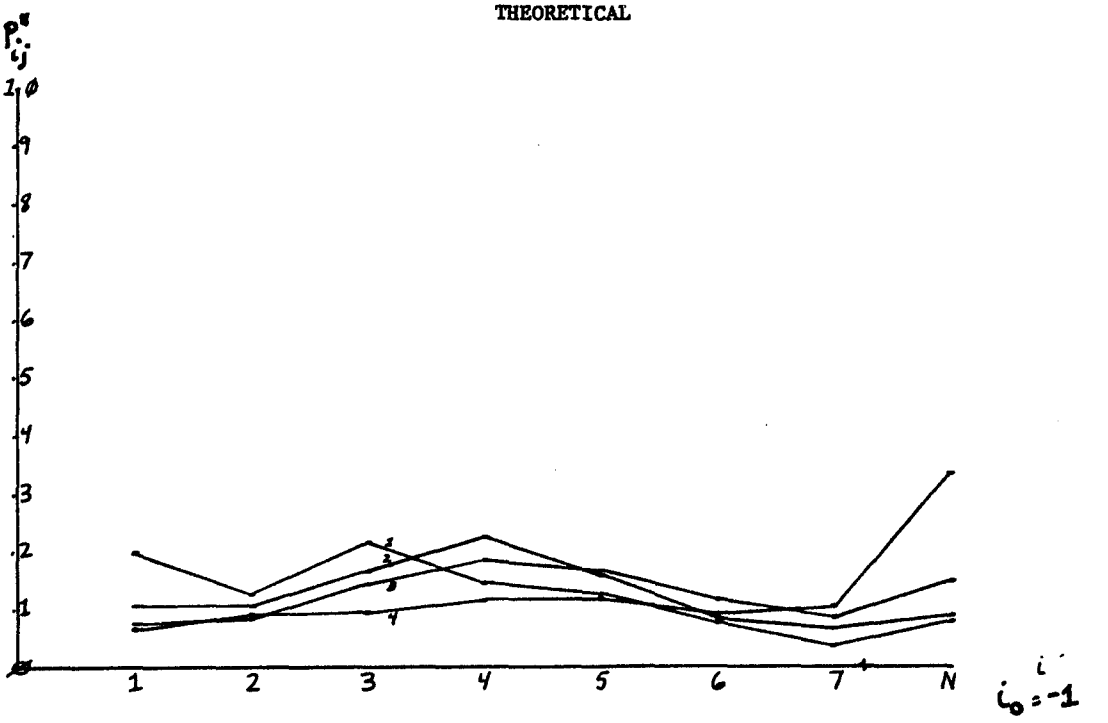


SUBJECT A.R. CONDITION: RECALL ARROW AT 75 MSEC. FIG.13.p.4.

DATA

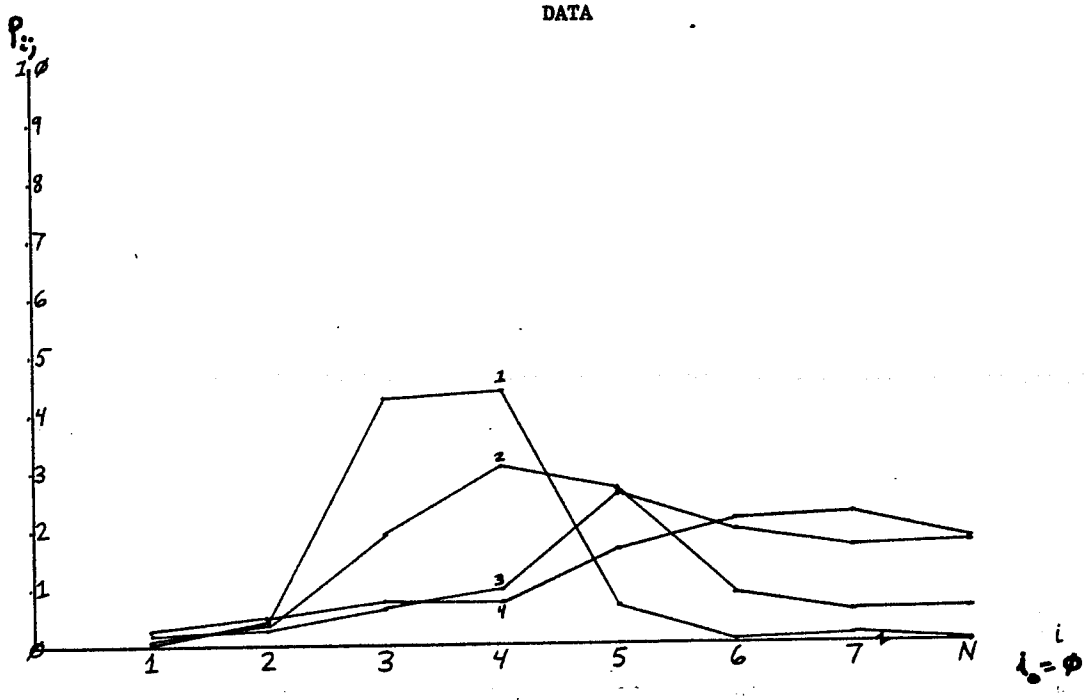


THEORETICAL

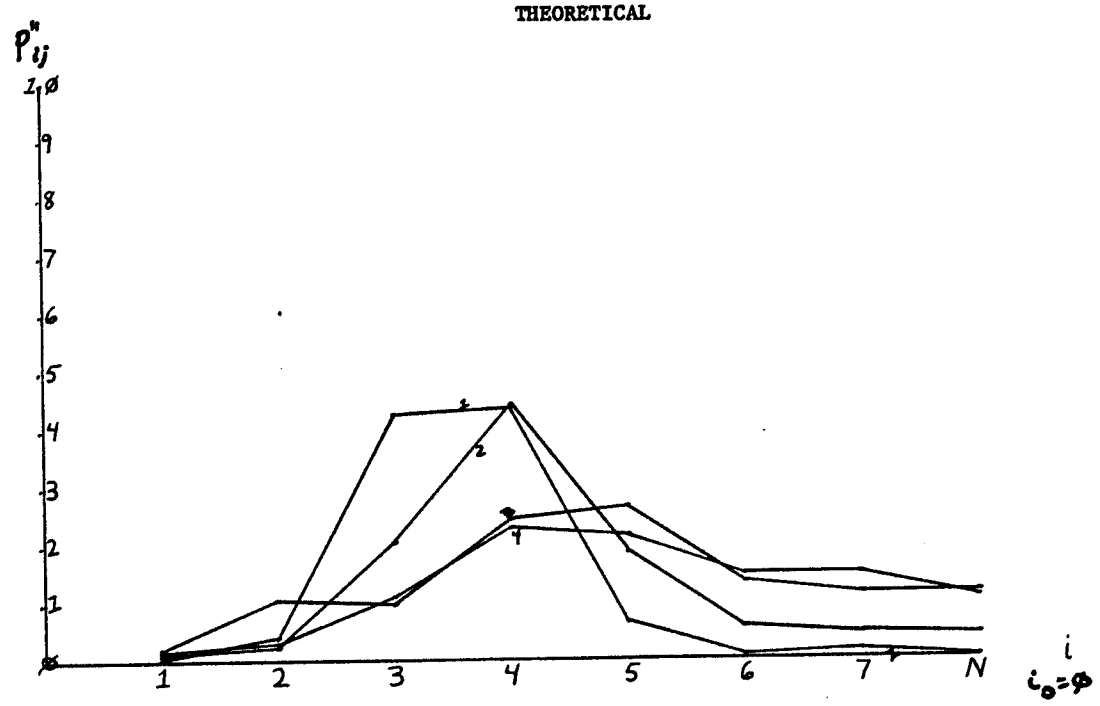


SUBJECT A.R. CONDITION: RECALL LETTER C AT 109 MSEC. FIG.13.p.5.

DATA

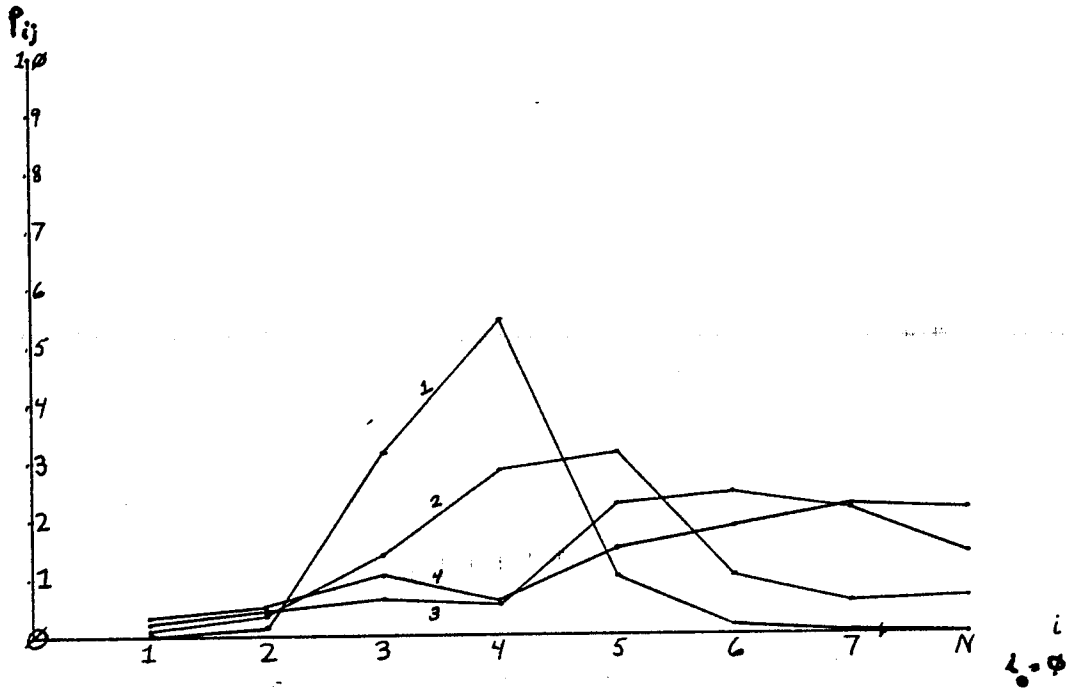


THEORETICAL

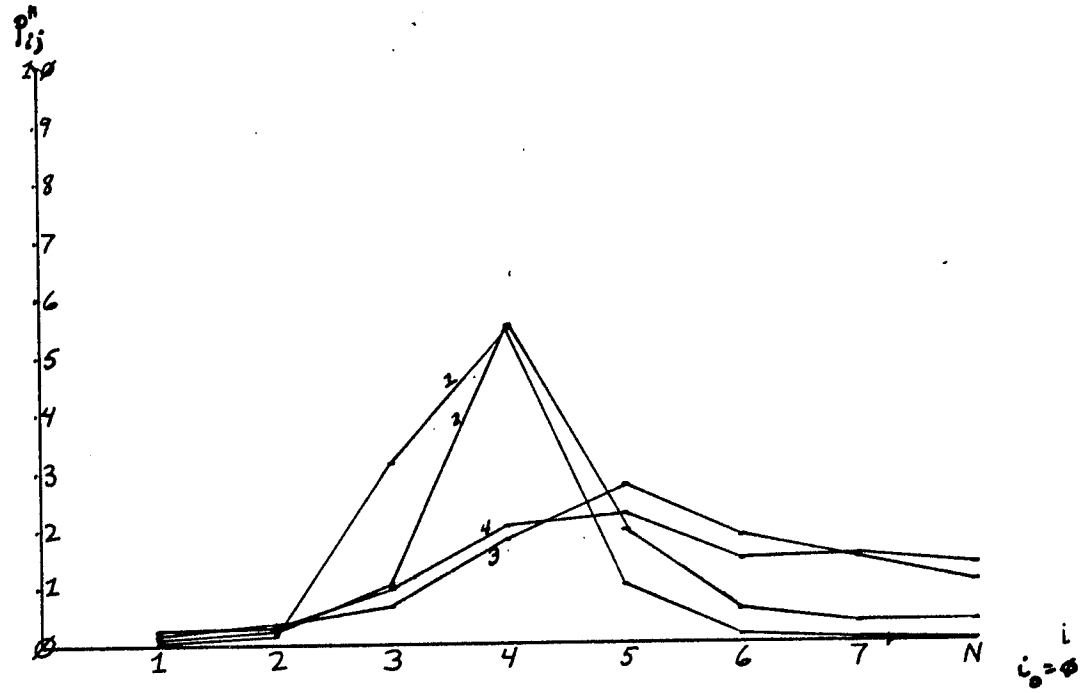


SUBJECT A.R. CONDITION: RECALL LETTER U AT 109 MSEC. FIG.13. p.6.

DATA

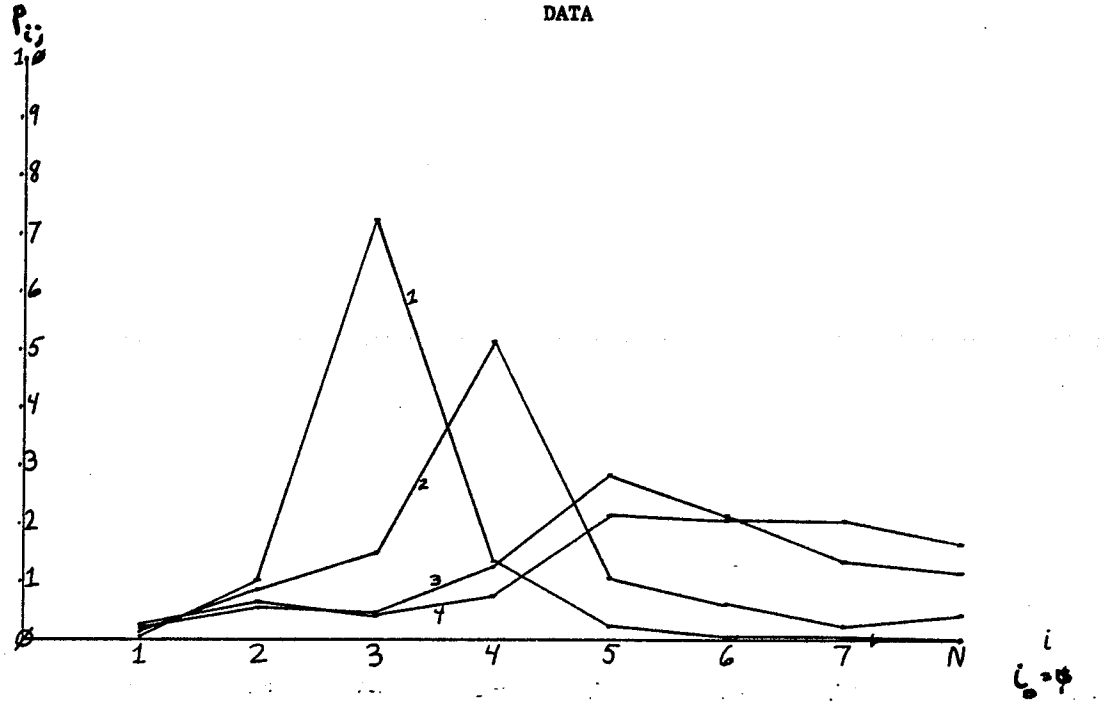


THEORETICAL

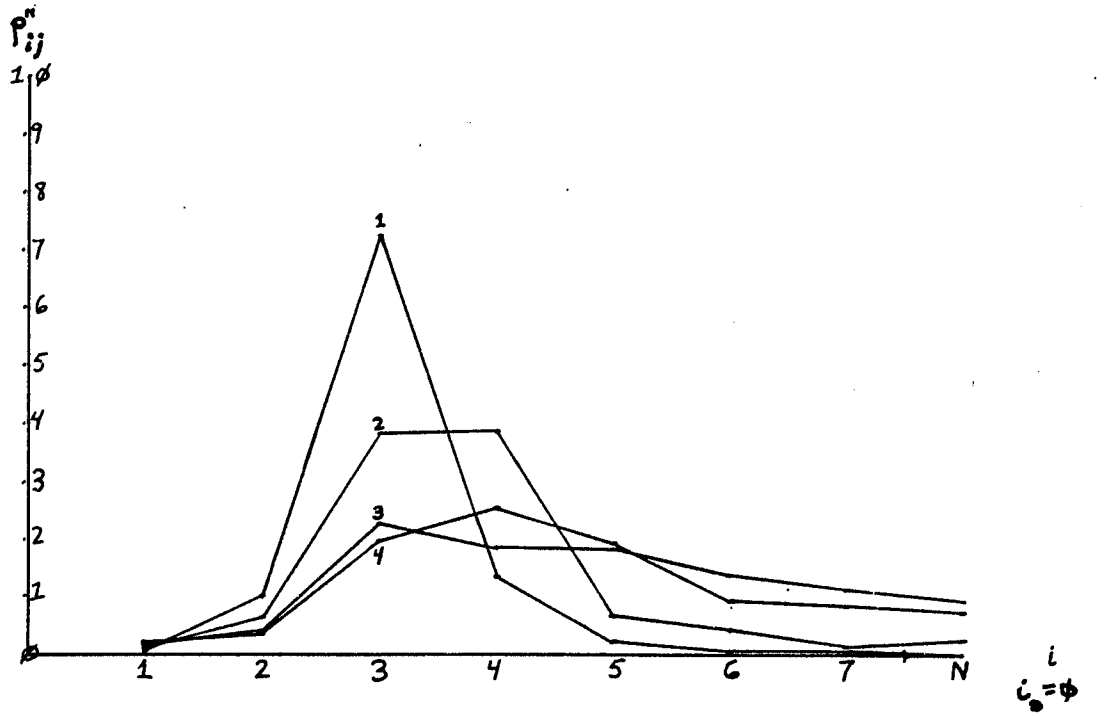


SUBJECT A.R. CONDITION: RECALL SQUARE AT 109MSEC. FIG.13.p.7.

DATA

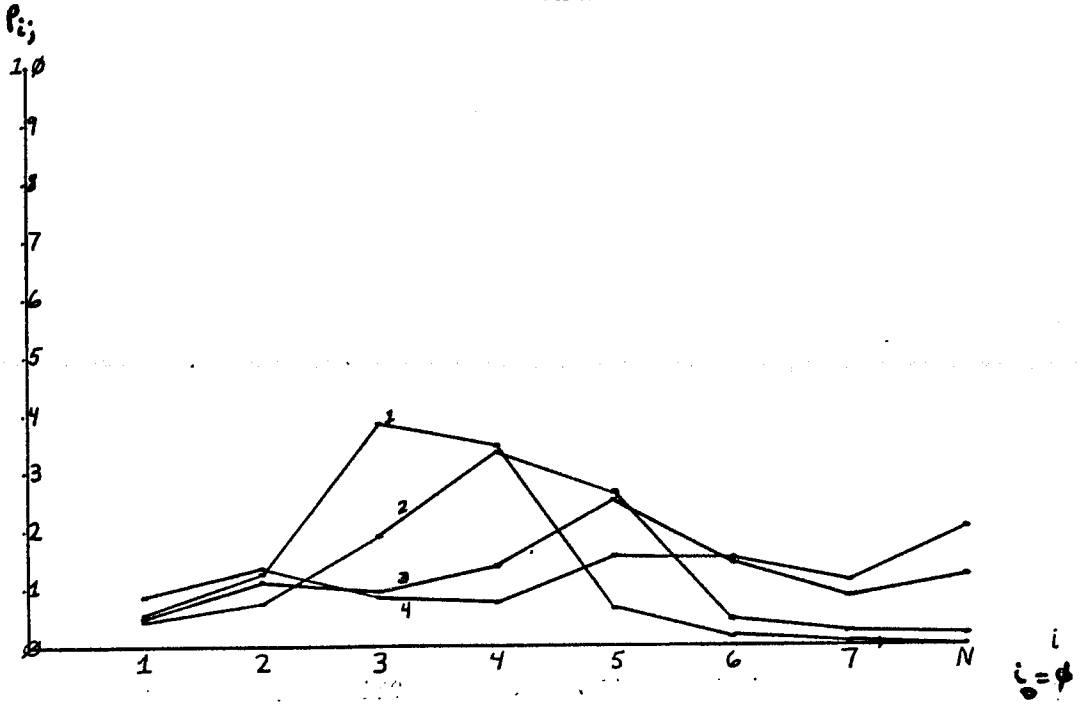


THEORETICAL

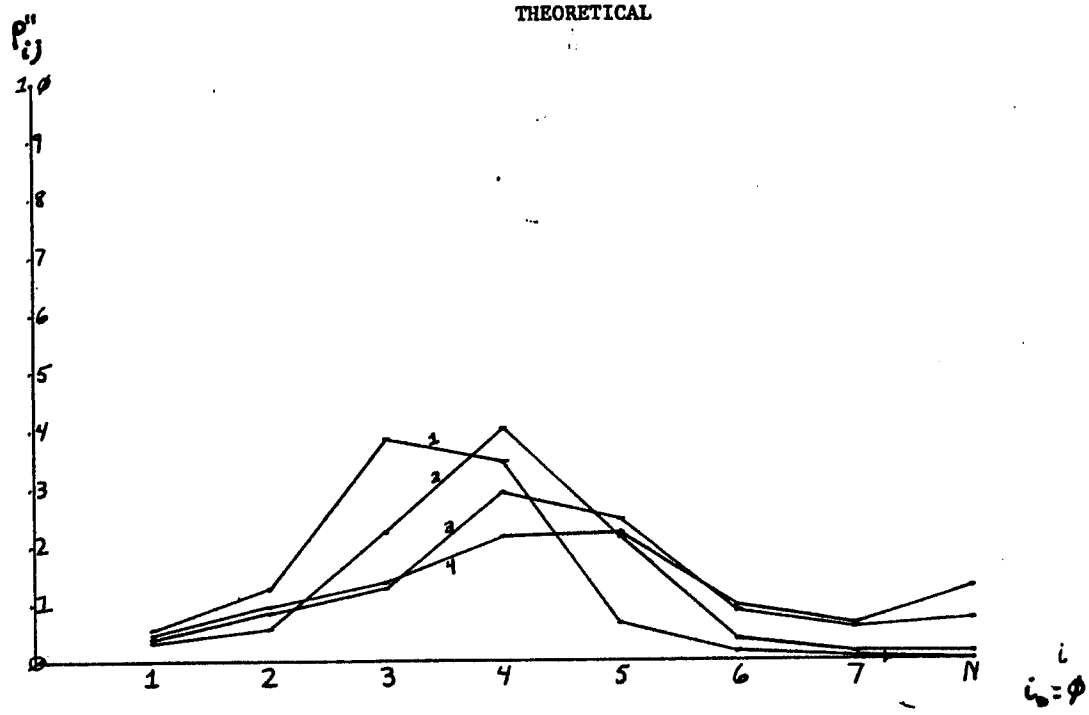


SUBJECT A.R. CONDITION: RECALL ARROW AT 109 MSEC. FIG.13. p.8.

DATA

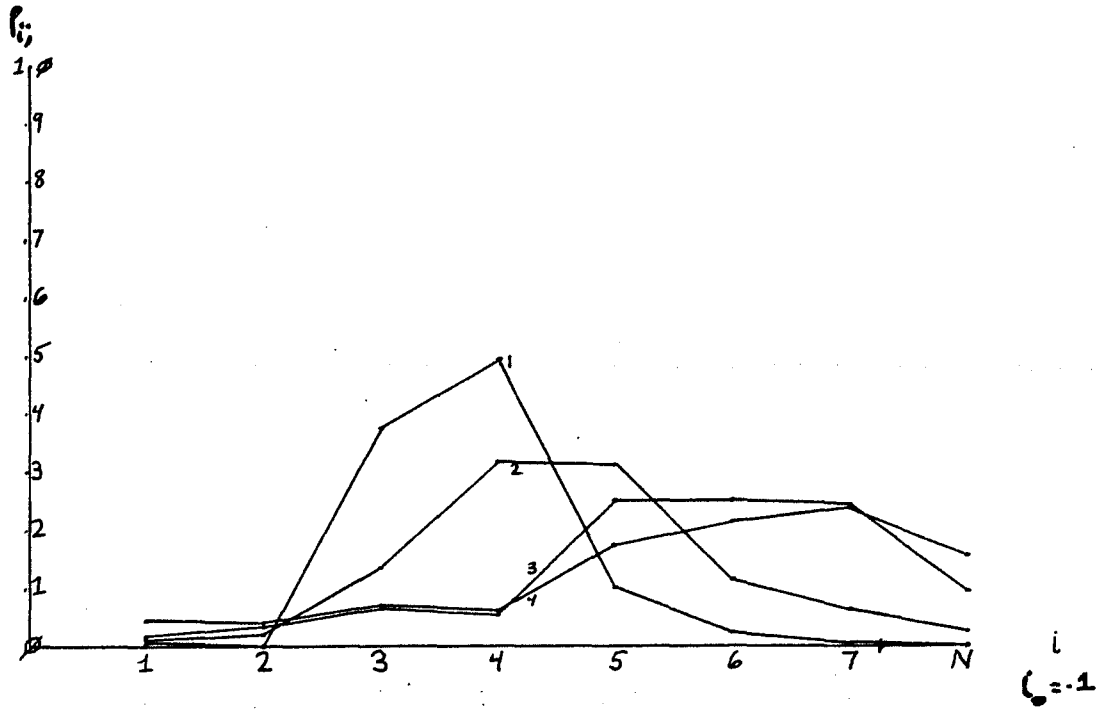


THEORETICAL

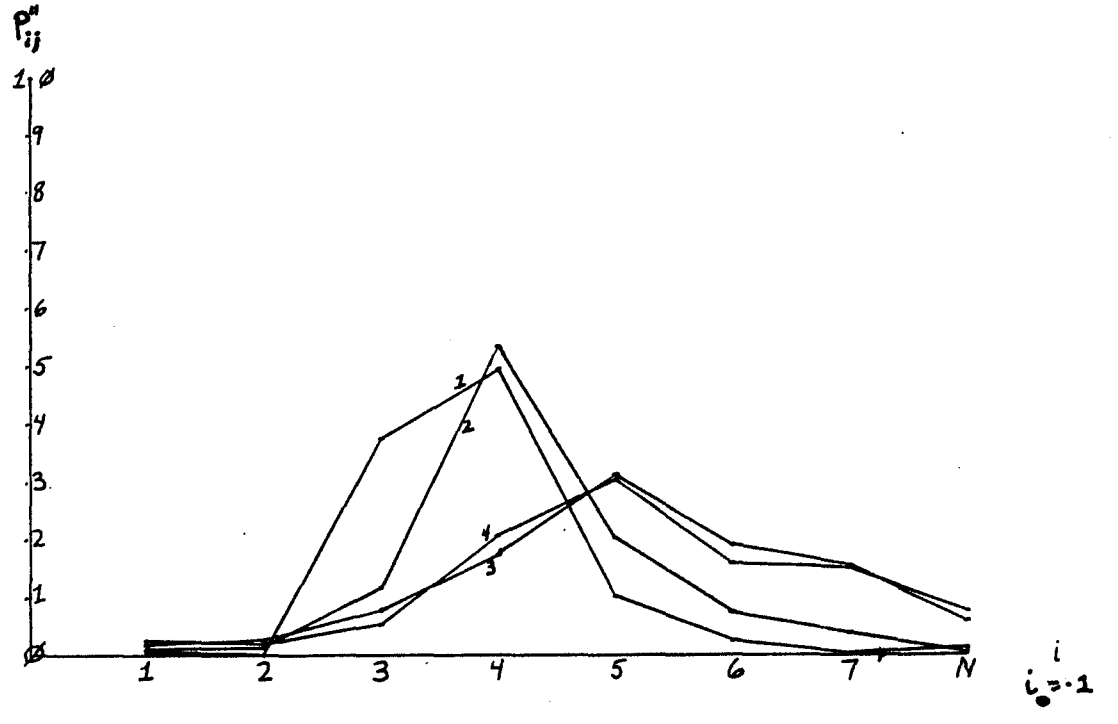


SUBJECT A.R. CONDITION: RECALL LETTER C AT 144 MSEC. FIG.13. p.9.

DATA

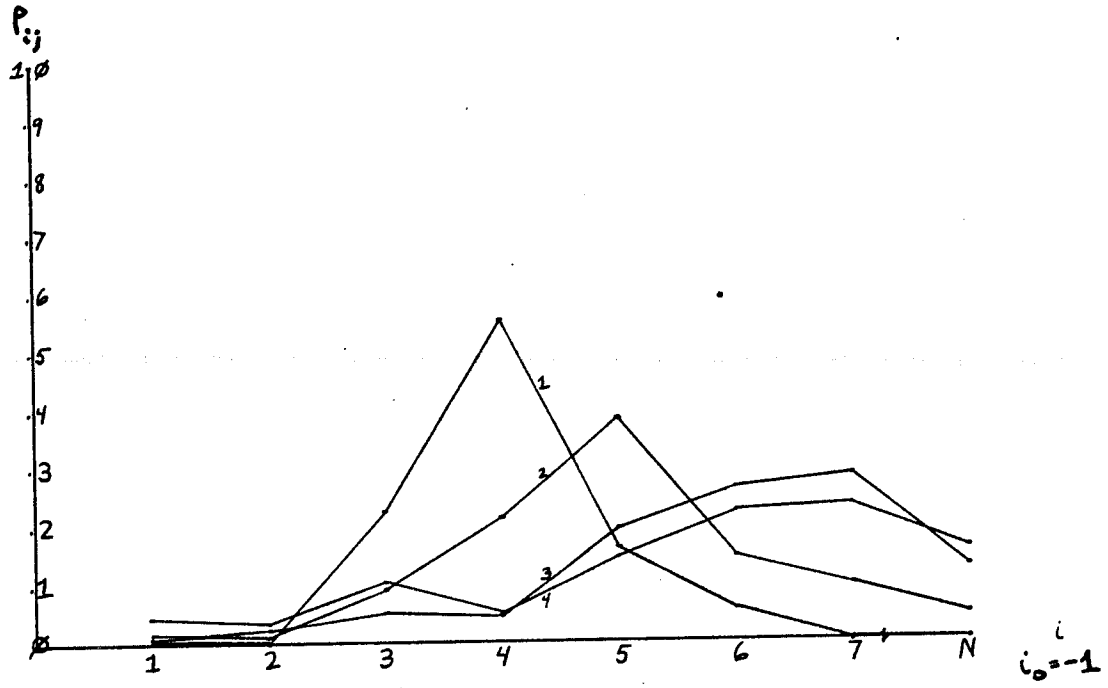


THEORETICAL

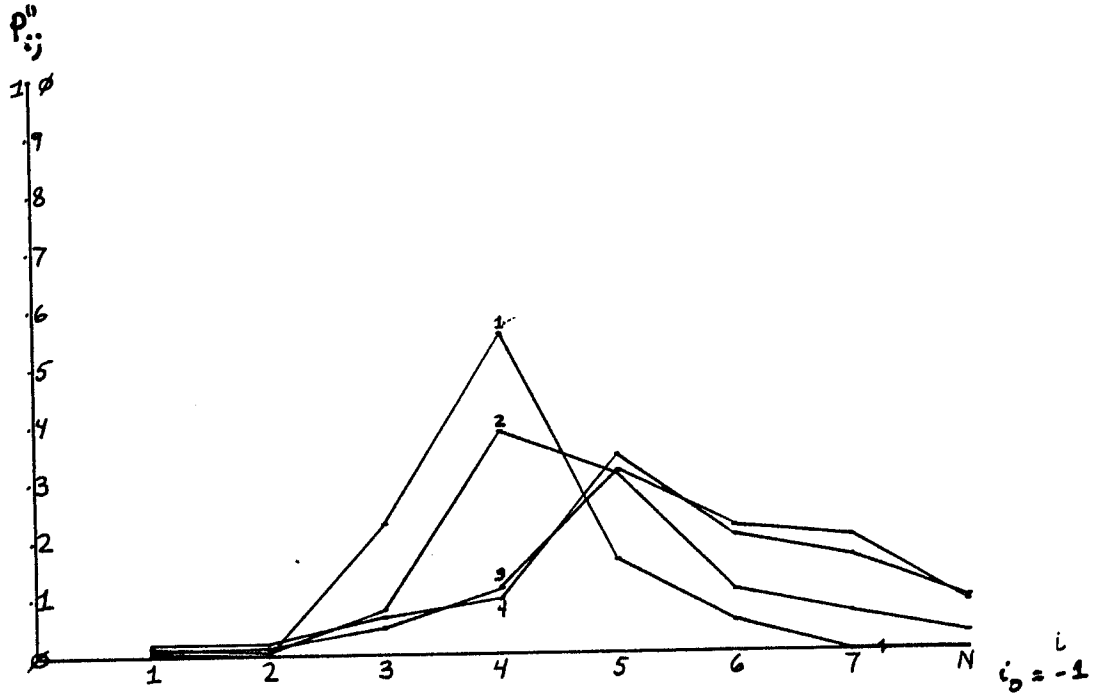


SUBJECT A.R. CONDITION: RECALL LETTER U AT 144 MSEC. FIG.13.p.10.

DATA

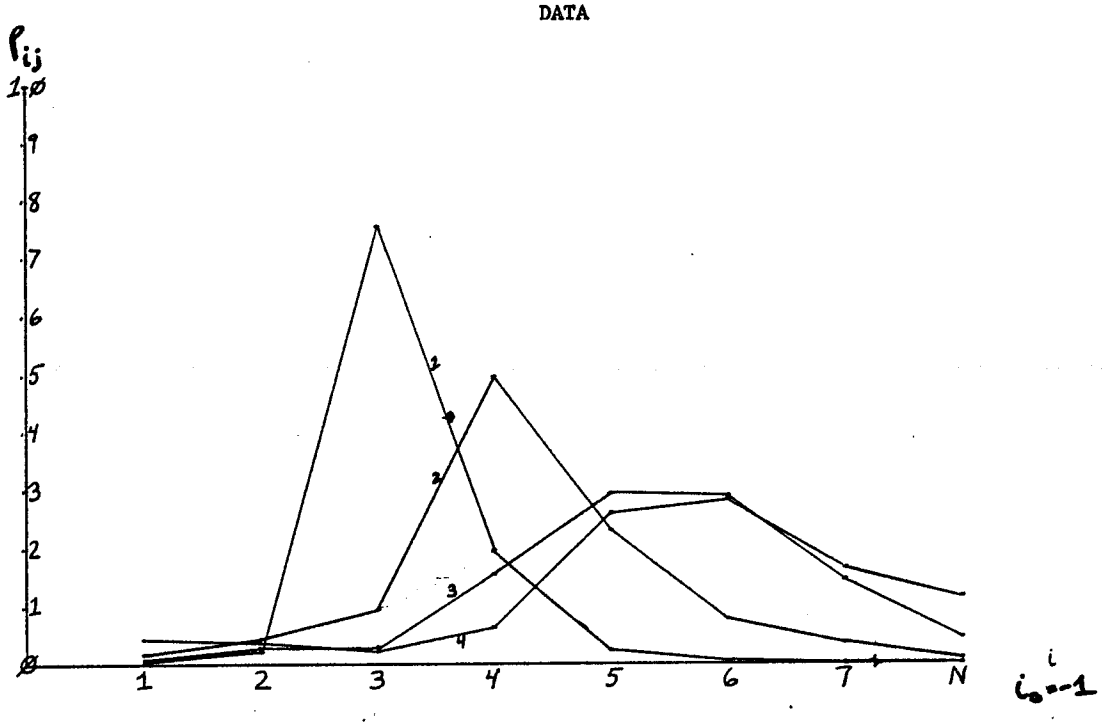


THEORETICAL

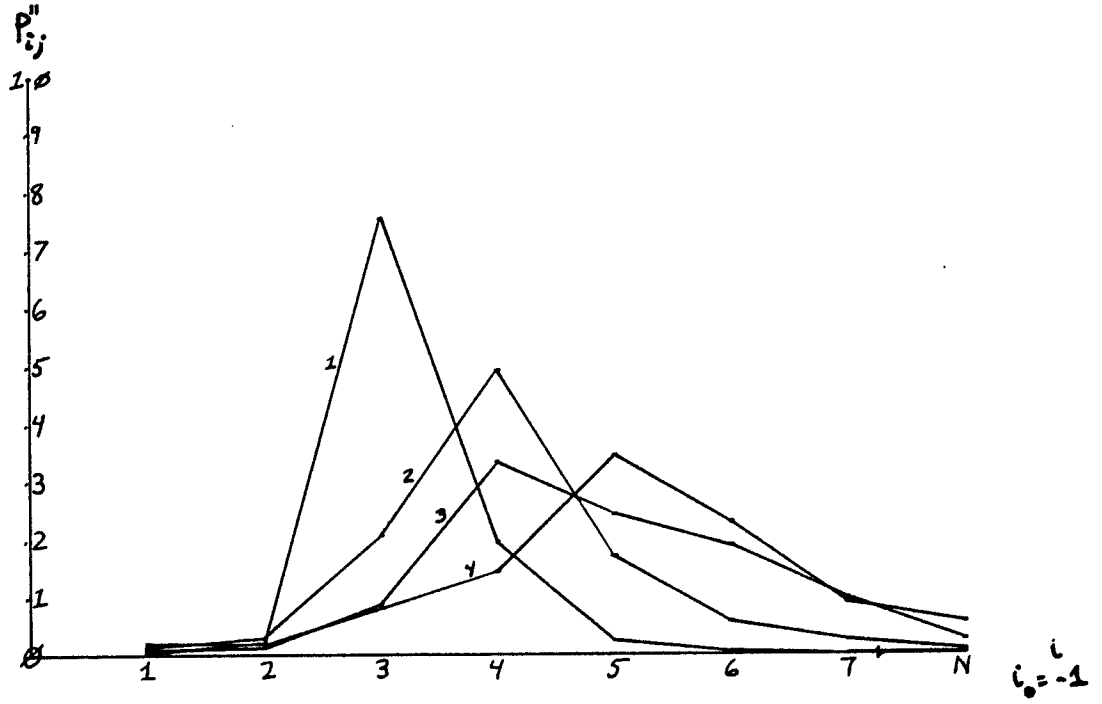


SUBJECT A.R. CONDITION: RECALL SQUARE AT 144MSEC. FIG.13.p.11.

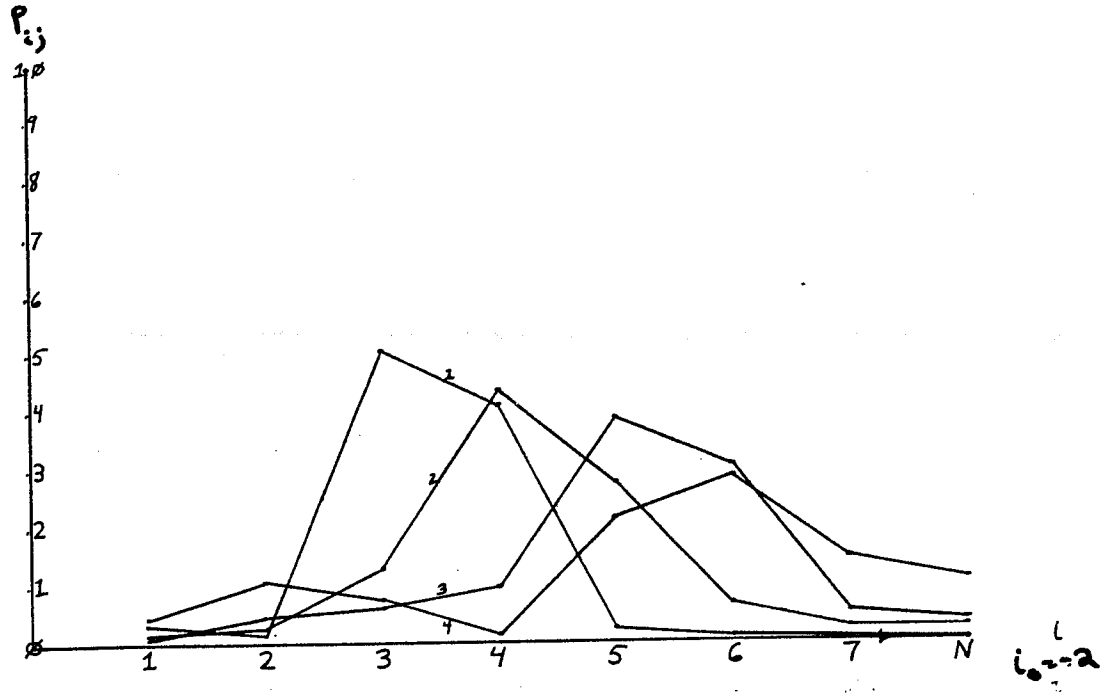
DATA

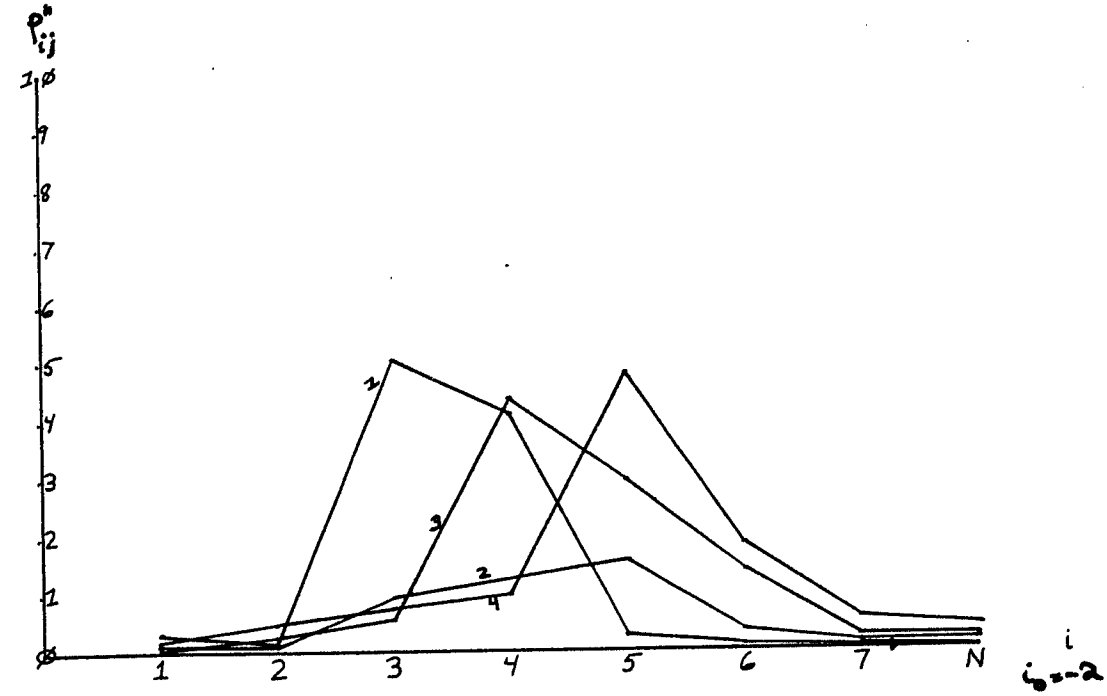


THEORETICAL



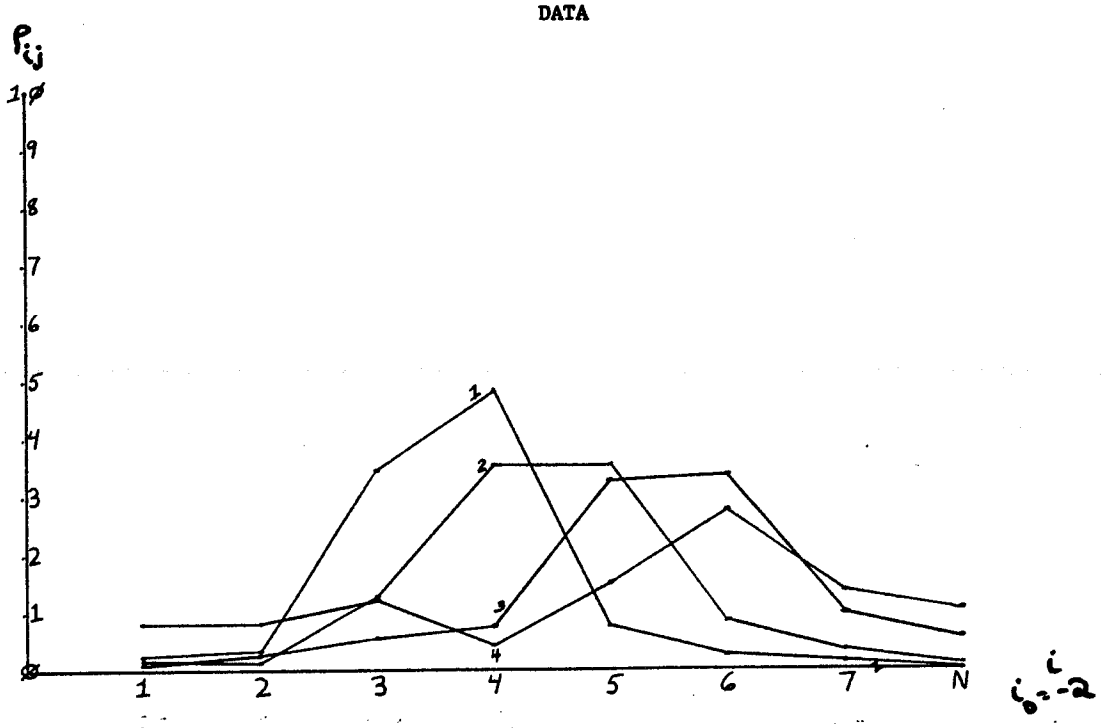
SUBJECT A.R. CONDITION: RECALL LETTER C AT 214 MSEC. FIG. 13 p. 12



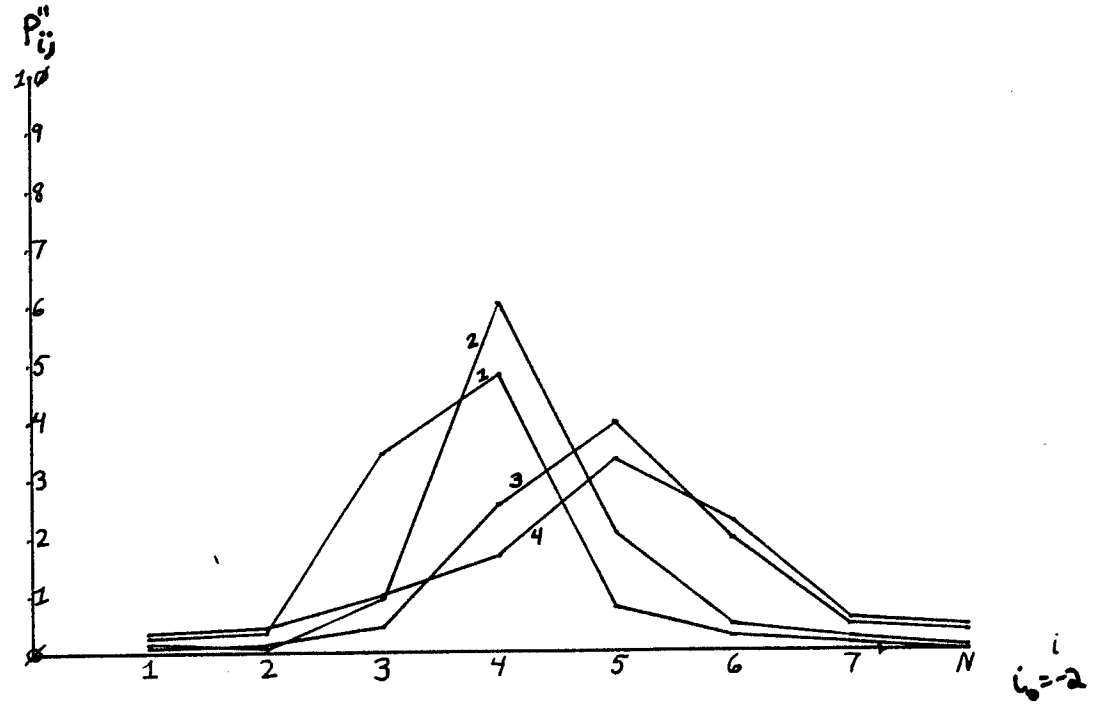


SUBJECT A.R. CONDITION: RECALL LETTER U AT 214 MSEC. FIG.13.p.13

DATA

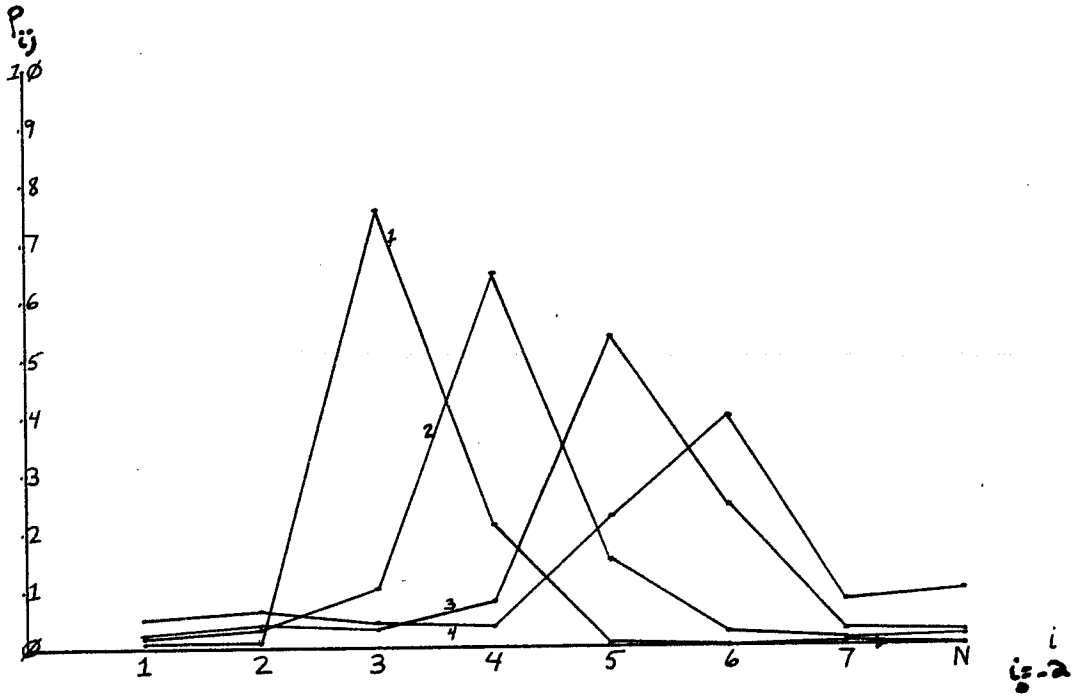


THEORETICAL

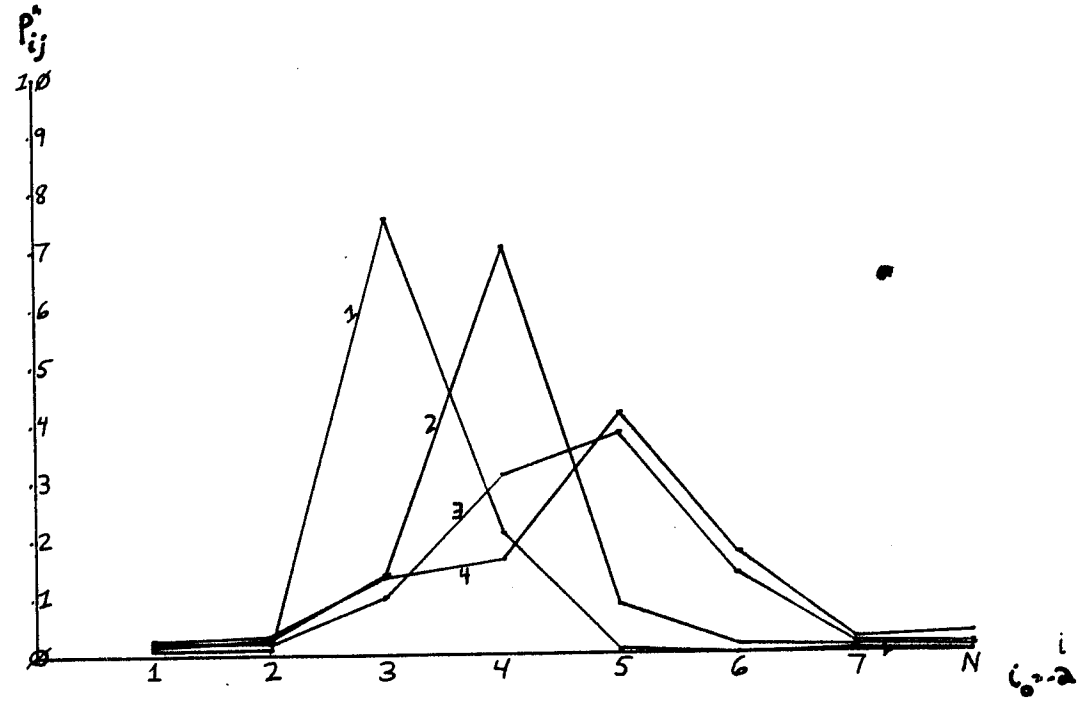


SUBJECT A.R. CONDITION: RECALL SQUARE AT 214 MSEC. FIG.13.p.14.

DATA

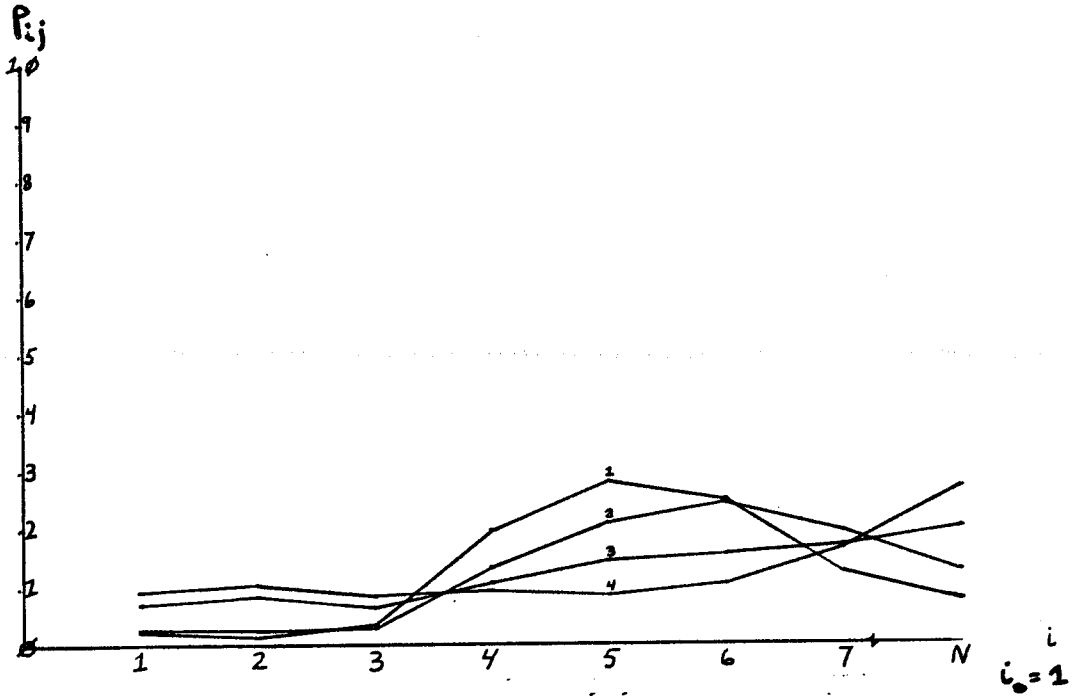


THEORETICAL

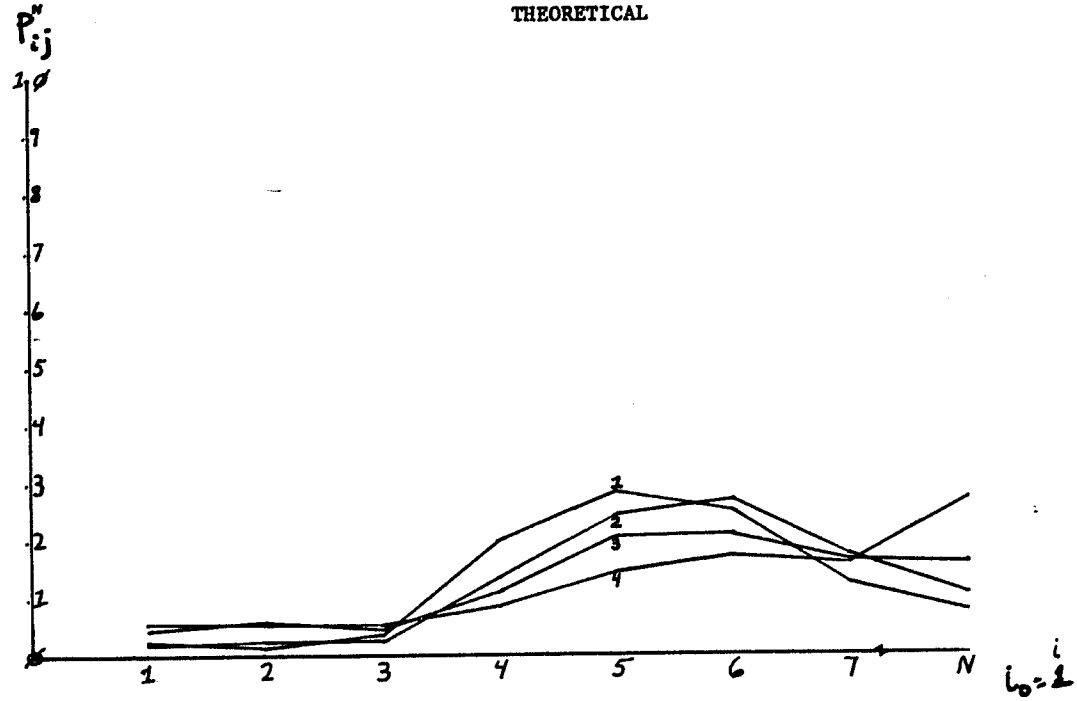


SUBJECT G.L. CONDITION: RECALL LETTER C AT 75 MSEC. FIG.13.p.15.

DATA

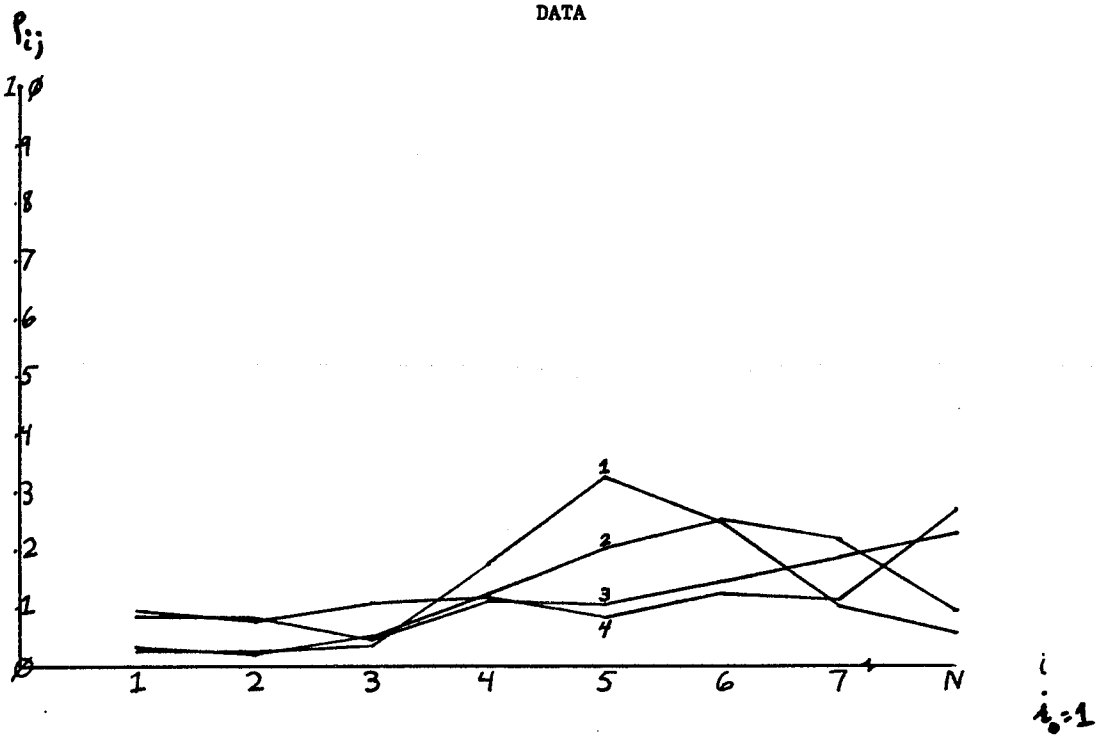


THEORETICAL

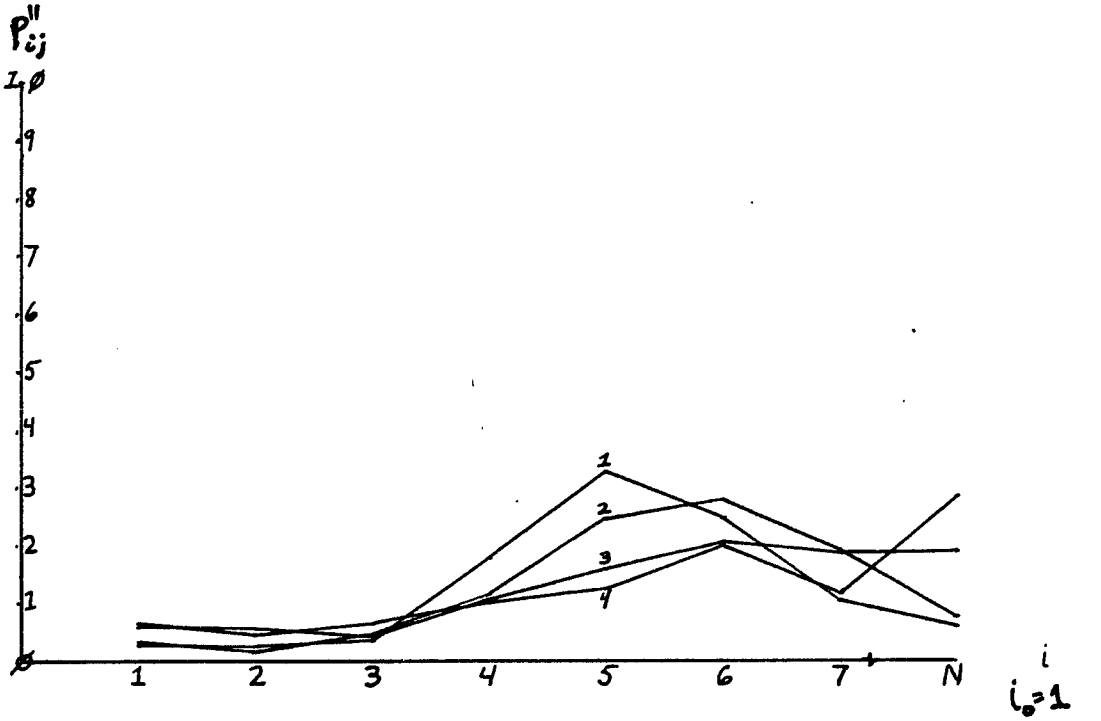


SUBJECT G.L. CONDITION: RECALL LETTER U AT 75 MSEC. FIG.13.p.16.

DATA

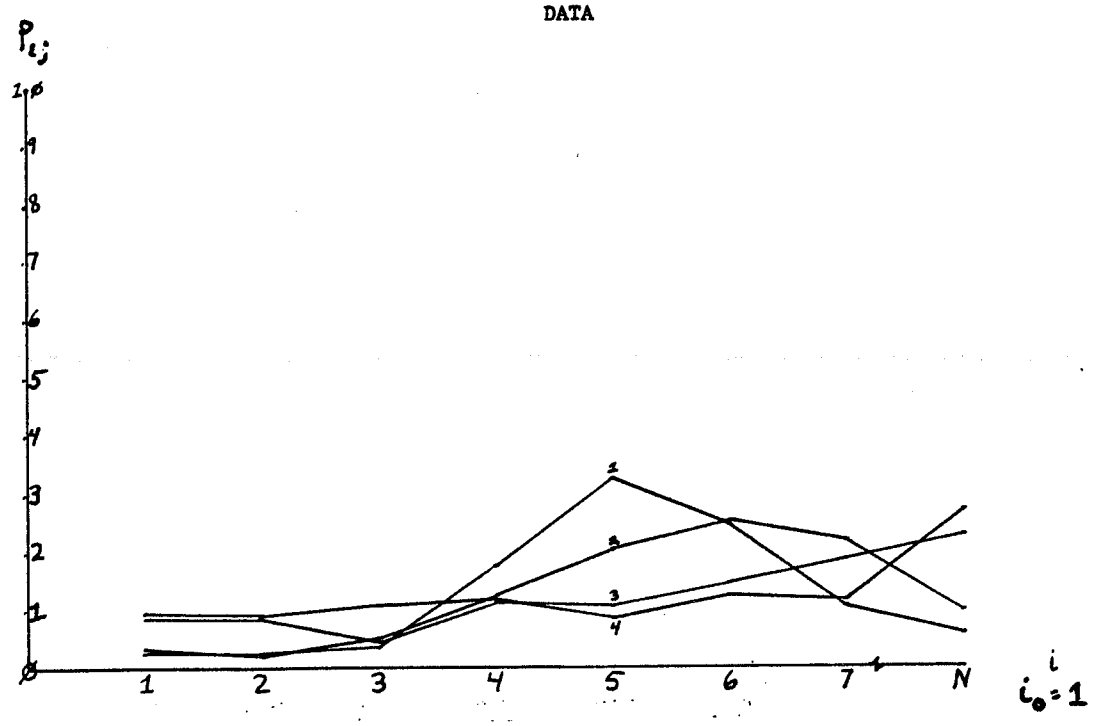


THEORETICAL

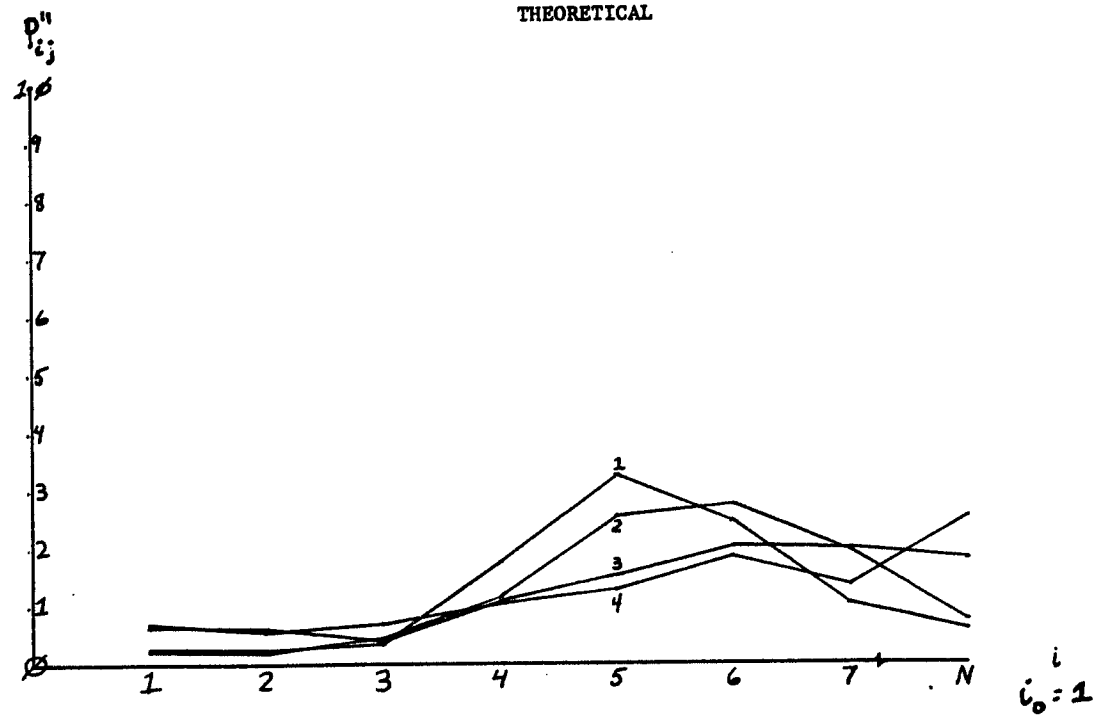


SUBJECT G.L. CONDITION: RECALL SQUARE AT 75 MSEC. FIG.13.p.17.

DATA

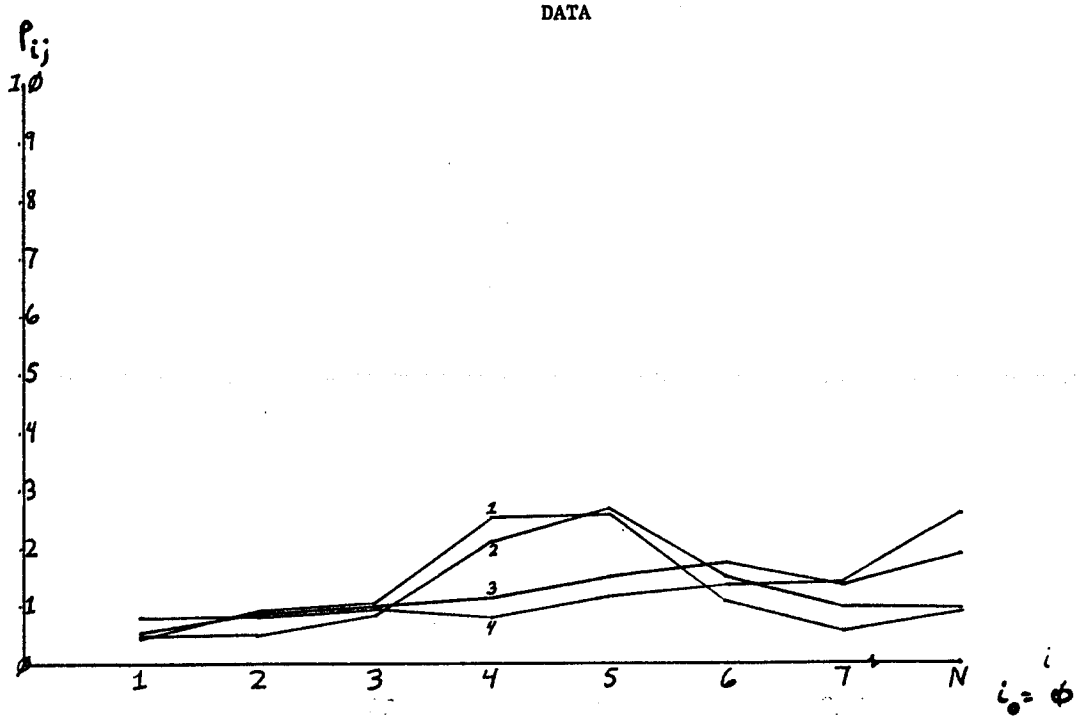


THEORETICAL

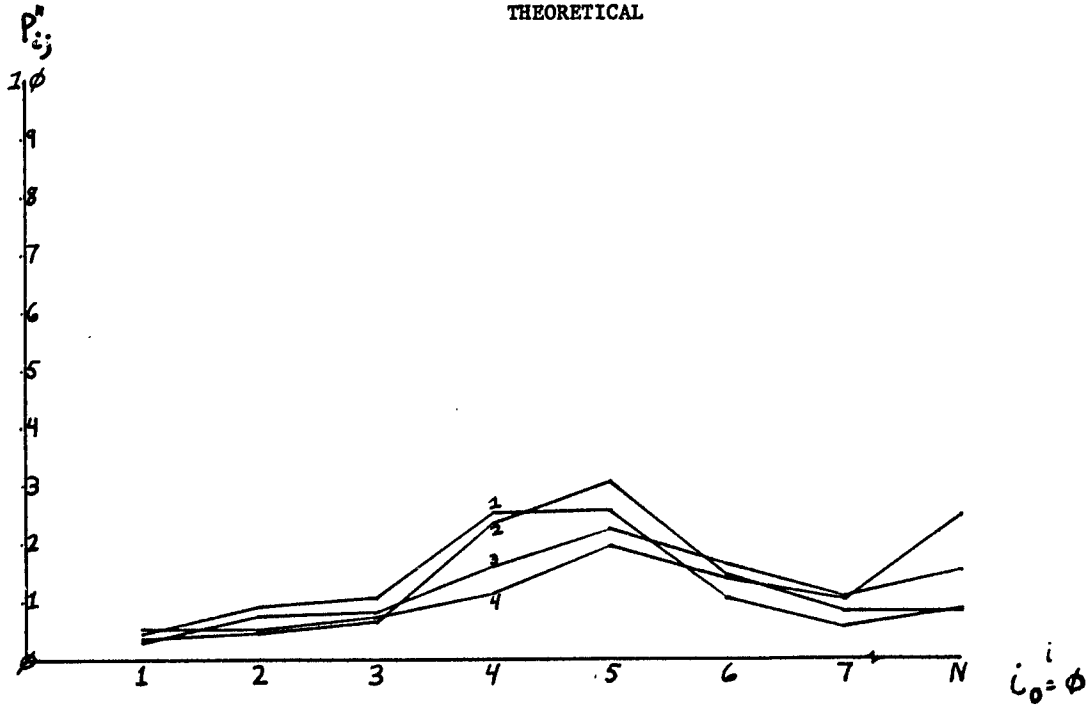


SUBJECT G.L. CONDITION: RECALL ARROW AT 75 MSEC. FIG.13.p.18.

DATA

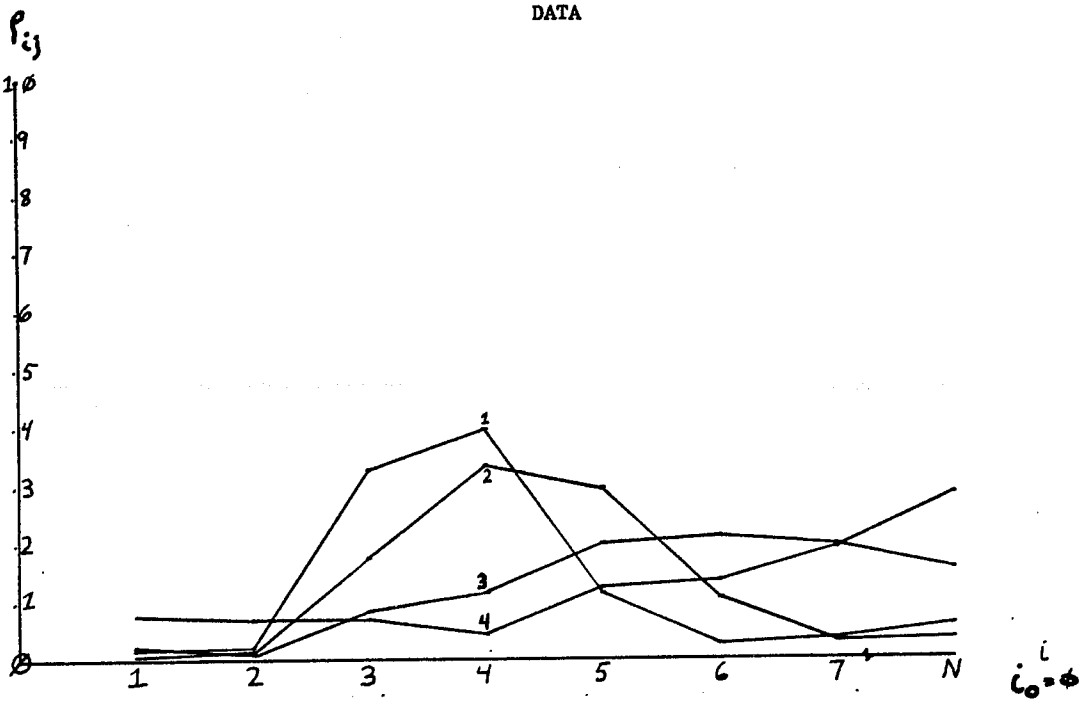


THEORETICAL

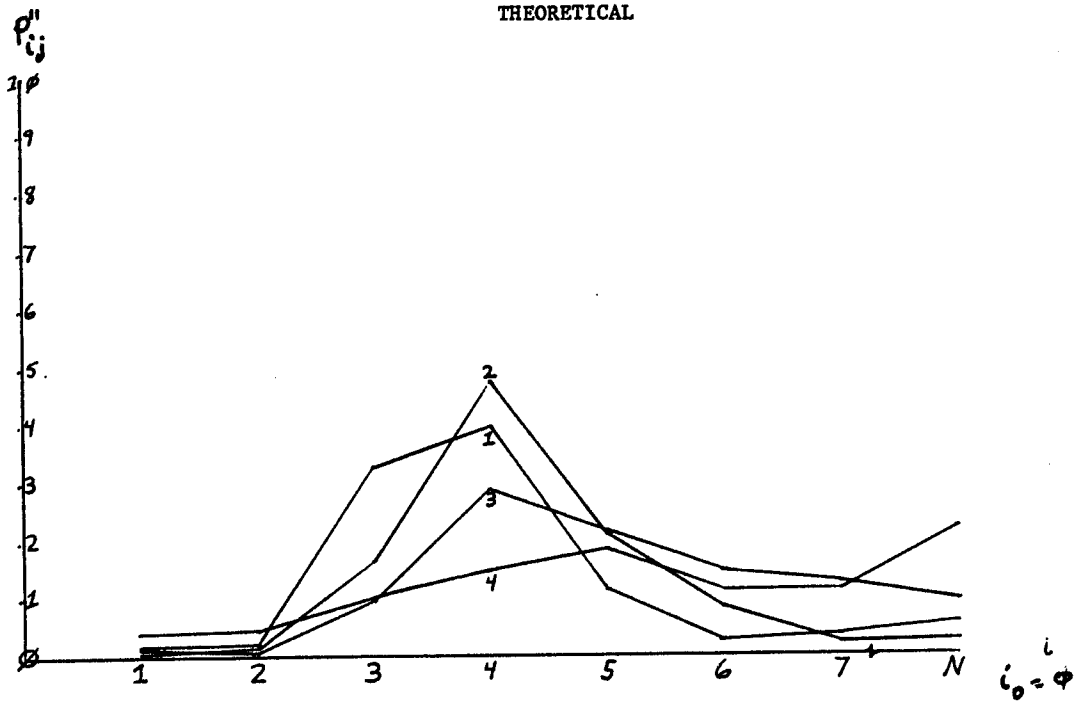


SUBJECT G.L. CONDITION: RECALL LETTER C AT 109 MSEC. FIG.13.p.19.

DATA

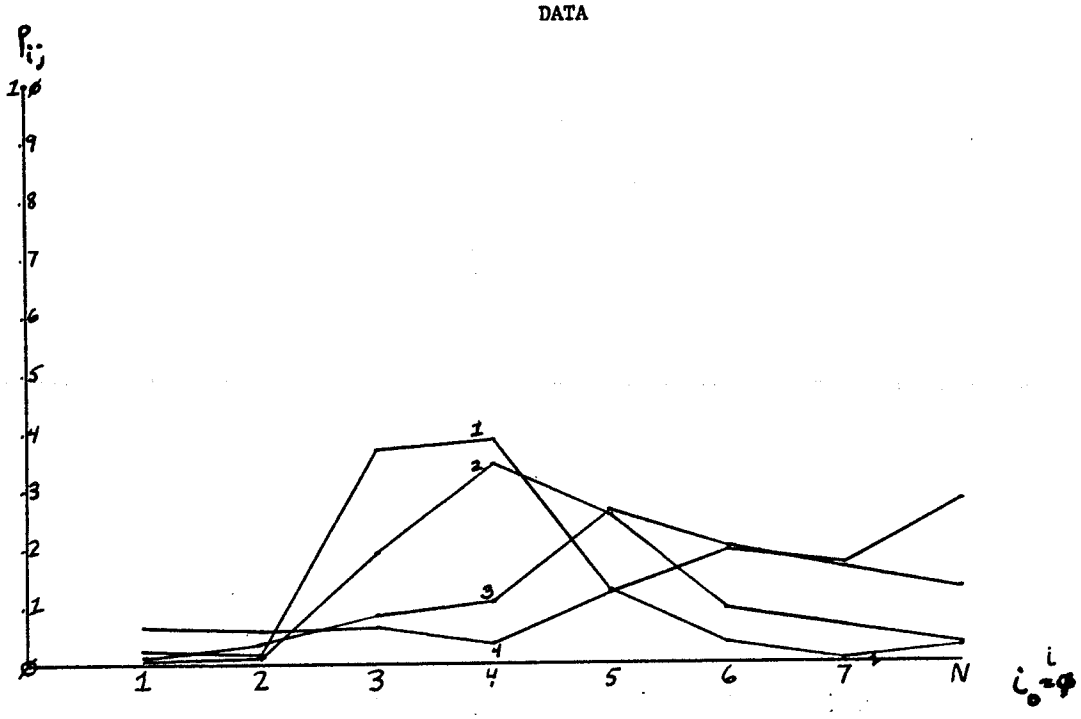


THEORETICAL

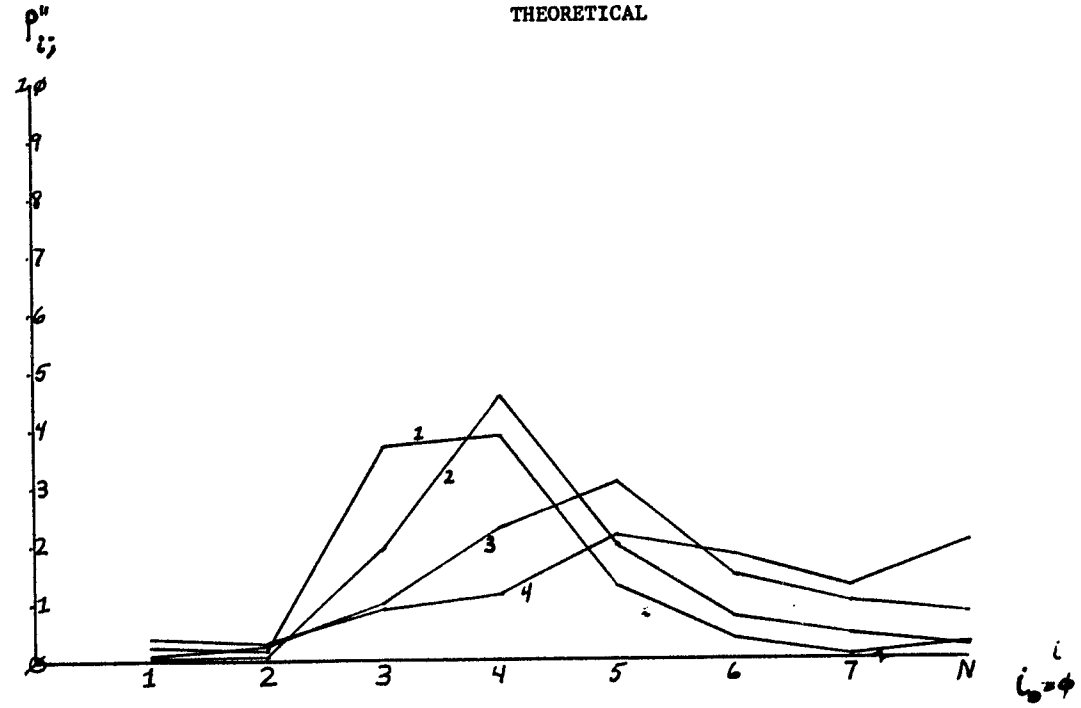


SUBJECT G.L. CONDITION: RECALL LETTER U AT 109 MSEC. FIG.13.p.20.

DATA

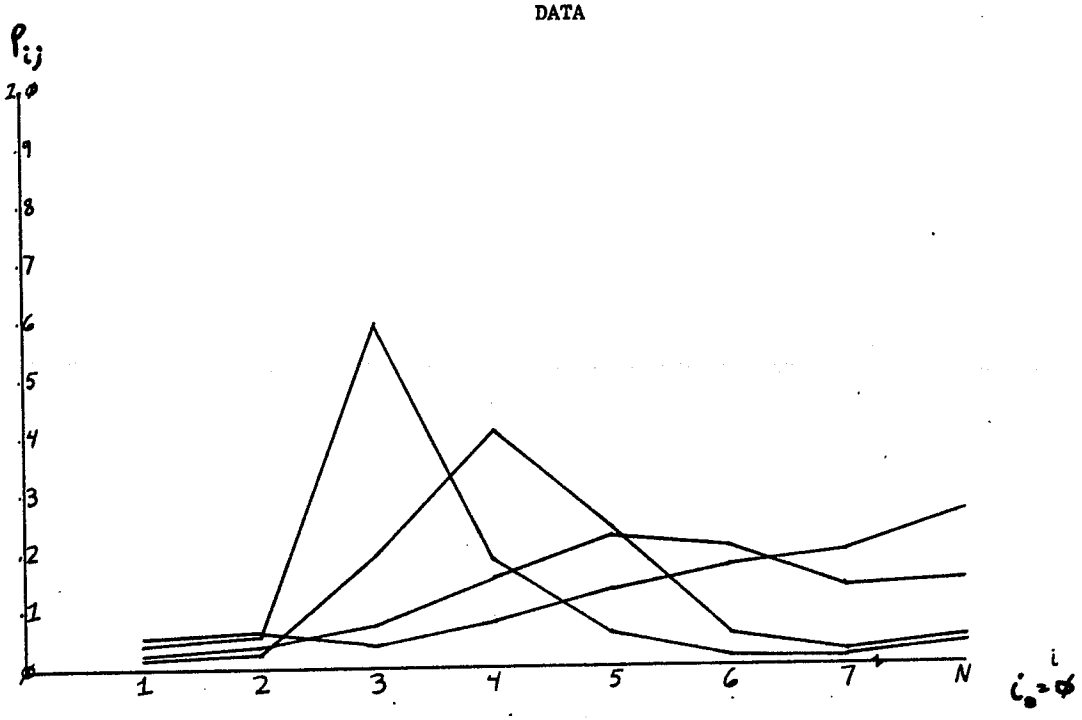


THEORETICAL

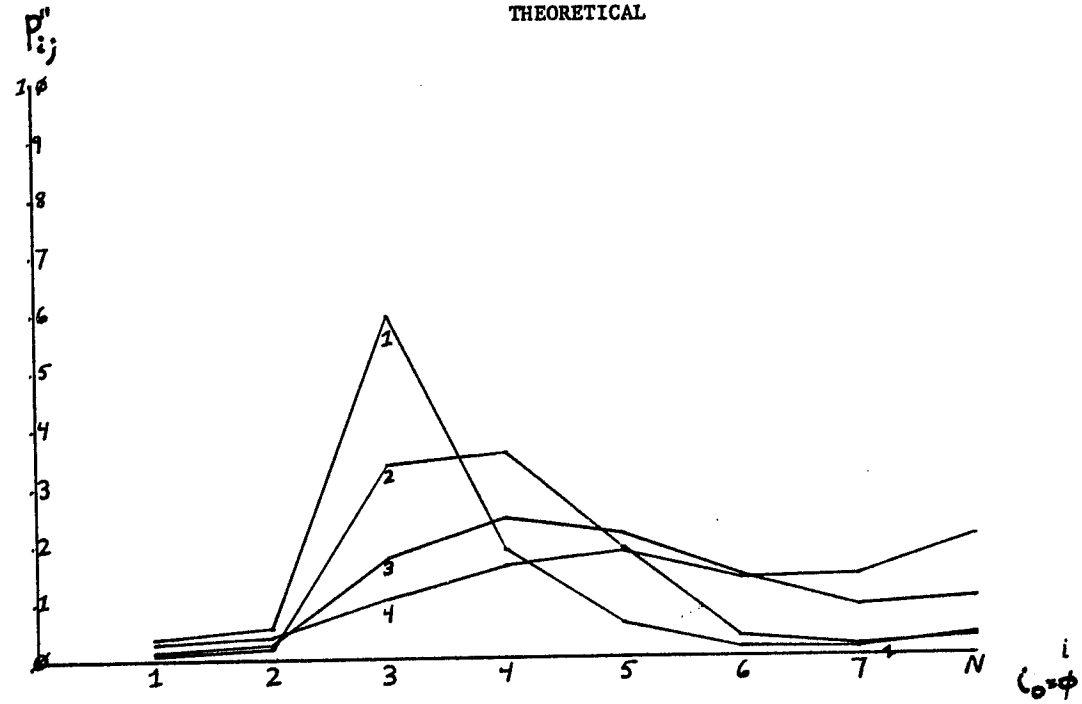


SUBJECT G.L. CONDITION: RECALL SQUARE AT 109 MSEC. FIG.13.p.21.

DATA

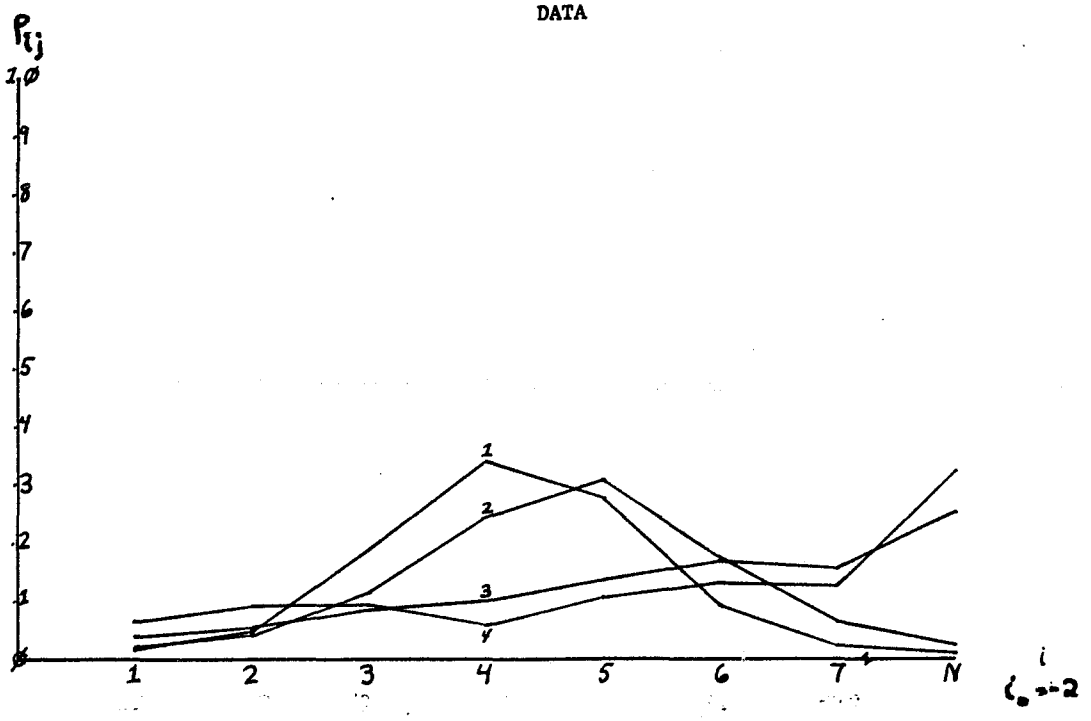


THEORETICAL

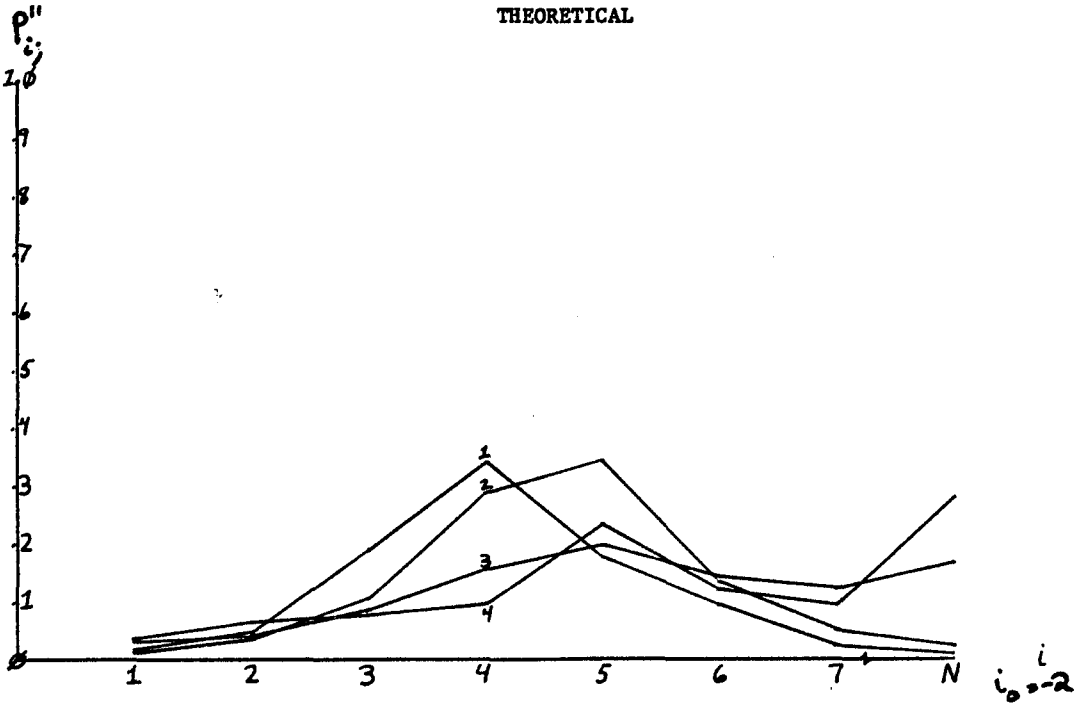


SUBJECT G.L. CONDITION: RECALL ARROW AT 109 MSEC. FIG.13.p.22.

DATA

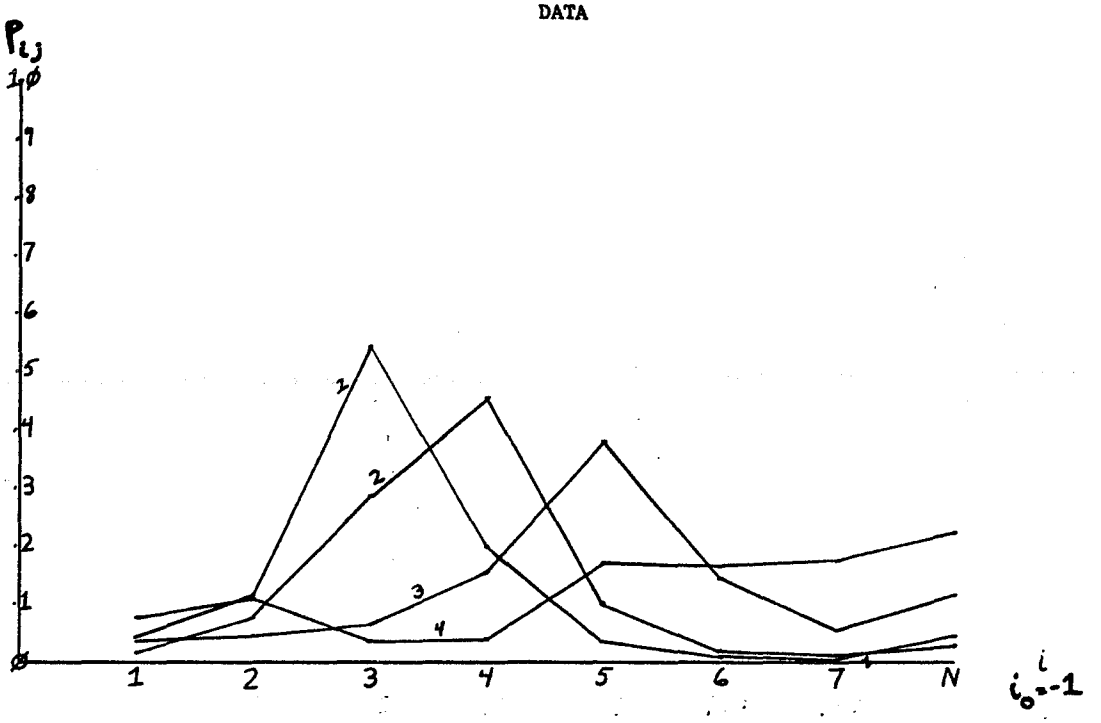


THEORETICAL

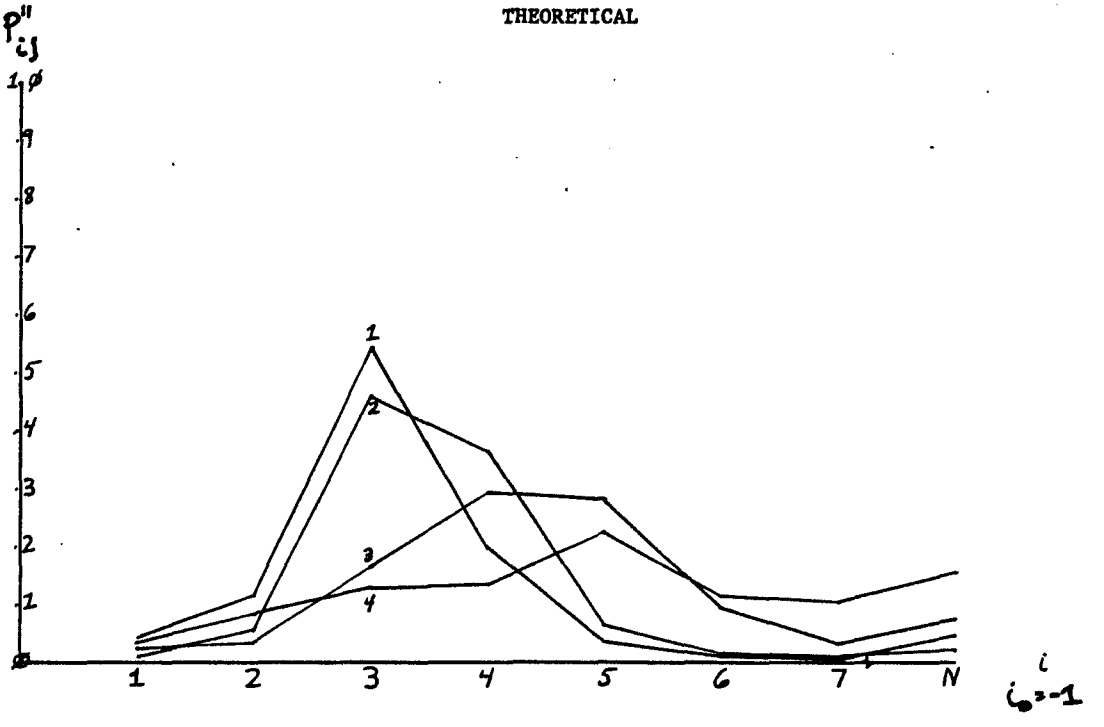


SUBJECT G.L. CONDITION: RECALL LETTER C AT 144 MSEC. FIG.13.p.23.

DATA

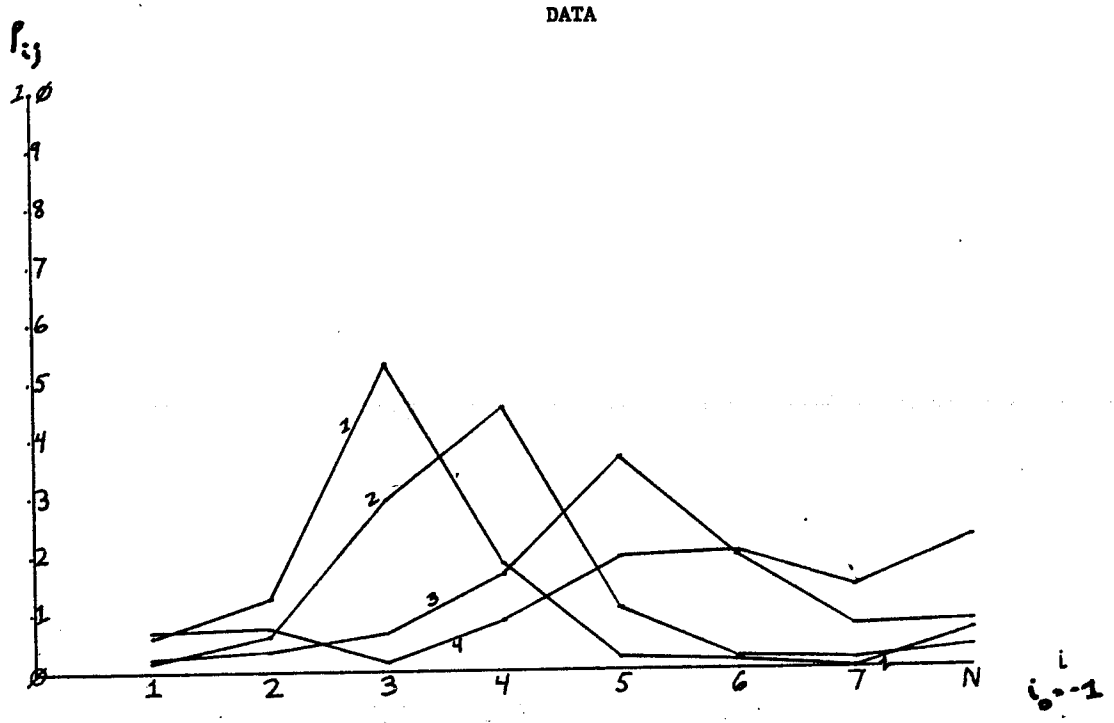


THEORETICAL

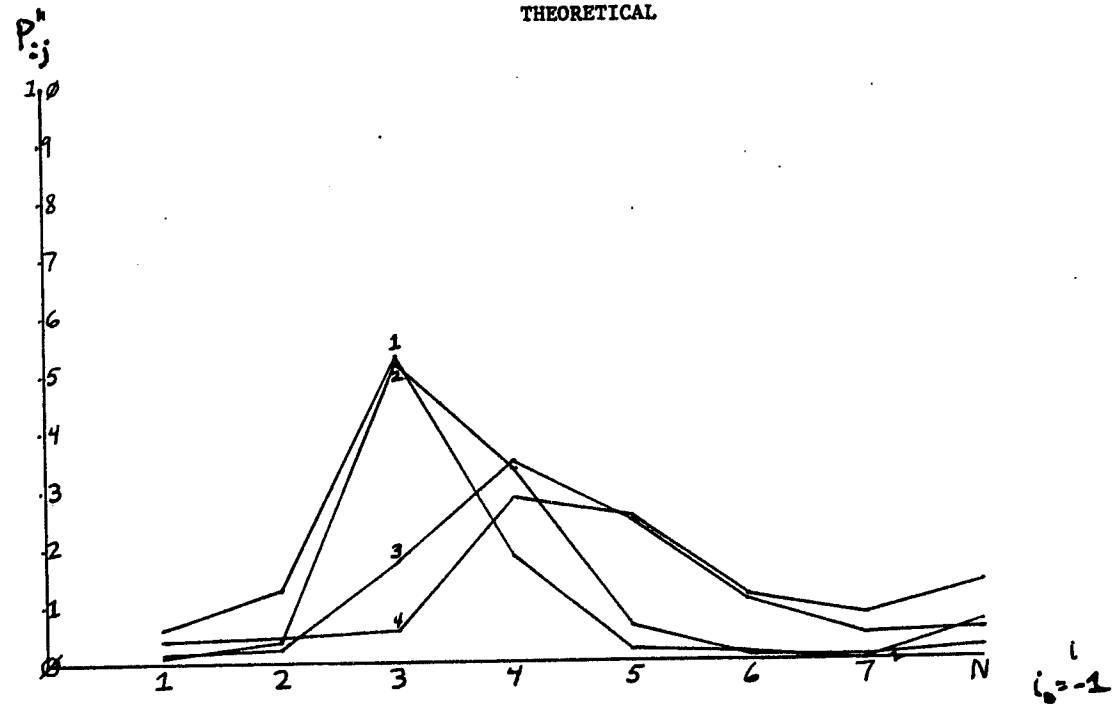


SUBJECT G.L. CONDITION: RECALL LETTER U AT 144 MSEC. FIG.13.p.24.

DATA

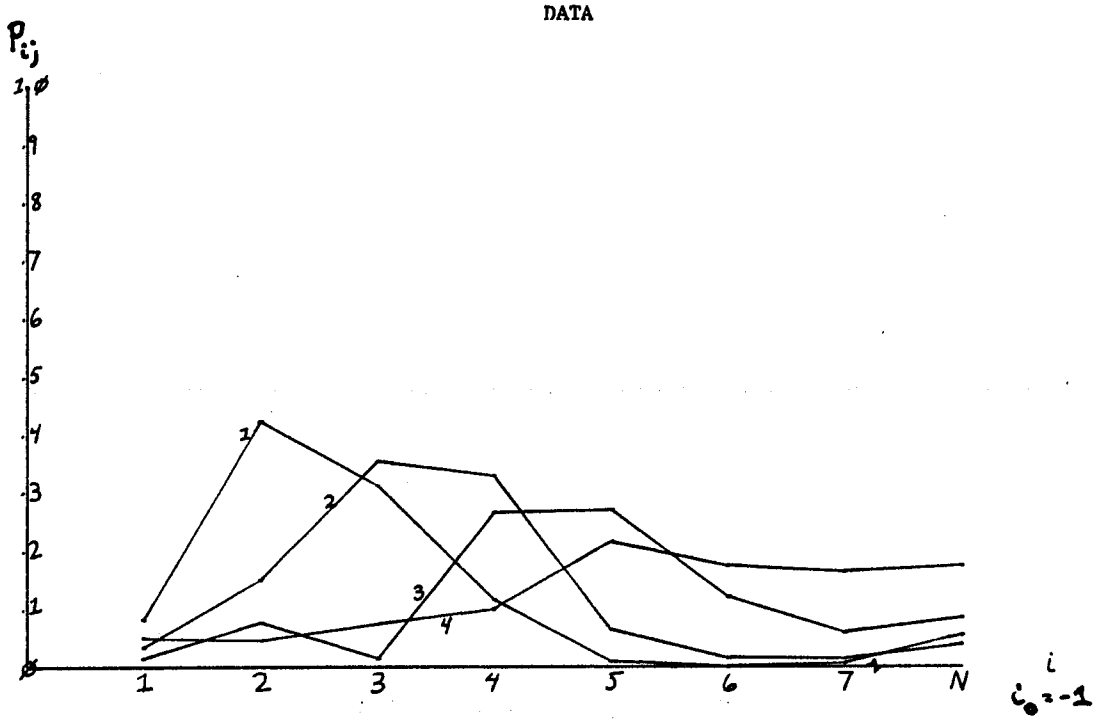


THEORETICAL

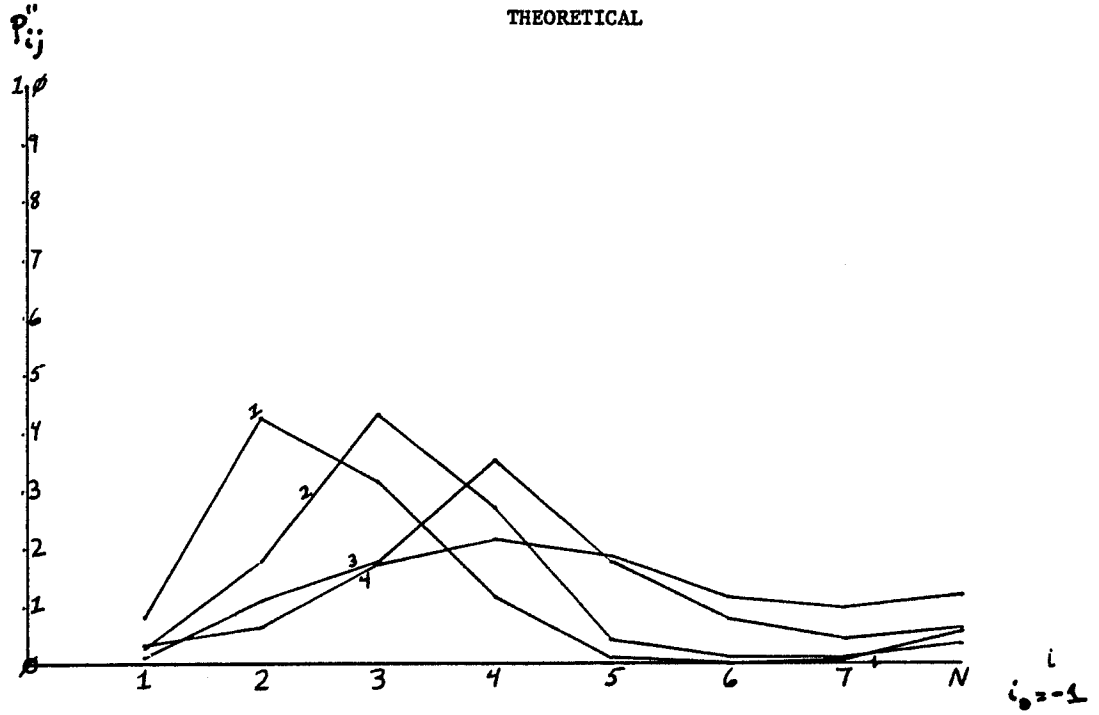


SUBJECT G.L. CONDITION: RECALL SQUARE AT 44 MSEC. FIG.13.p.25.

DATA

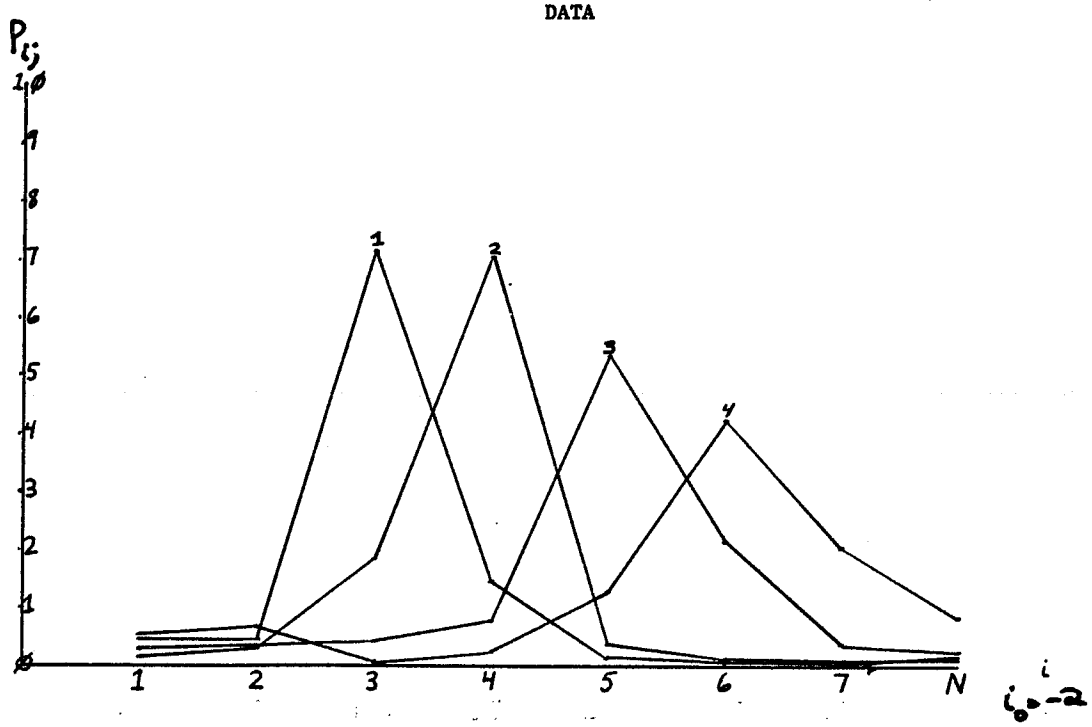


THEORETICAL

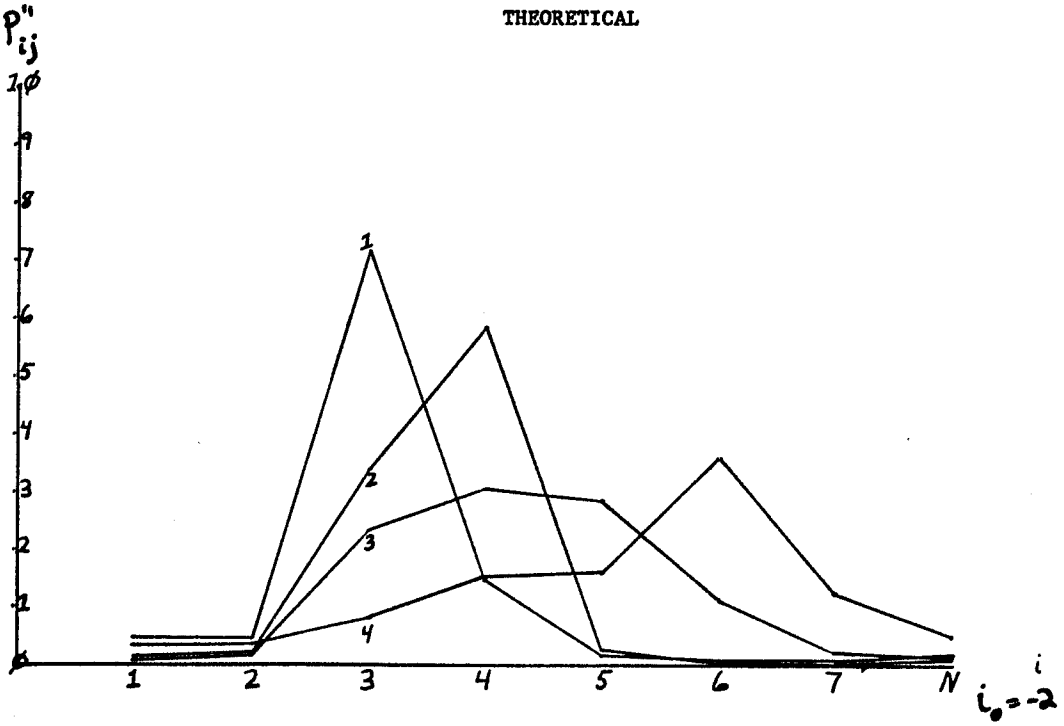


SUBJECT G.L. CONDITION: RECALL LETTER C AT 214 MSEC. FIG.13.p.26.

DATA

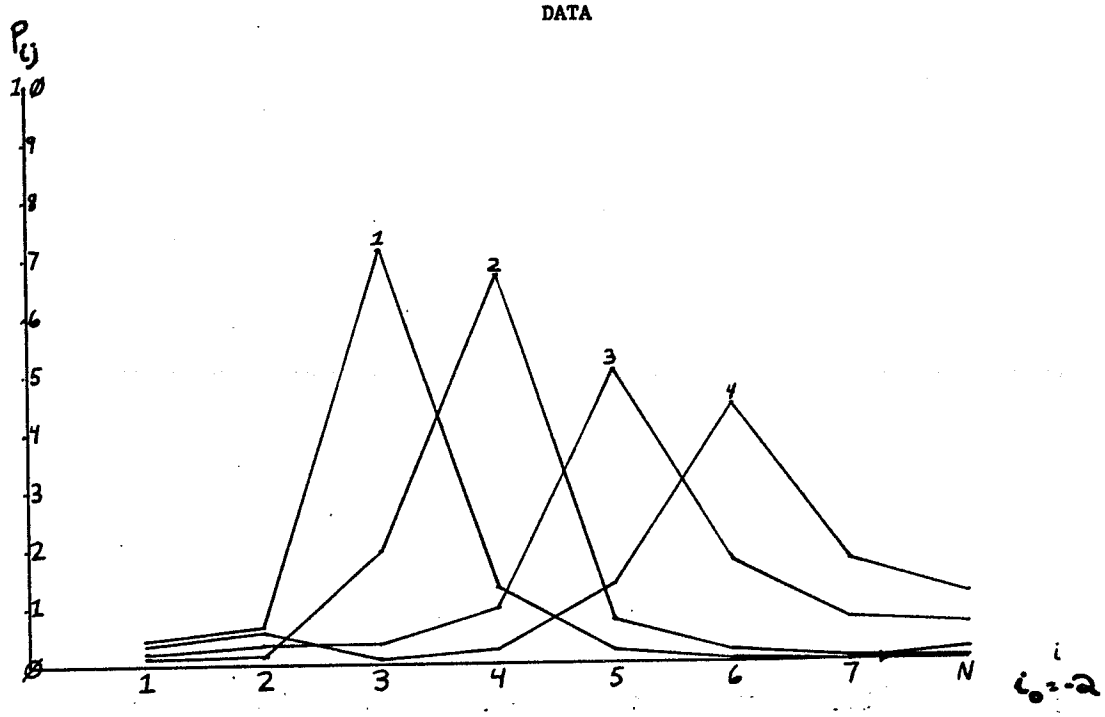


THEORETICAL

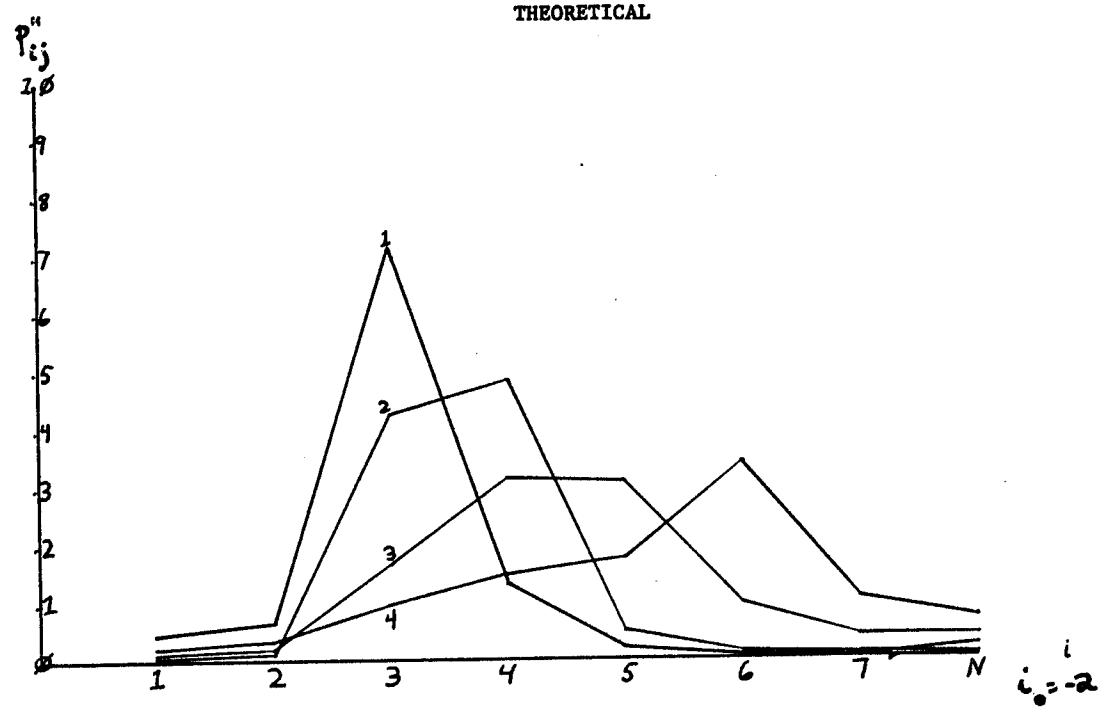


SUBJECT G.L. CONDITION: RECALL LETTER U AT 214 MSEC. FIG.13.p.27.

DATA

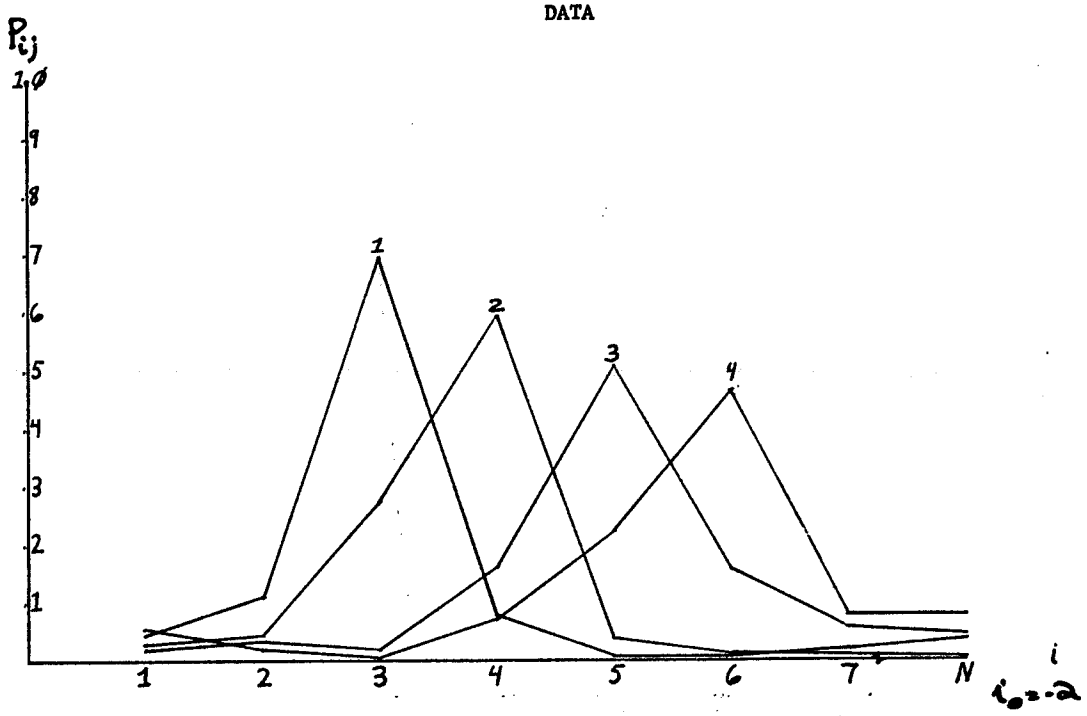


THEORETICAL

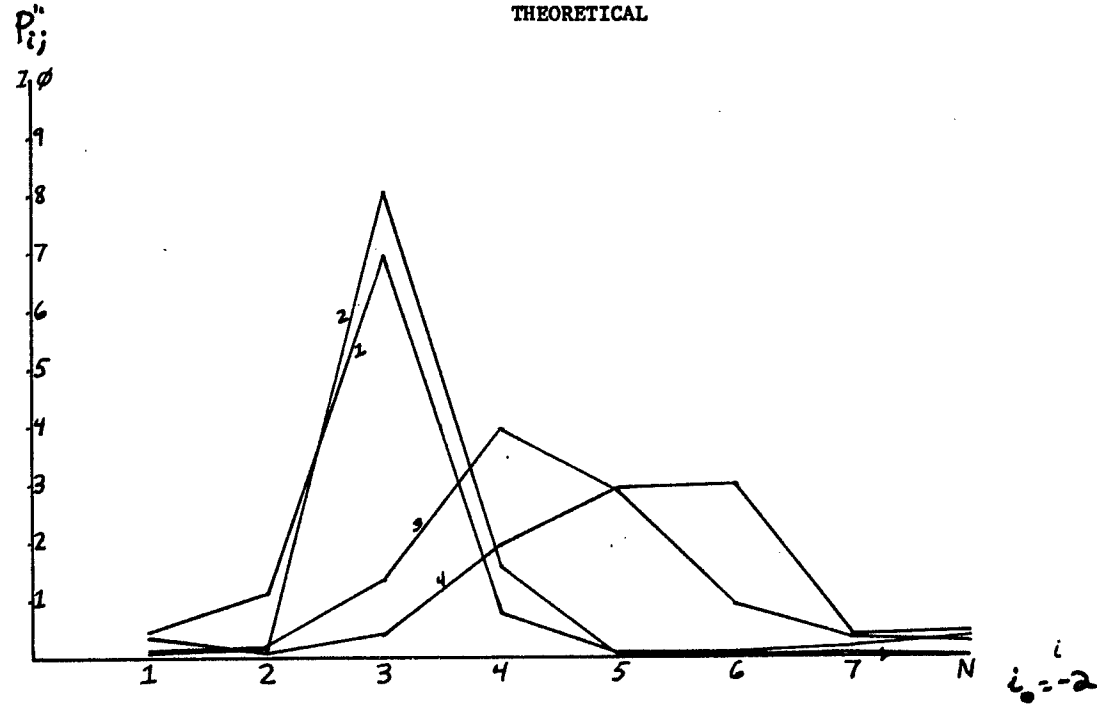


SUBJECT G.L. CONDITION: RECALL SQUARE AT 214 MSEC. FIG.13.p.28.

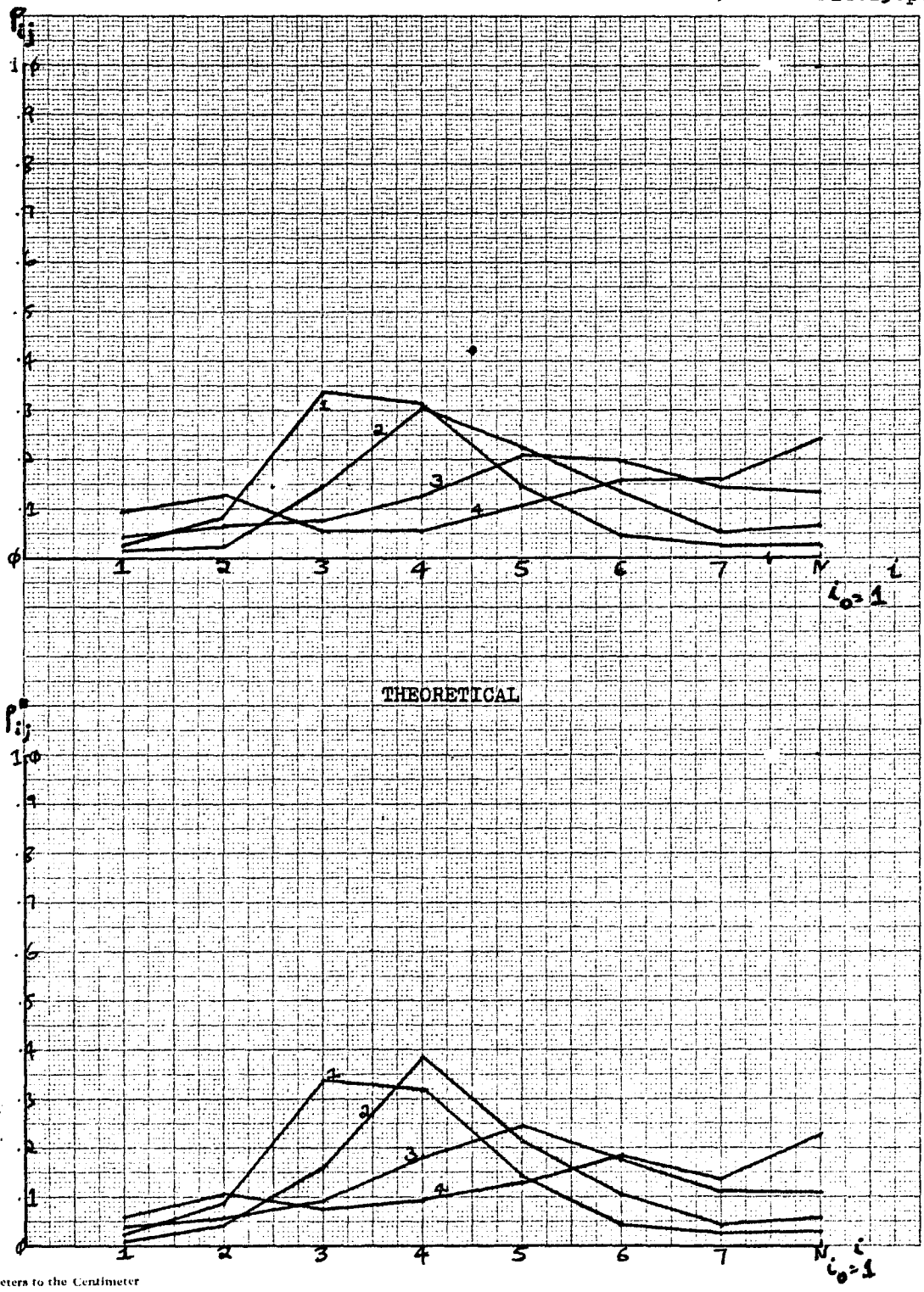
DATA



THEORETICAL

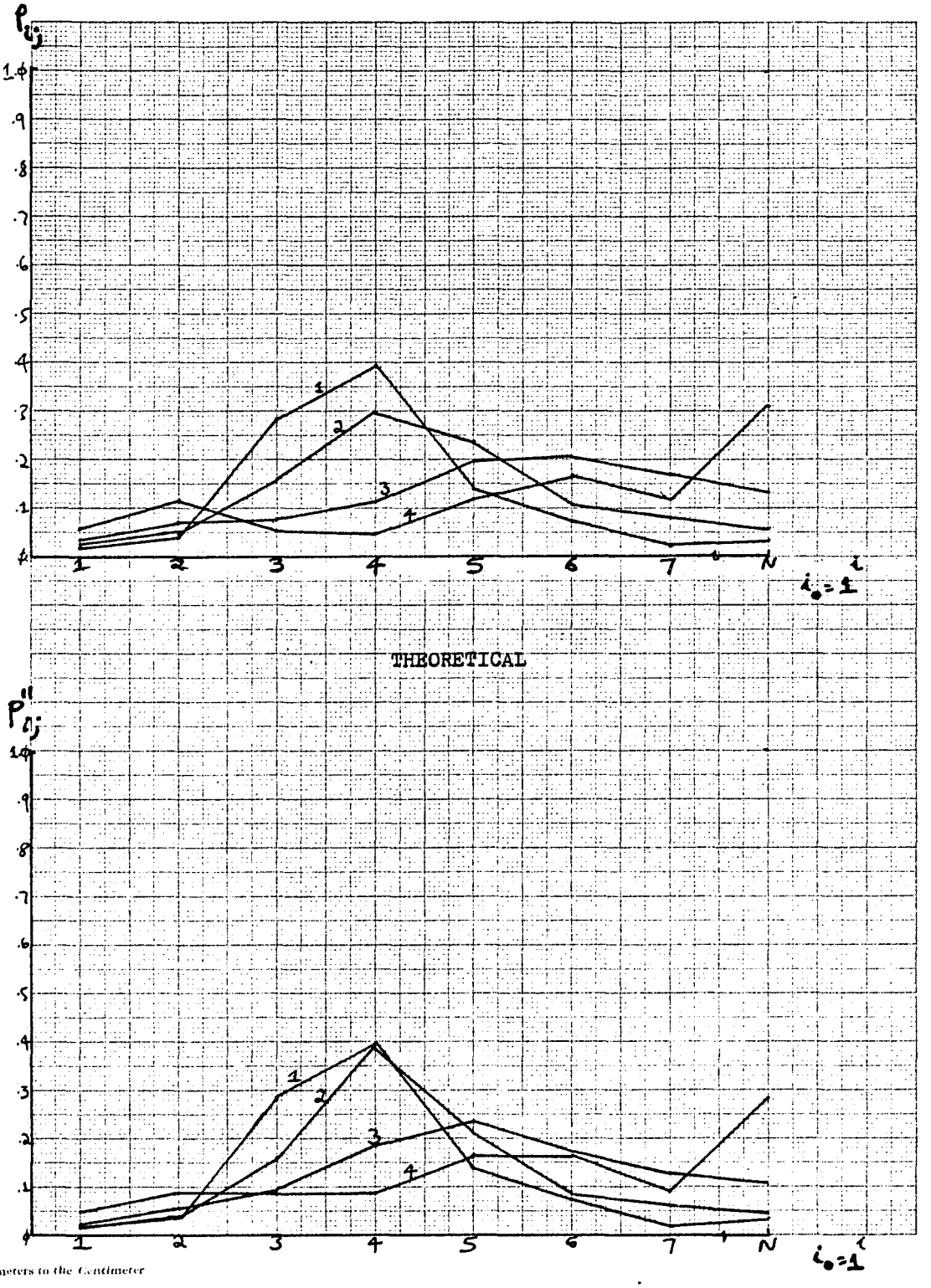


SUBJECT: A.K. CONDITION: RECALL LETTER C AT 109 MSEC. FIG.13.p.29.



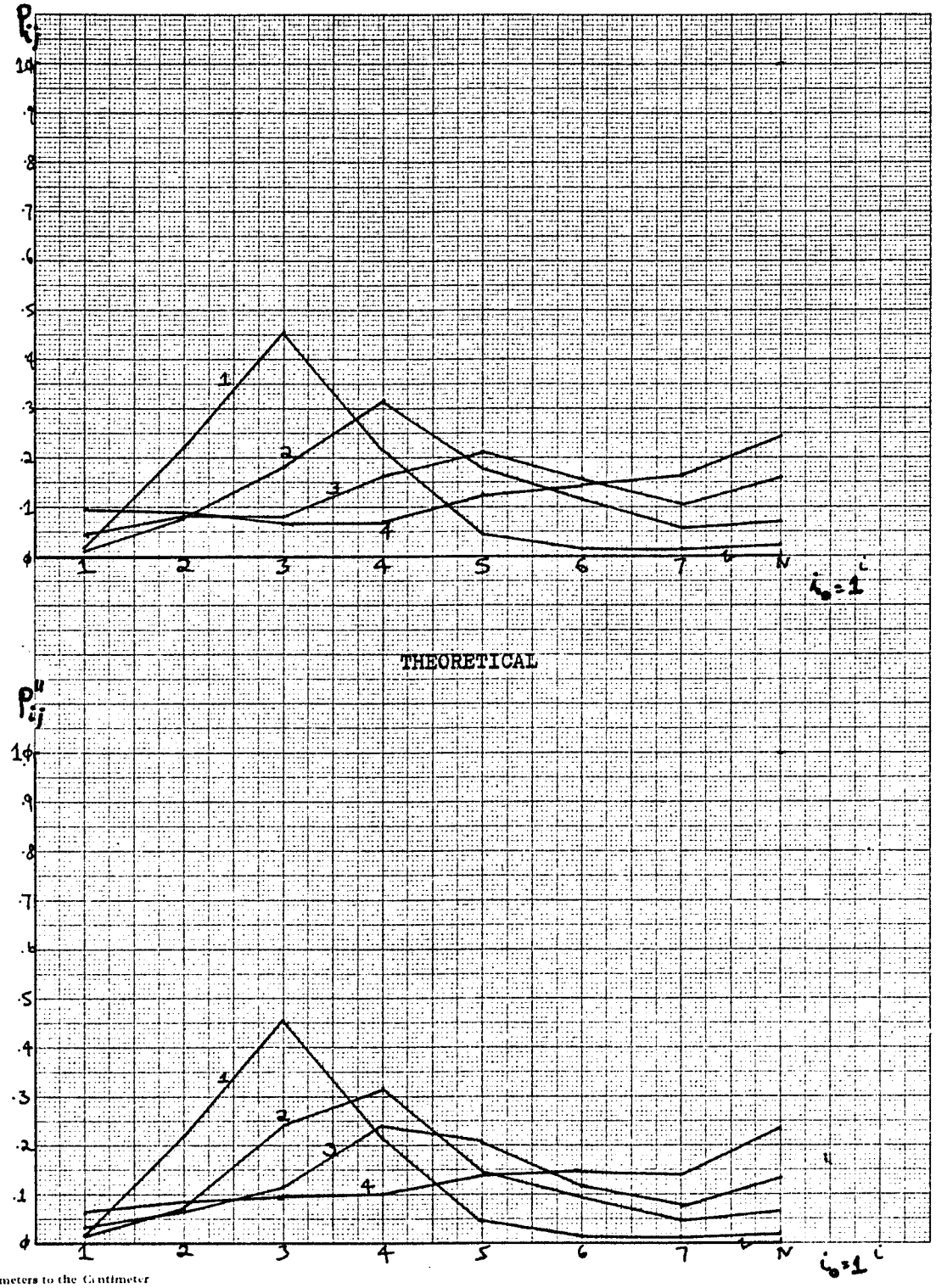
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL LETTER U AT 109 MSEC.FIG.13.p.30.



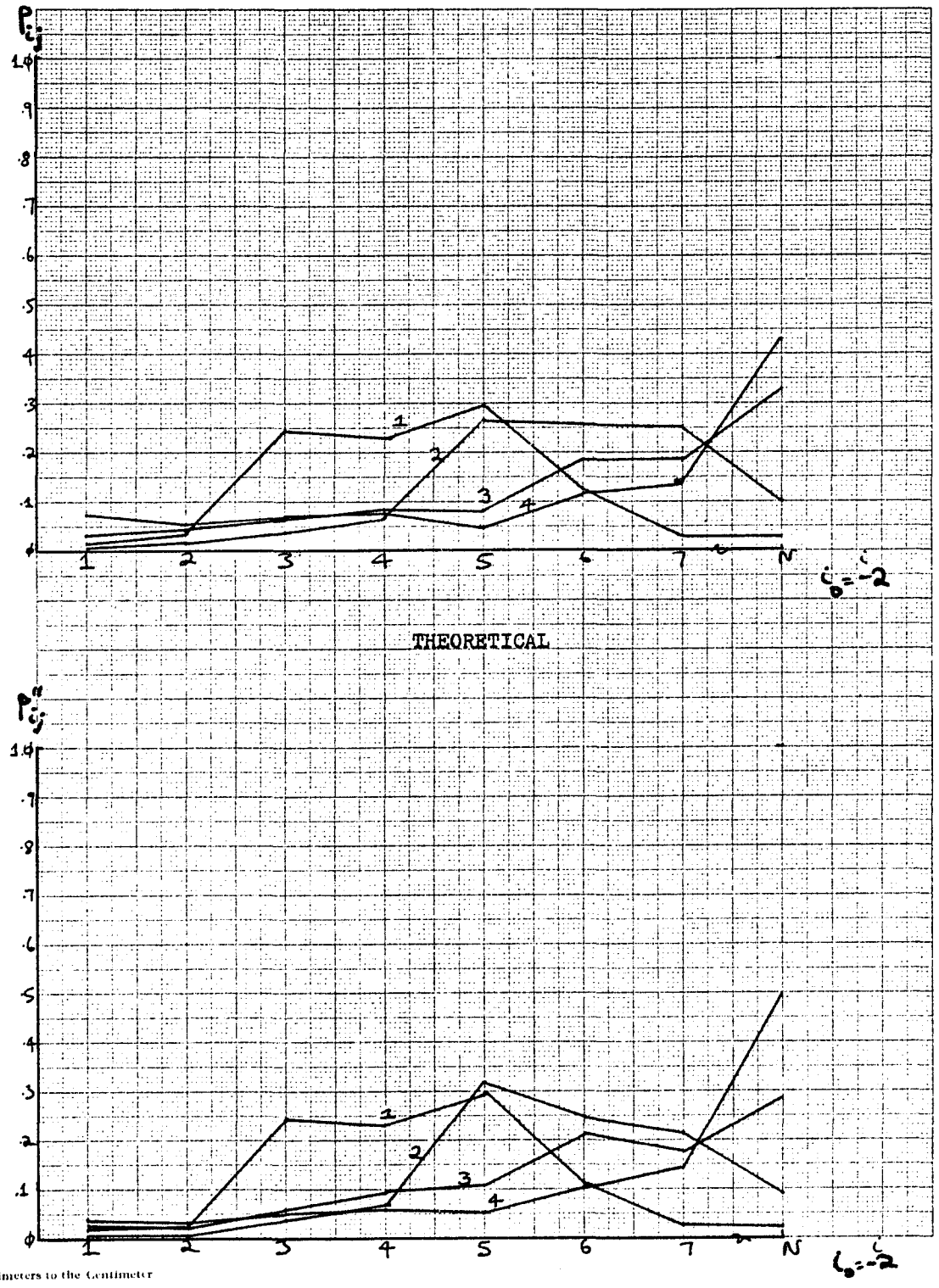
To Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL SQUARE AT 109 MSEC. FIG.13.p.31.



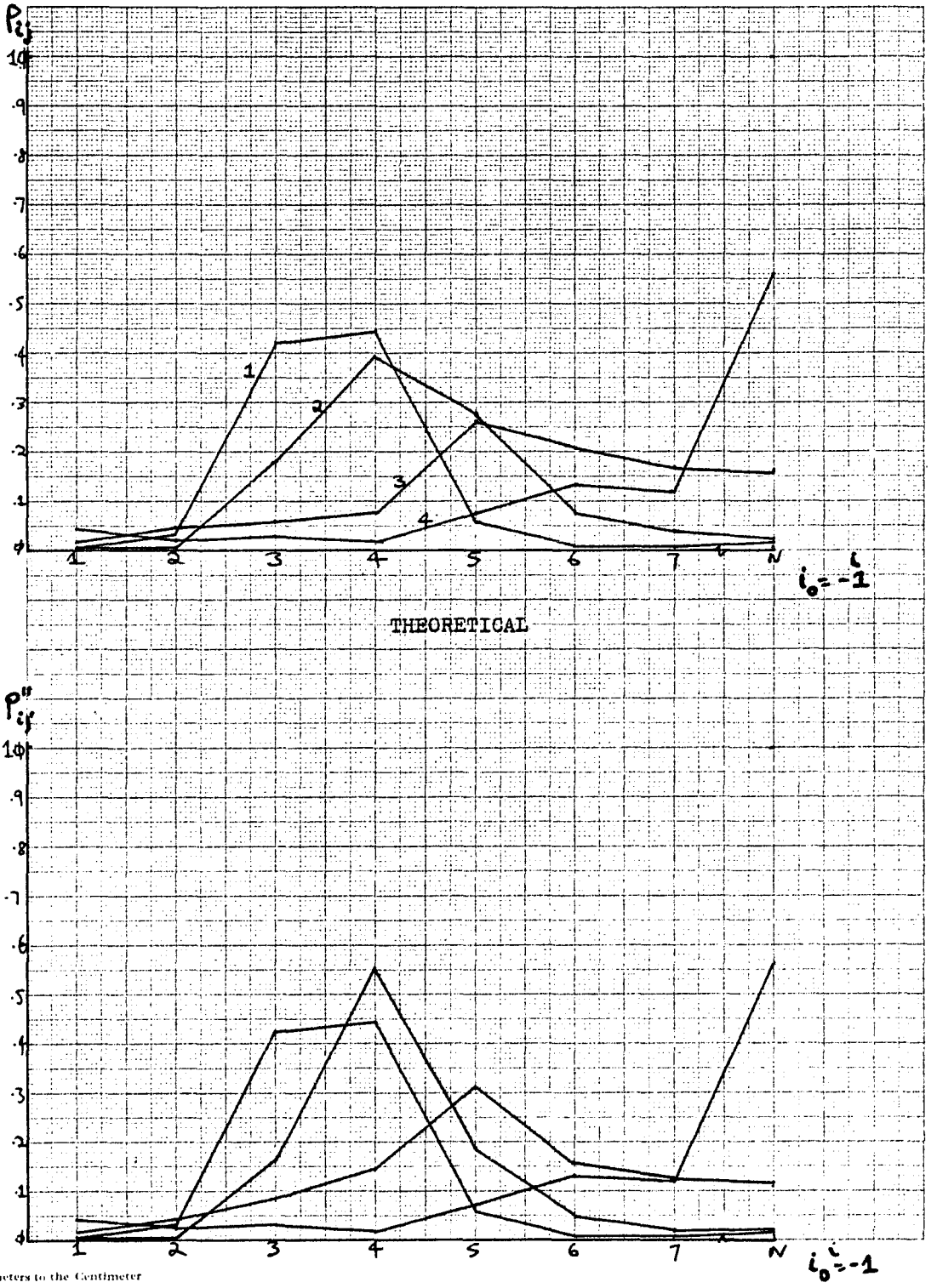
10 Millimeters to the Centimeter

SUBJECT:A.K. CONDITION: RECALL ARROW AT 109 MSEC. FIG.13.p.32.



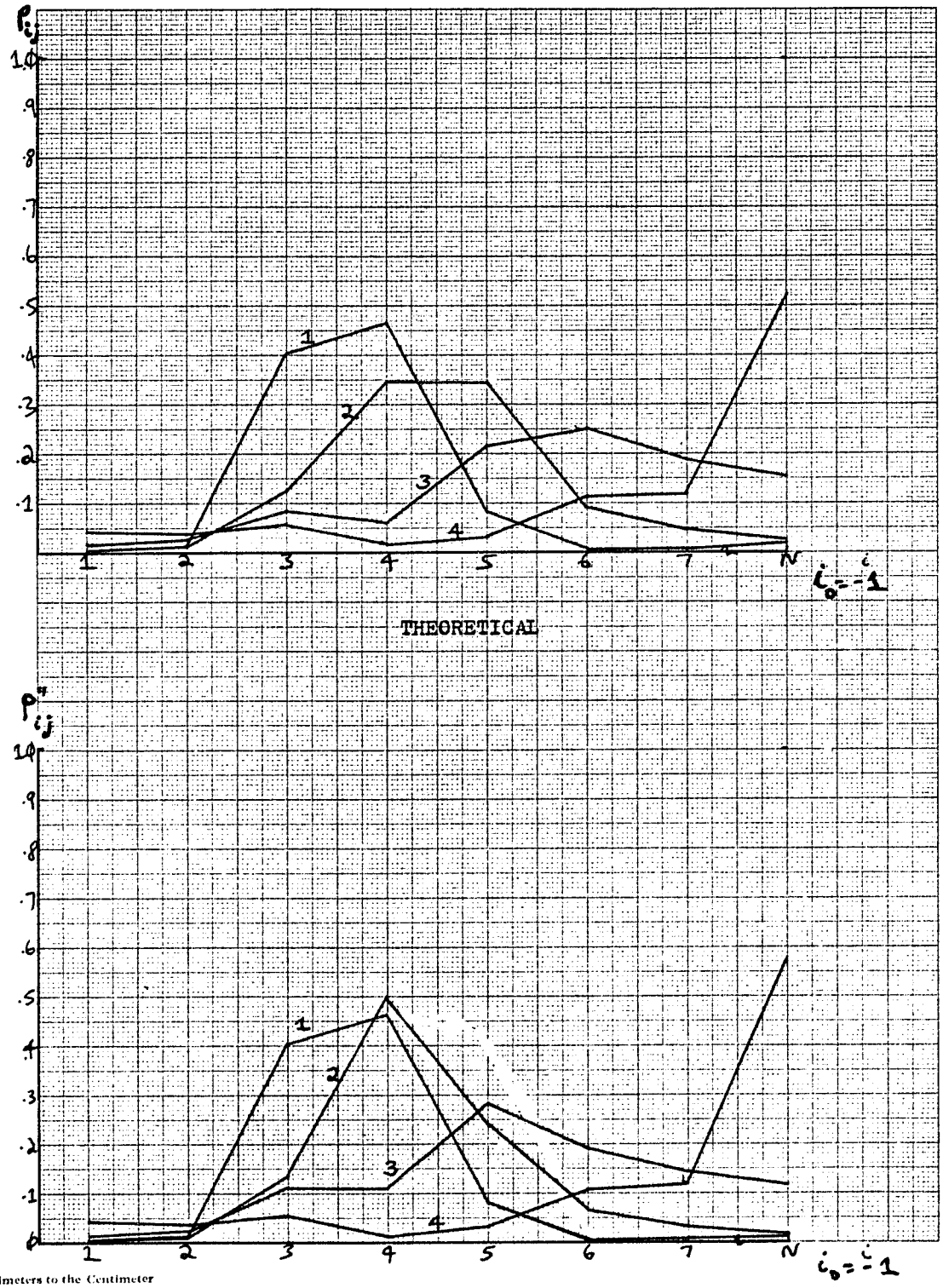
50 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL LETTER C AT 144 MSEC. FIG.13.p.33.



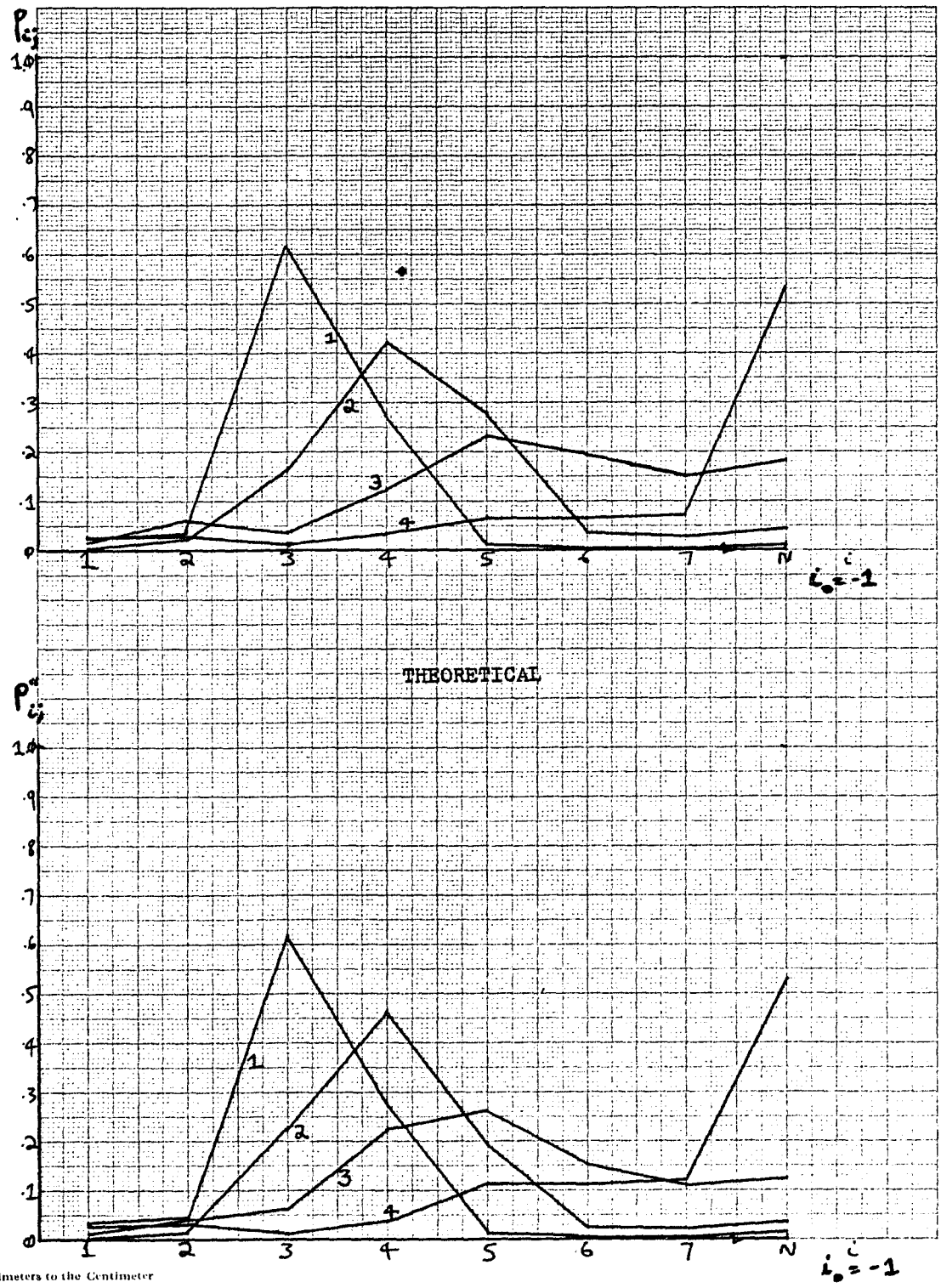
50 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL LETTER U AT 144 MSEC. FIG.13.p.34.



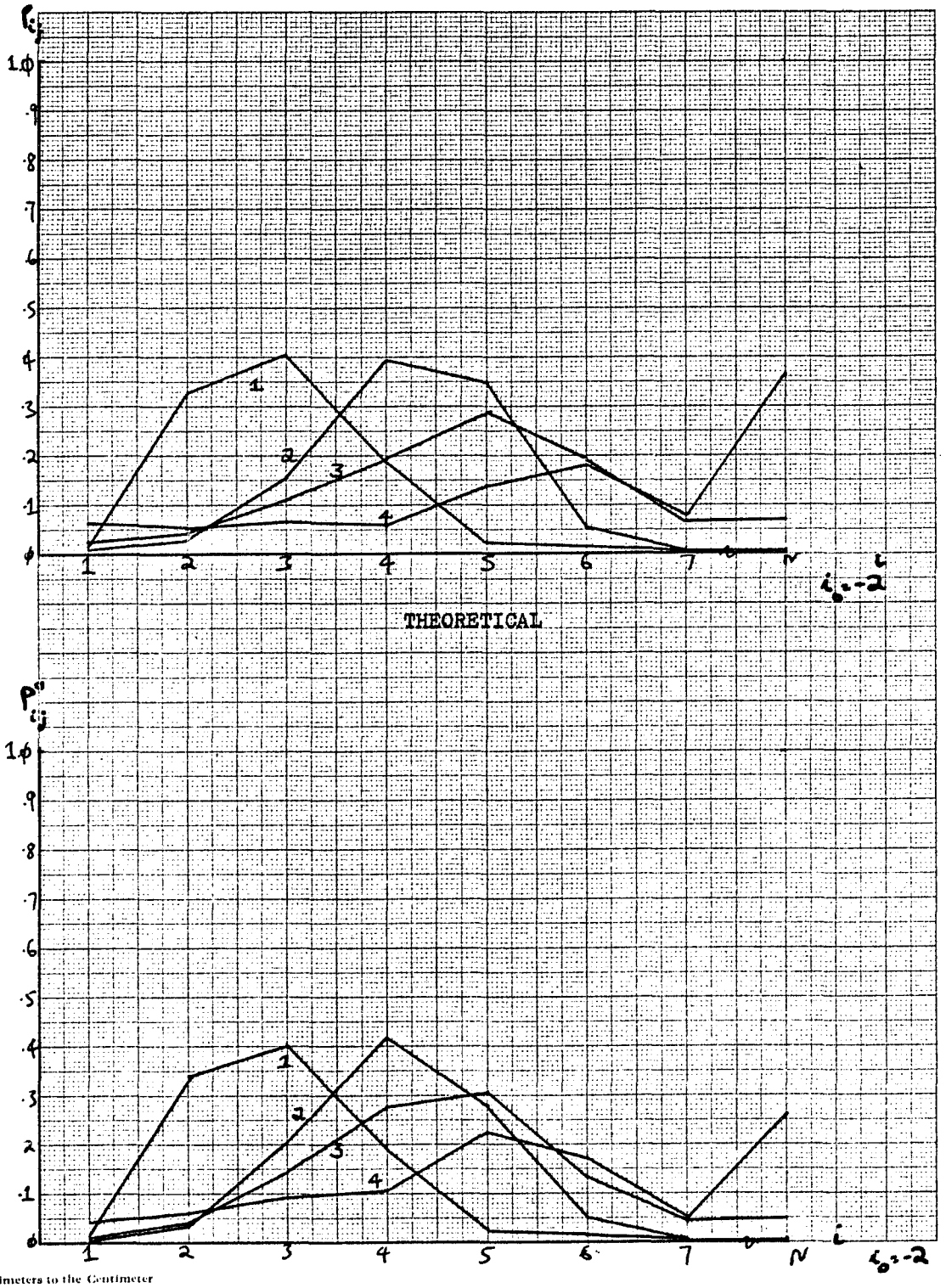
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL SQUARE AT 144 MSEC. FIG.13.p.35.



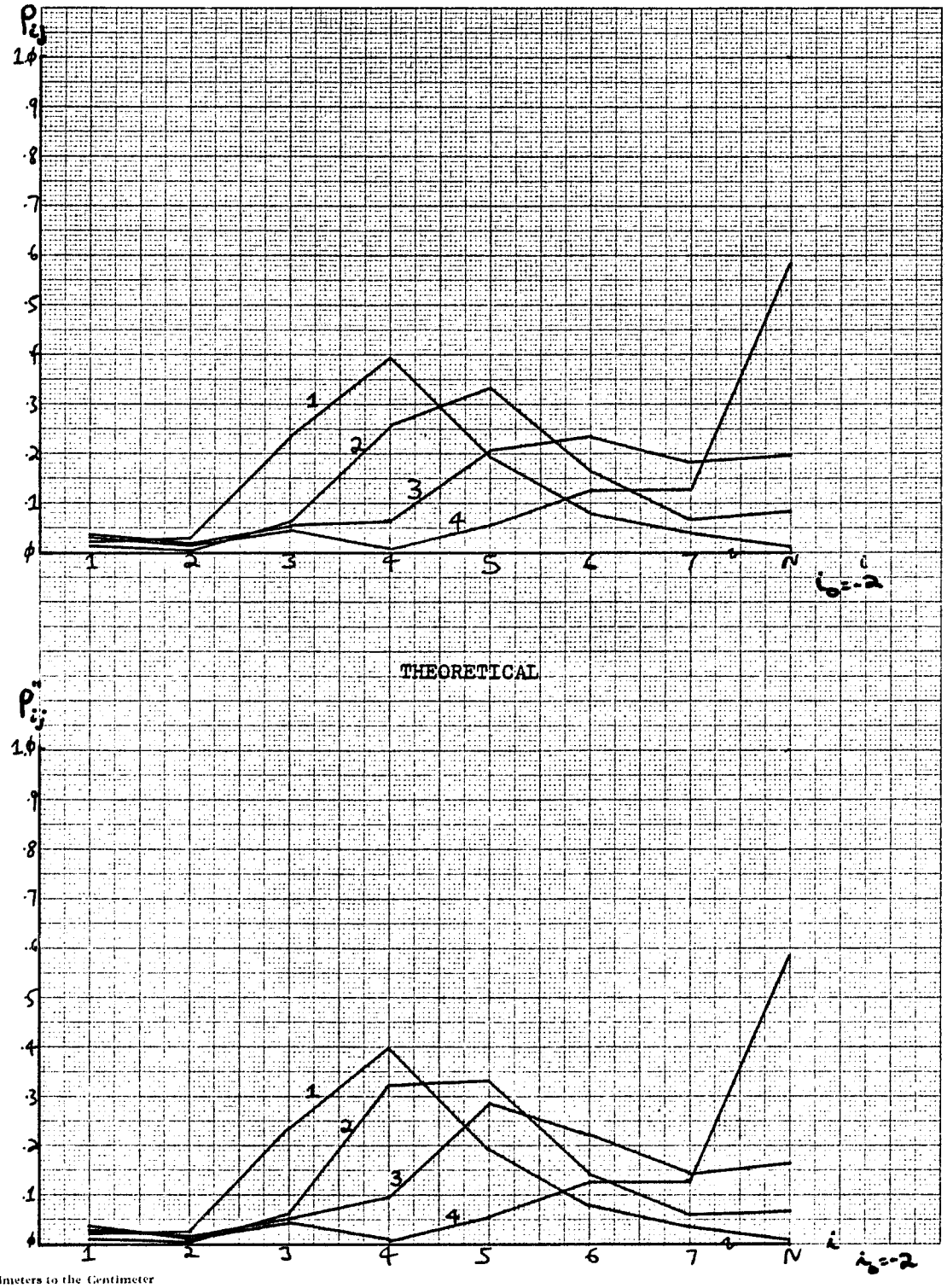
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL ARROW AT 144 MSEC.FIG.13.p.36.



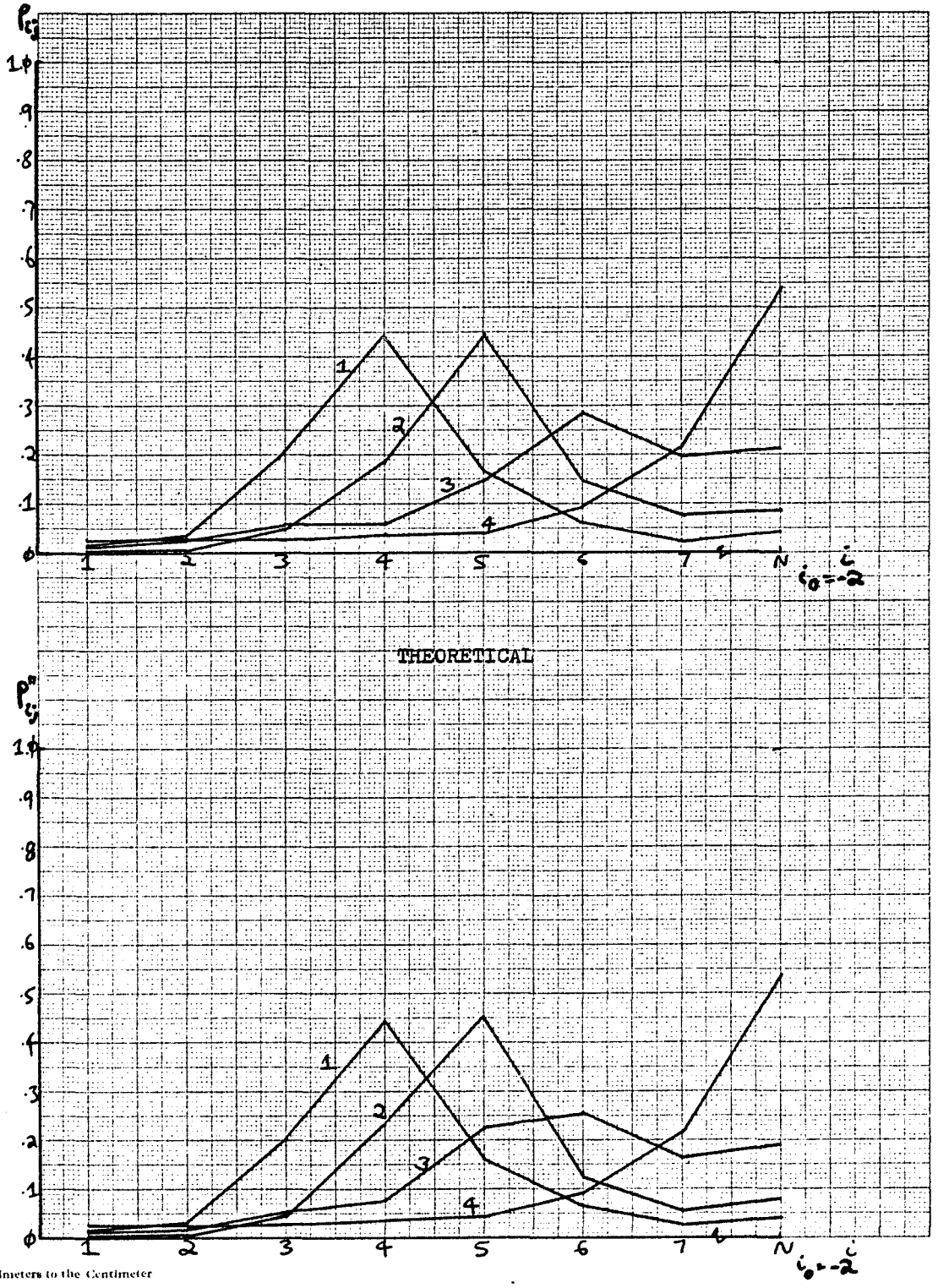
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL LETTER C AT 178 MSEC. FIG.13.p.37



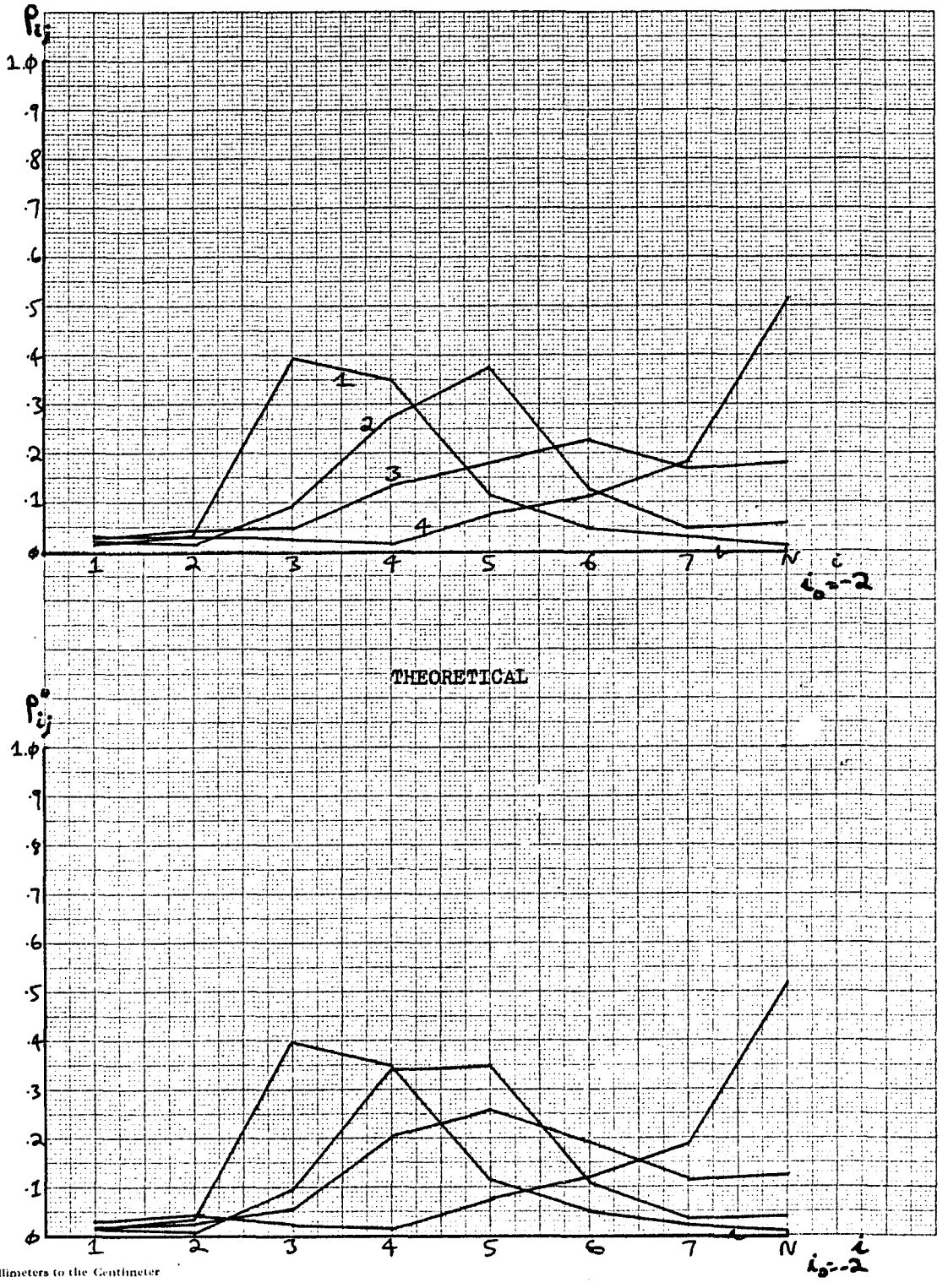
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL LETTER U AT 178 MSEC.FIG.13.p.38.



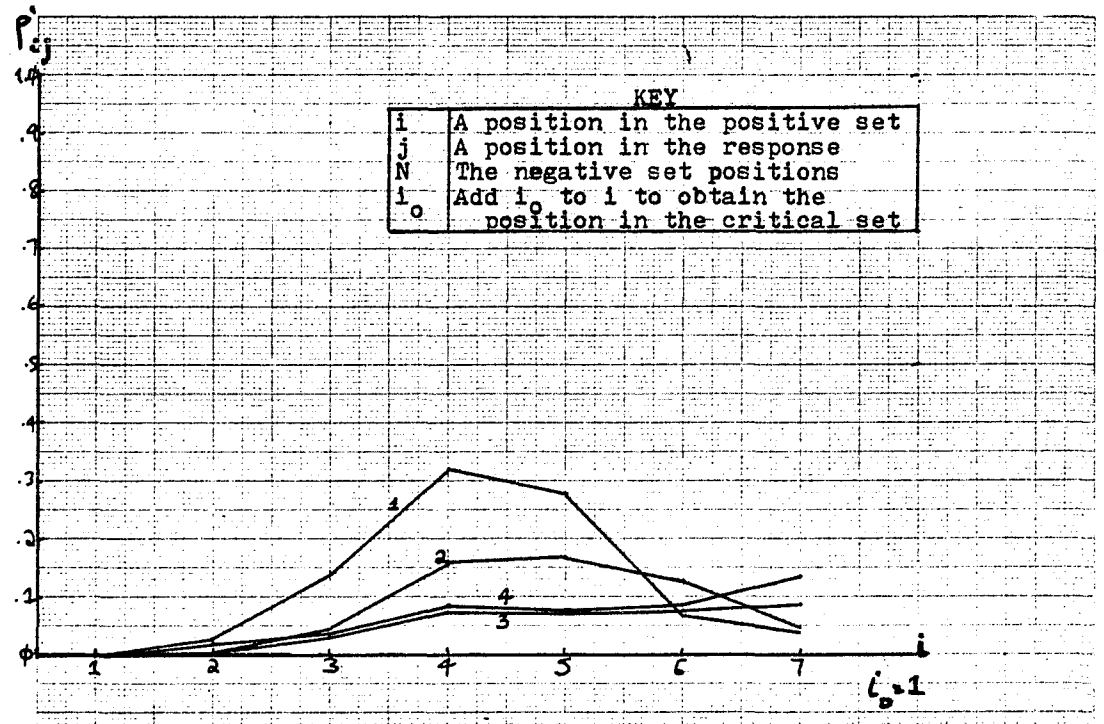
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL SQUARE AT 178 MSEC. FIG. 13. p. 39.

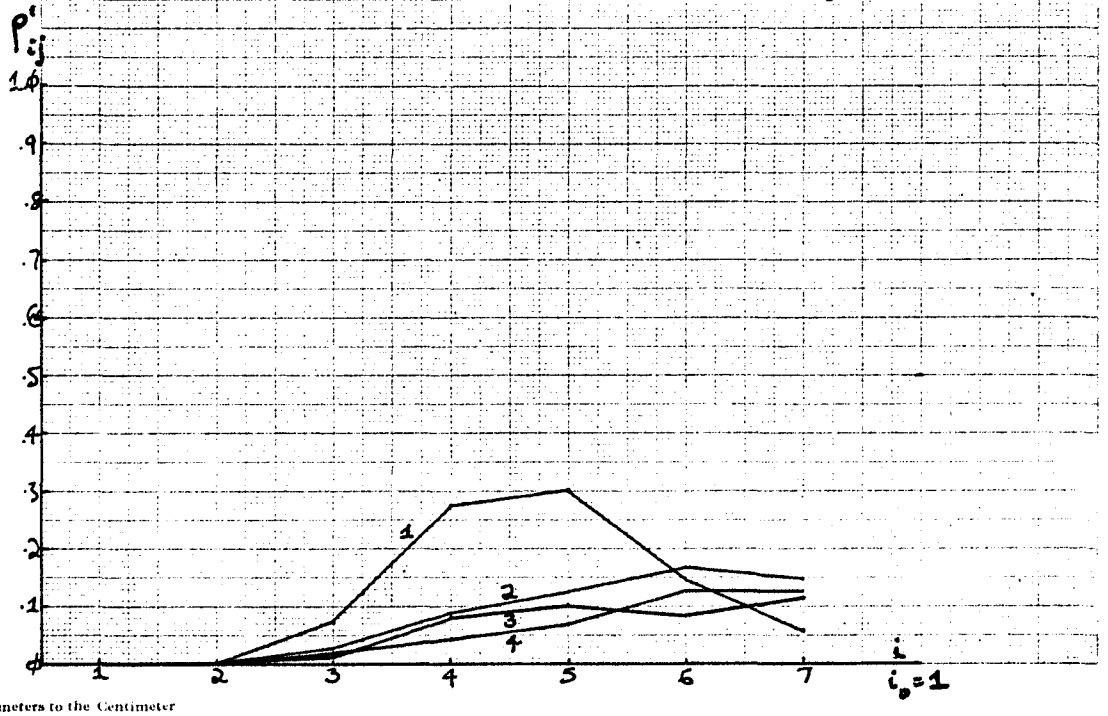


10 Millimeters to the Centimeter

SUBJECT: A.R. RECALL 4 LETTER C AT 75 MSEC. FIG.14.p.1.

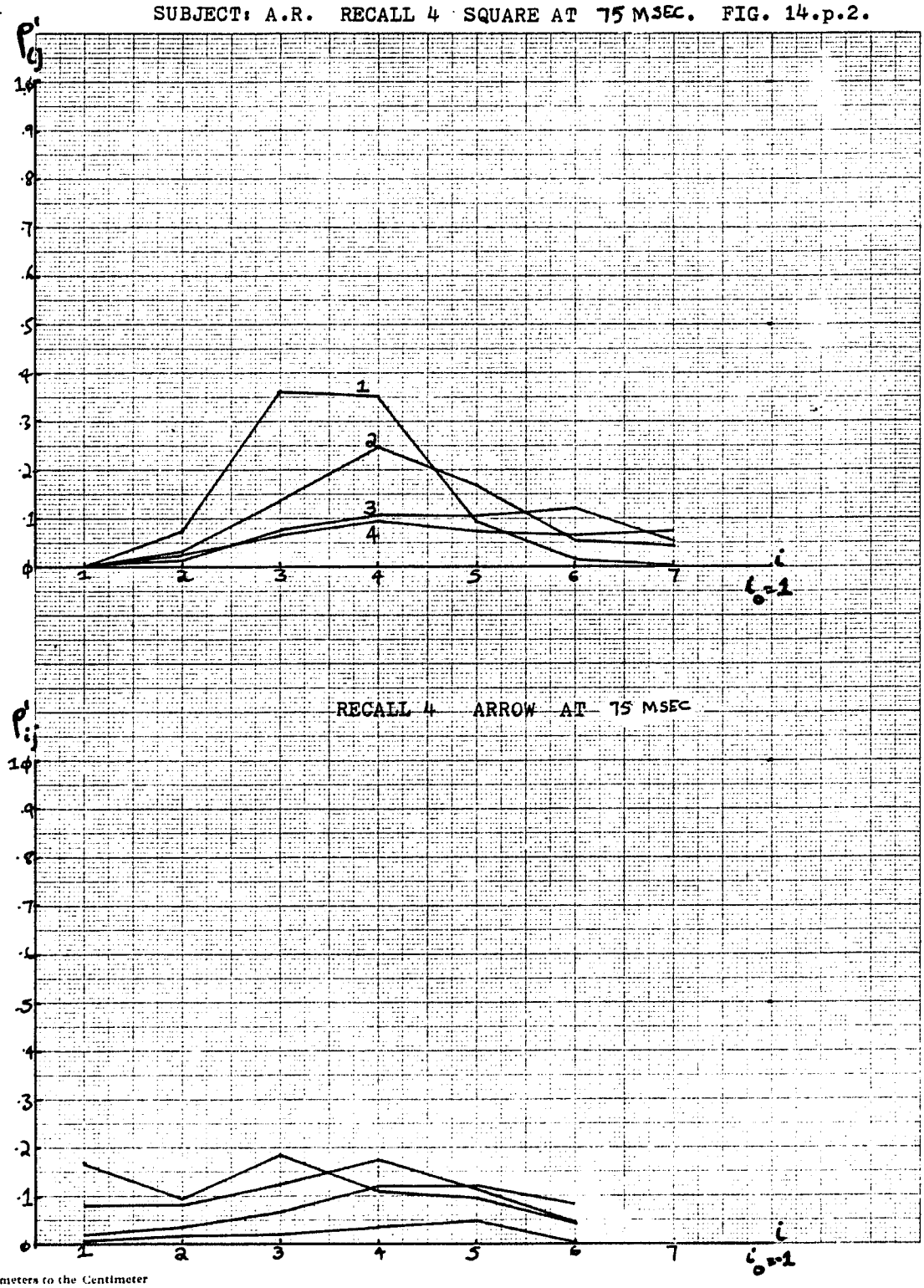


RECALL 4 LETTER U AT 75 MSEC



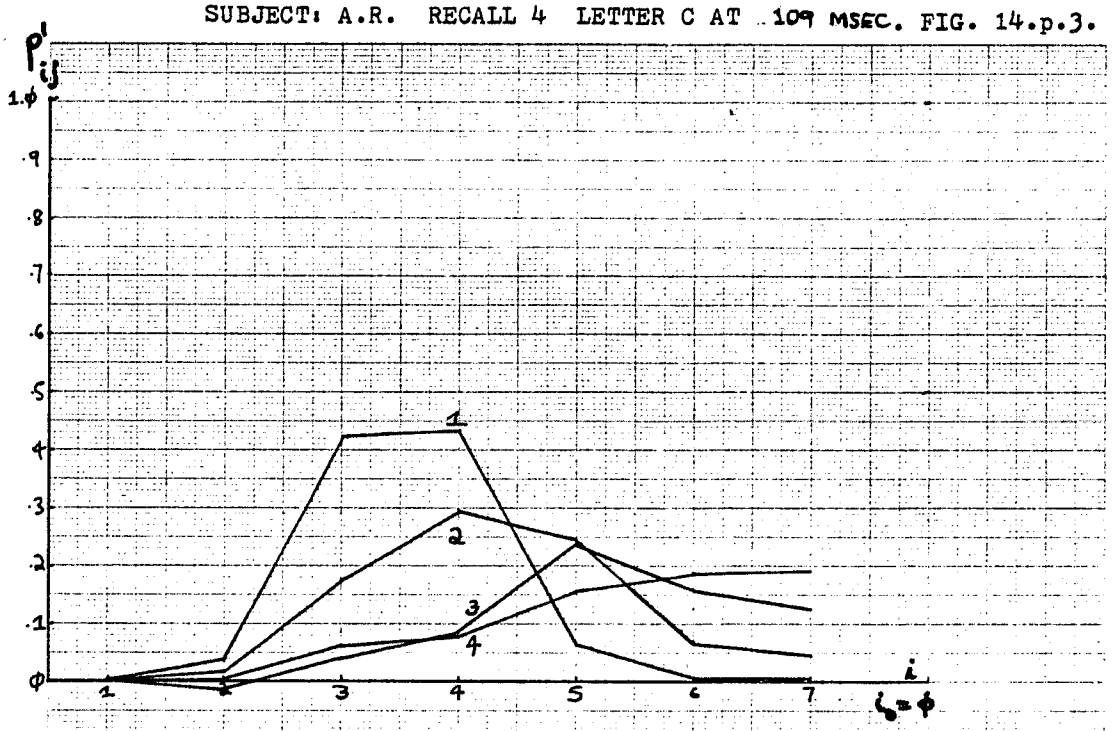
10 Millimeters to the Centimeter

SUBJECT: A.R. RECALL 4 SQUARE AT 75 MSEC. FIG. 14.p.2.

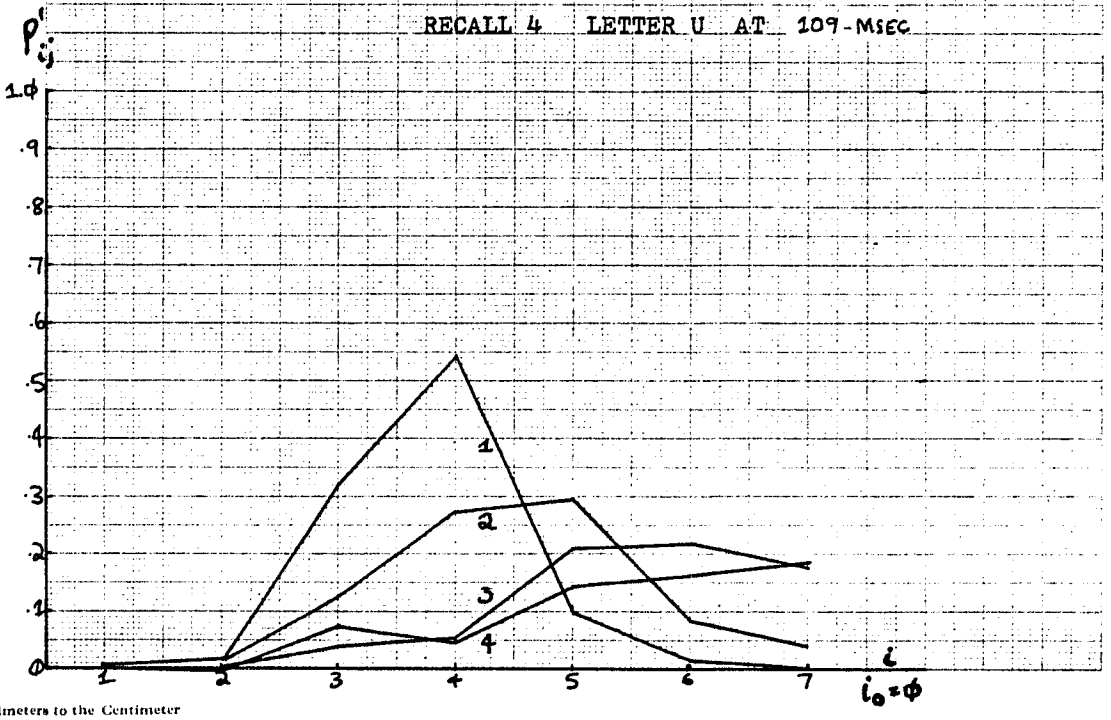


10 Millimeters to the Centimeter

SUBJECT: A.R. RECALL 4 LETTER C AT 109 MSEC. FIG. 14.p.3.

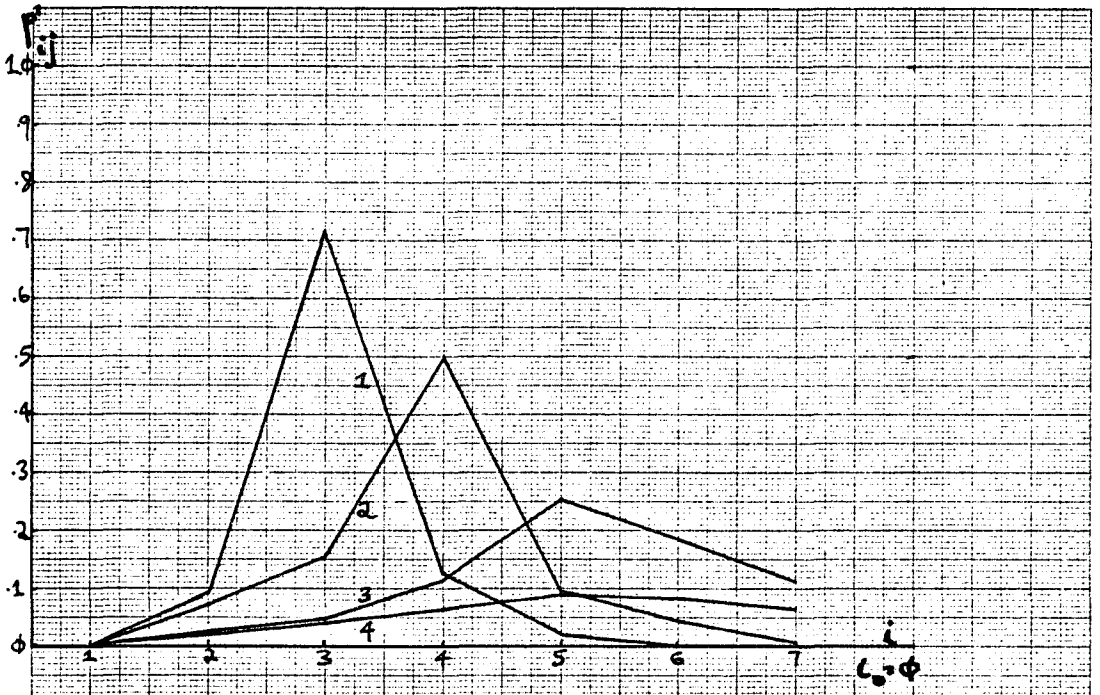


RECALL 4 LETTER U AT 109-MSEC

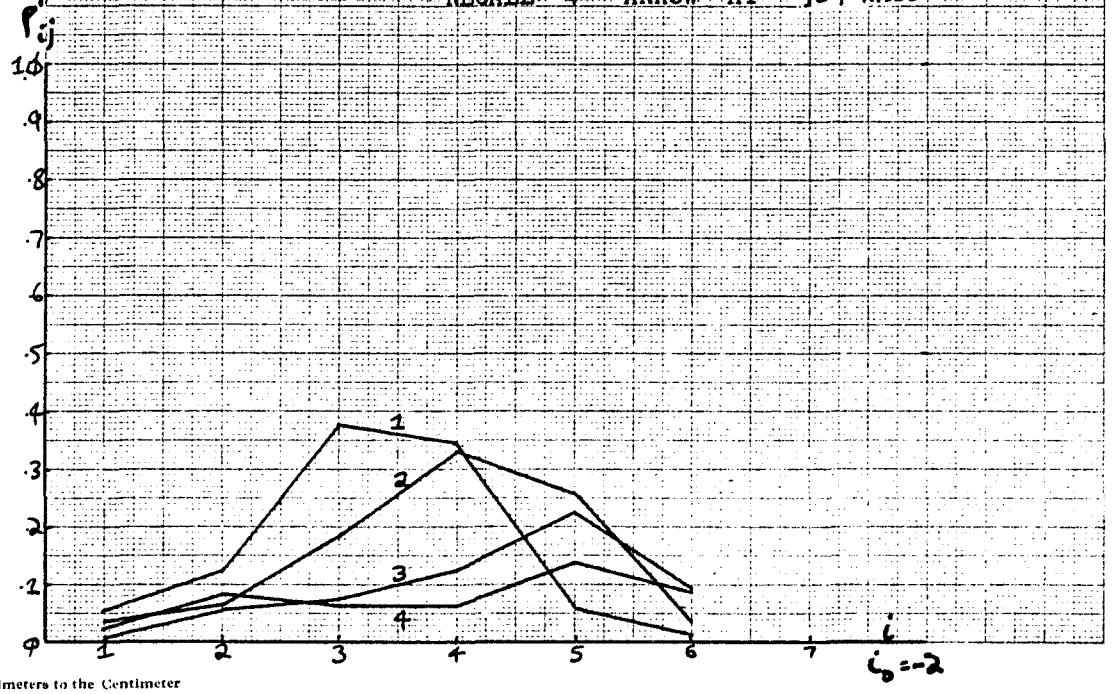


10 Millimeters to the Centimeter

SUBJECT: A.R. RECALL 4 SQUARE AT 109 MSEC. FIG.14.p.4.

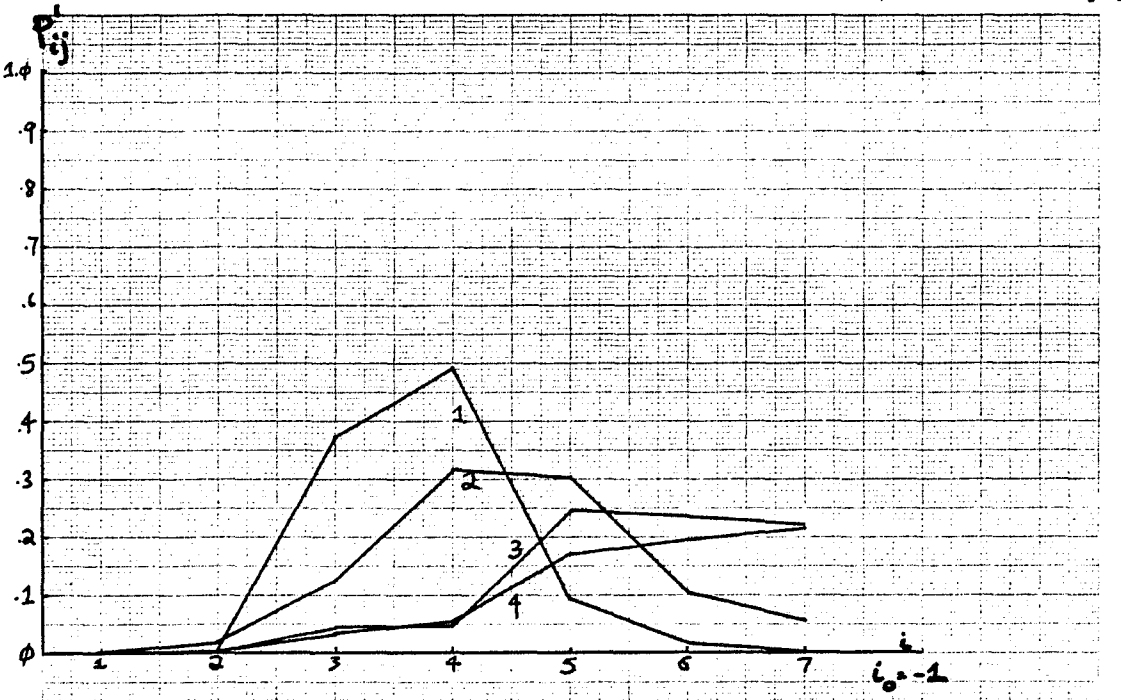


RECALL 4 ARROW AT 109 MSEC

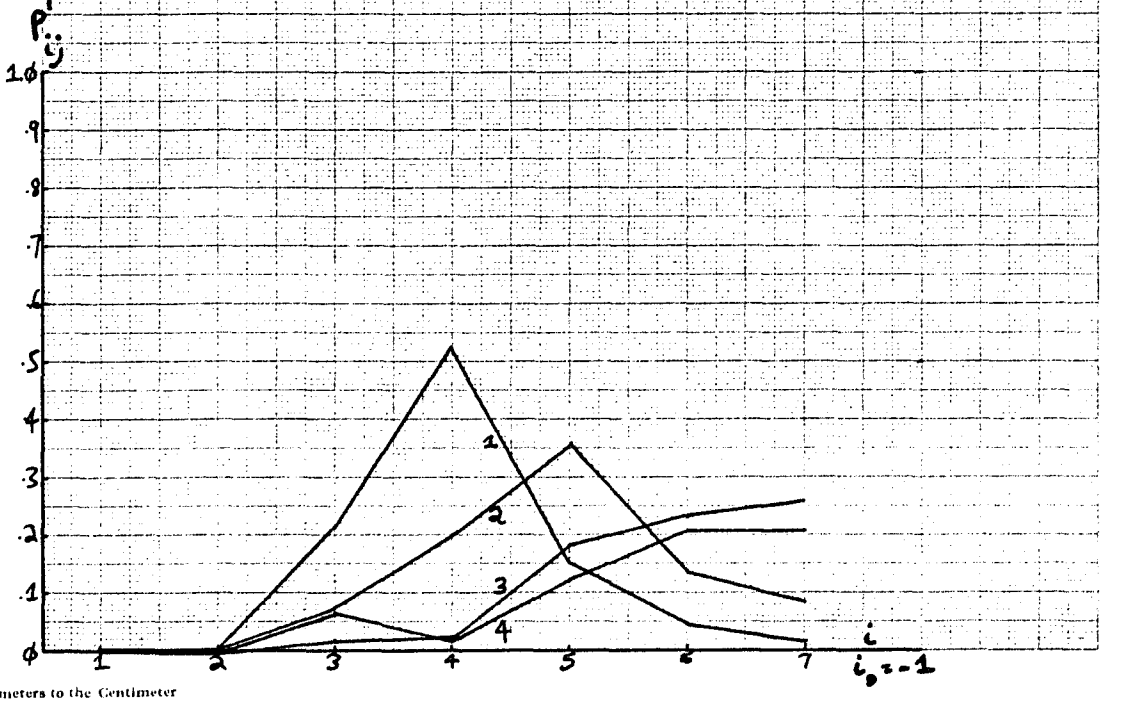


10 Millimeters to the Centimeter

SUBJECT : A.R. RECALL 4 LETTER C AT 144 MSEC. FIG. 14. p. 5.

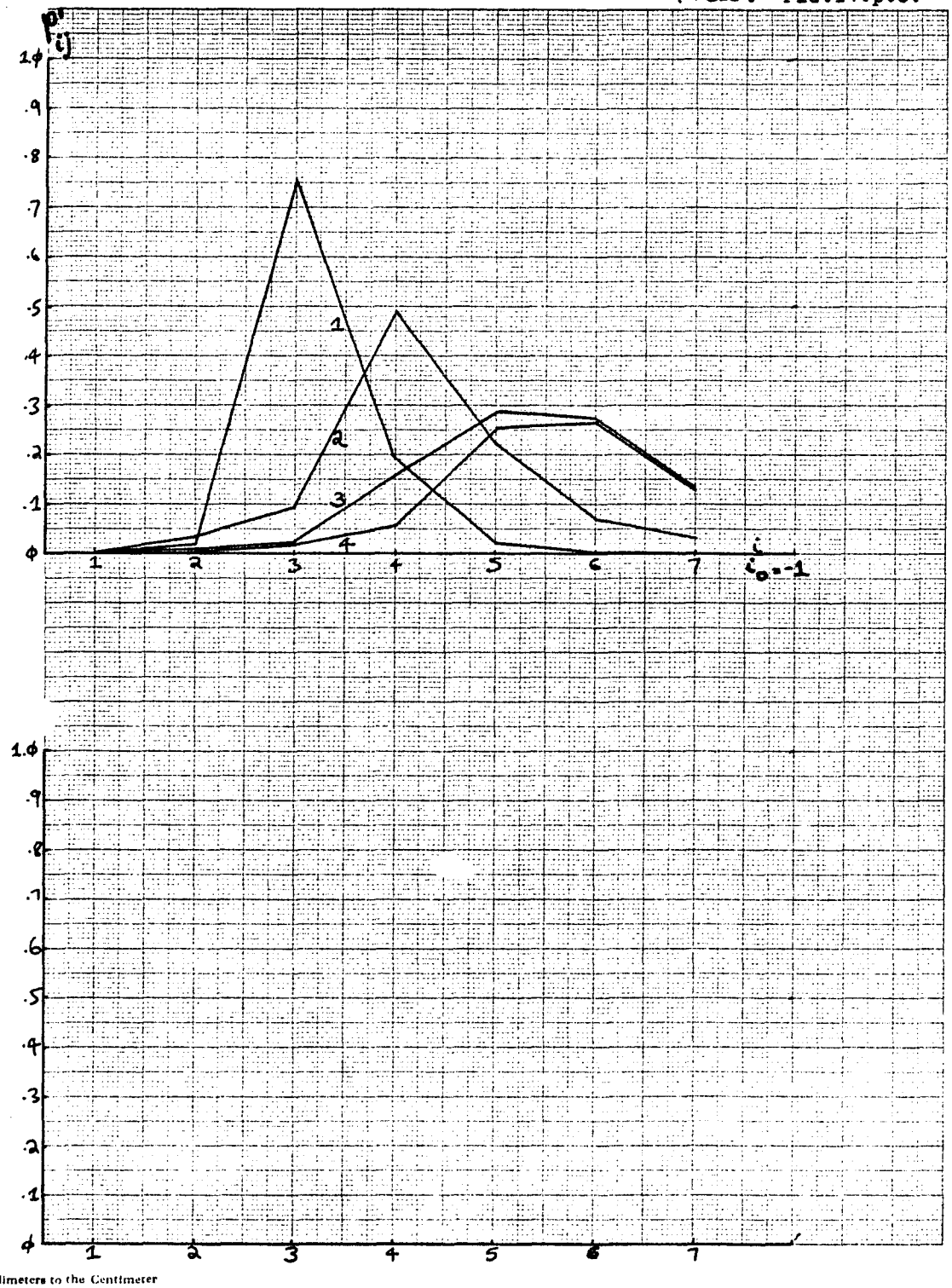


RECALL 4 LETTER U AT 144 MSEC



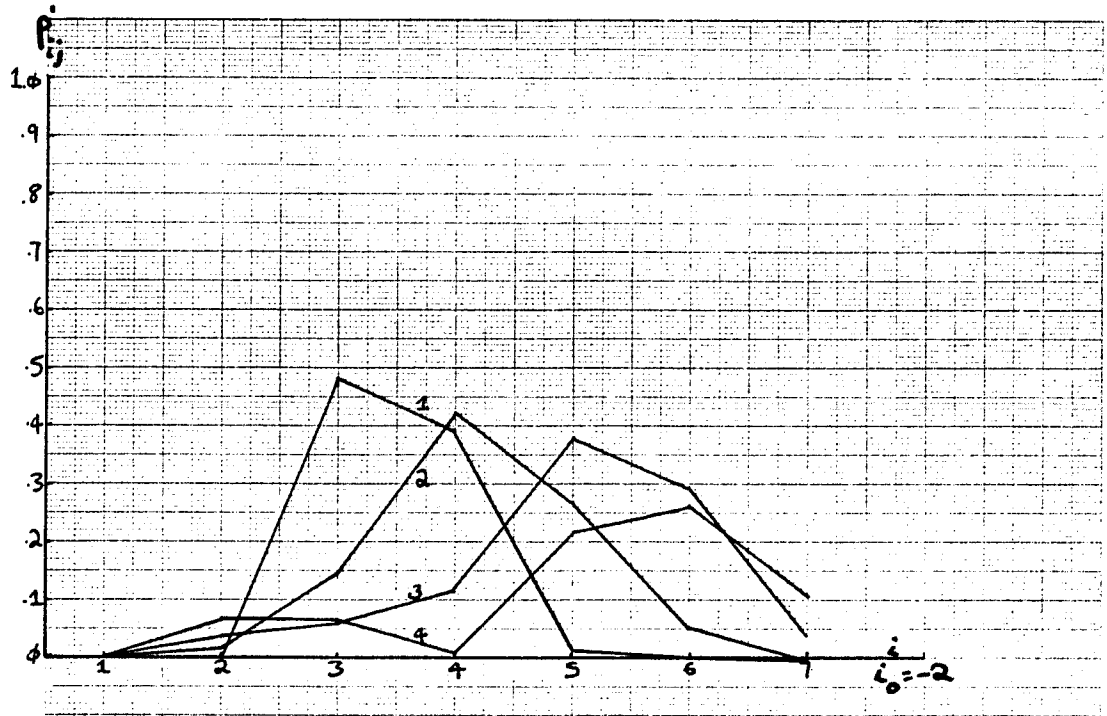
10 Millimeters to the Centimeter

SUBJECT: A.R. RECALL 4 SQUARE AT 144 MSEC. FIG.14.p.6.

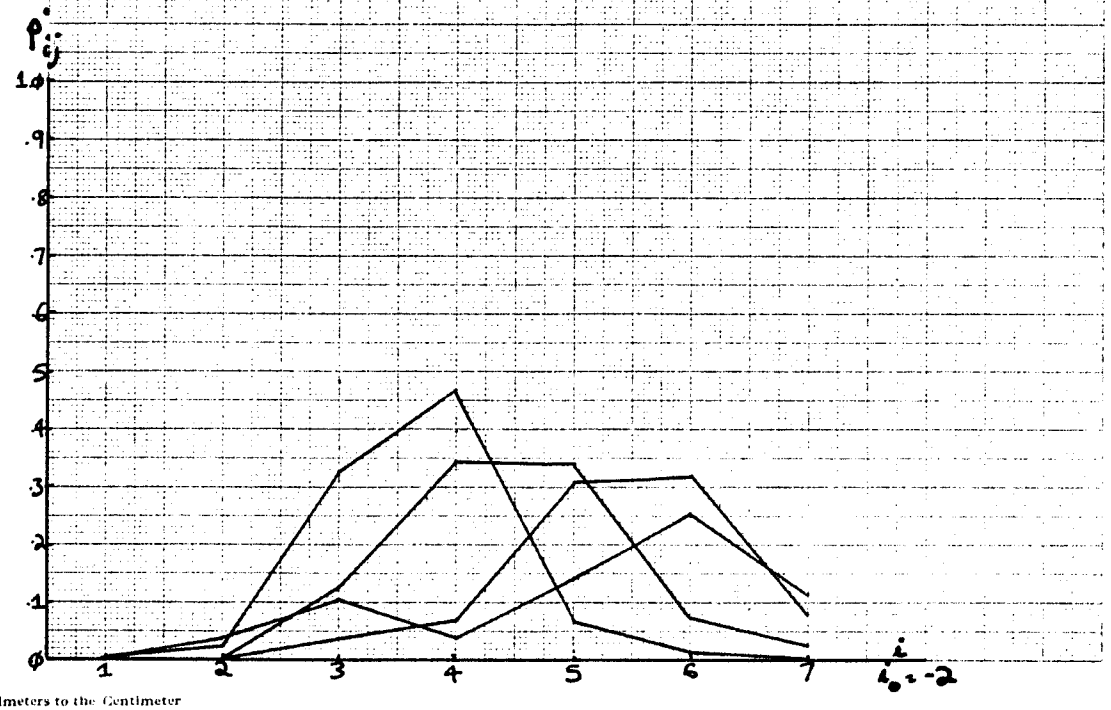


10 Millimeters to the Centimeter

SUBJECT:A.R. RECALL 4 LETTER C AT 214 MSEC. FIG.14.p.7.

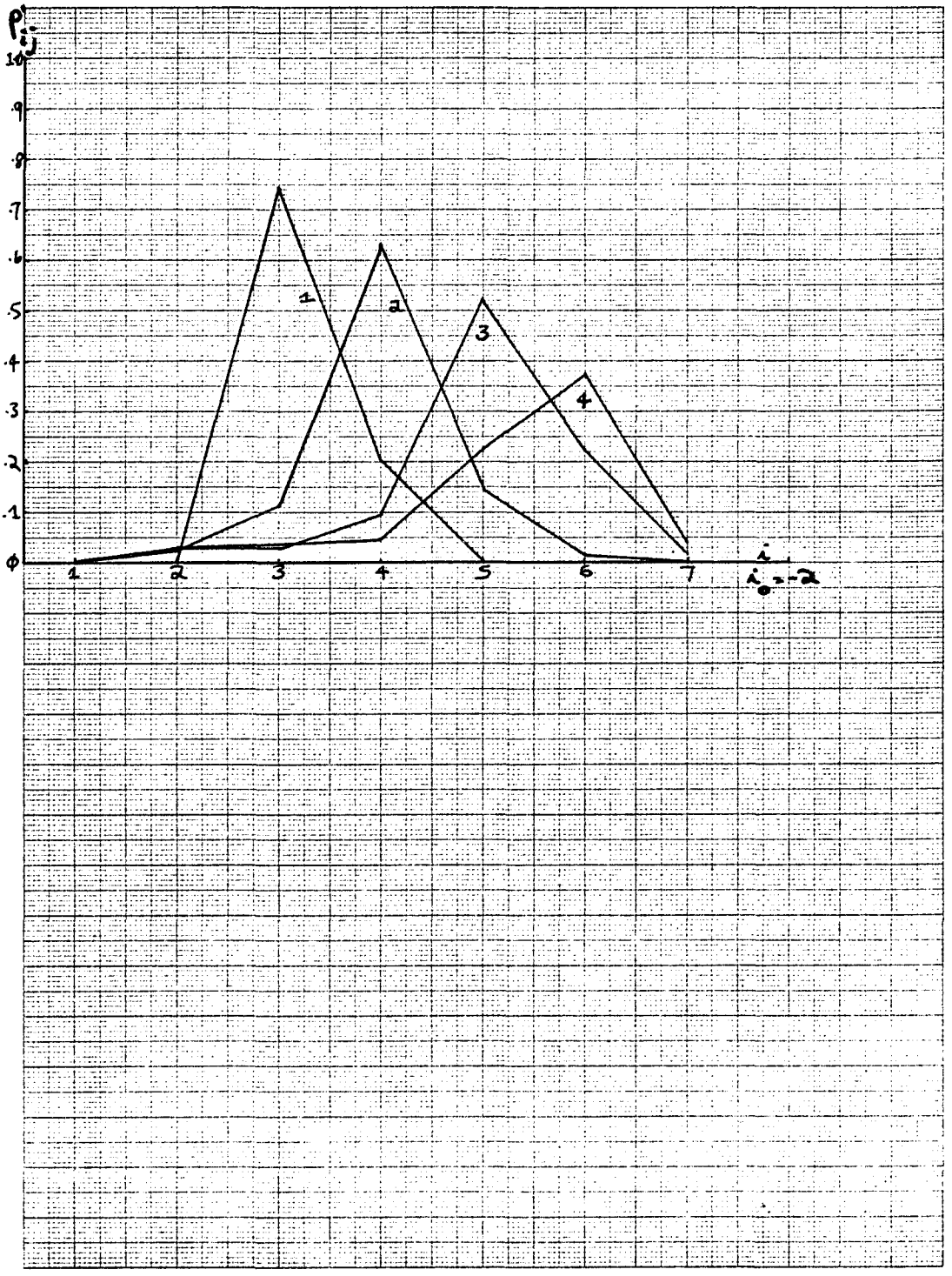


RECALL 4 LETTER U AT 214 MSEC



10 Millimeters to the Centimeter

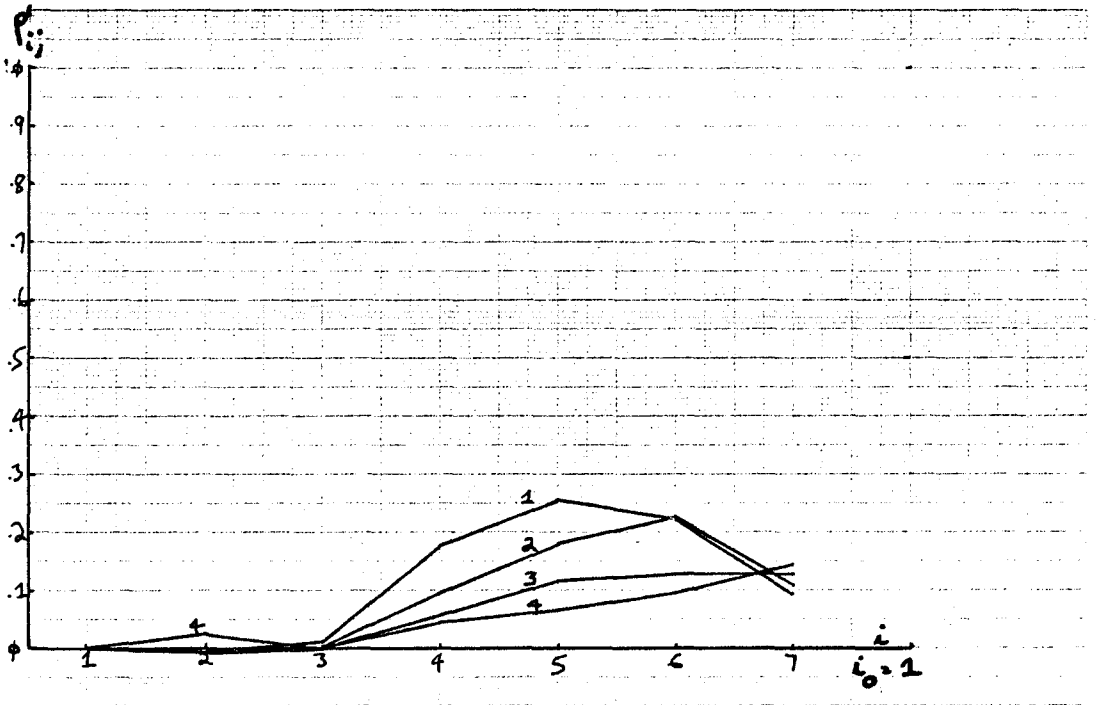
SUBJECT: A.R. RECALL 4 SQUARE AT 214 msec. FIG.14.p.8.



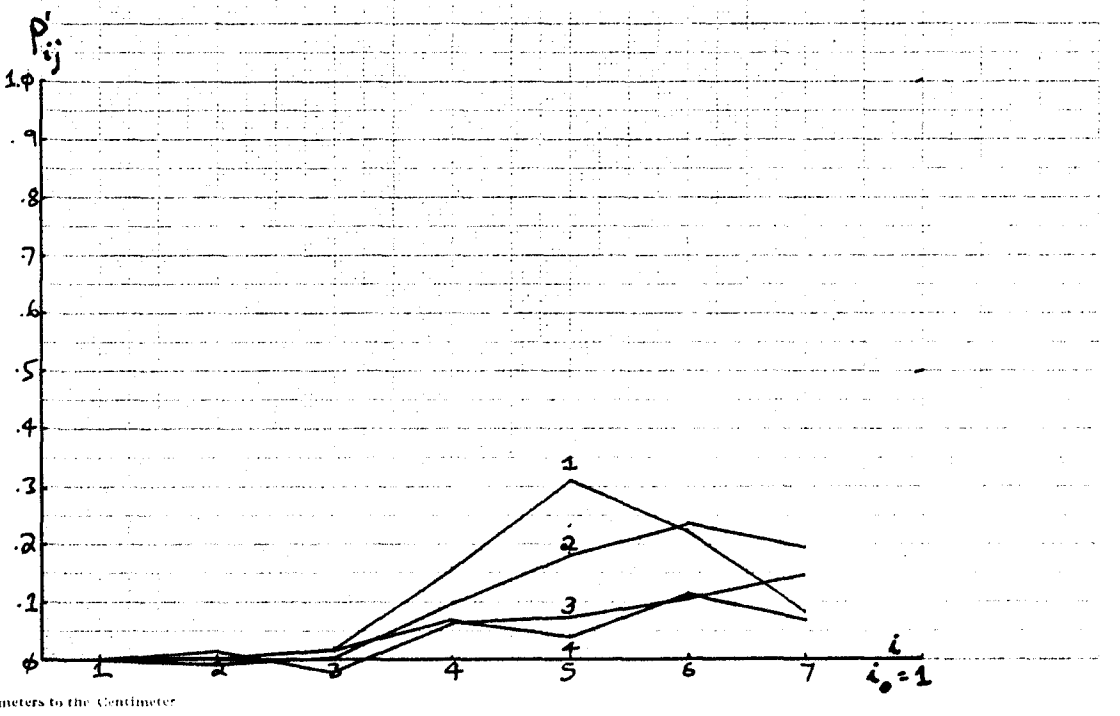
10 Millimeters to the Centimeter

FIG.14.p.9.

SUBJECT: G.L. CONDITION: RECALL 4 . LETTER C AT 75 MSEC.



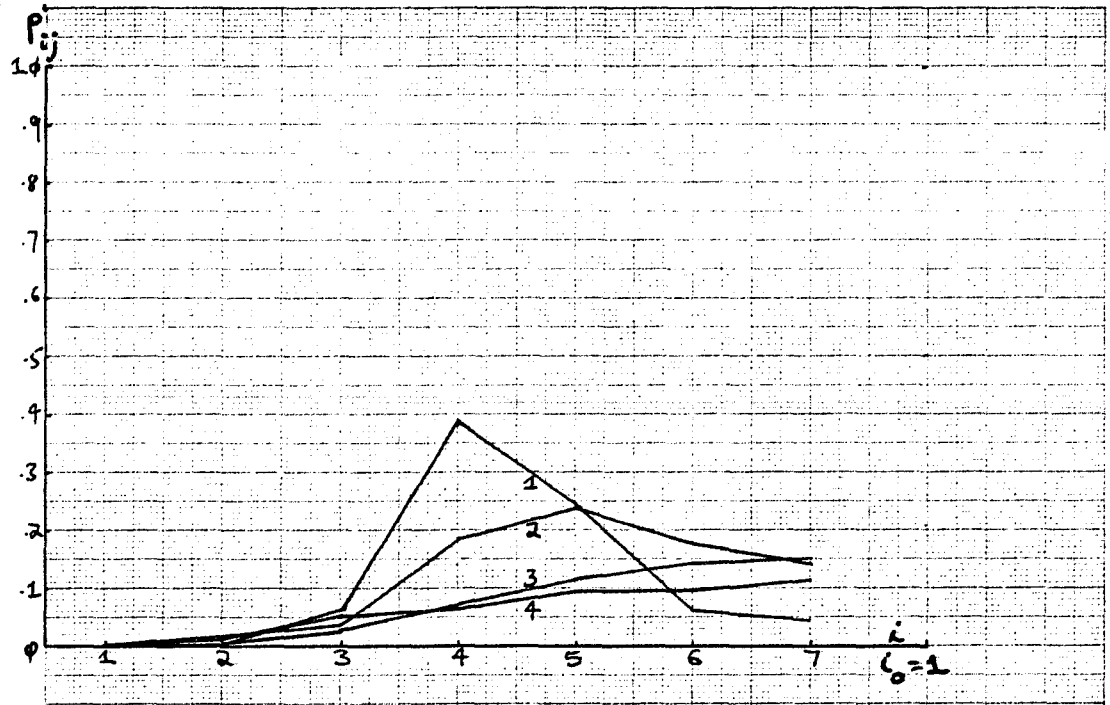
RECALL 4 LETTER U AT 75 MSEC



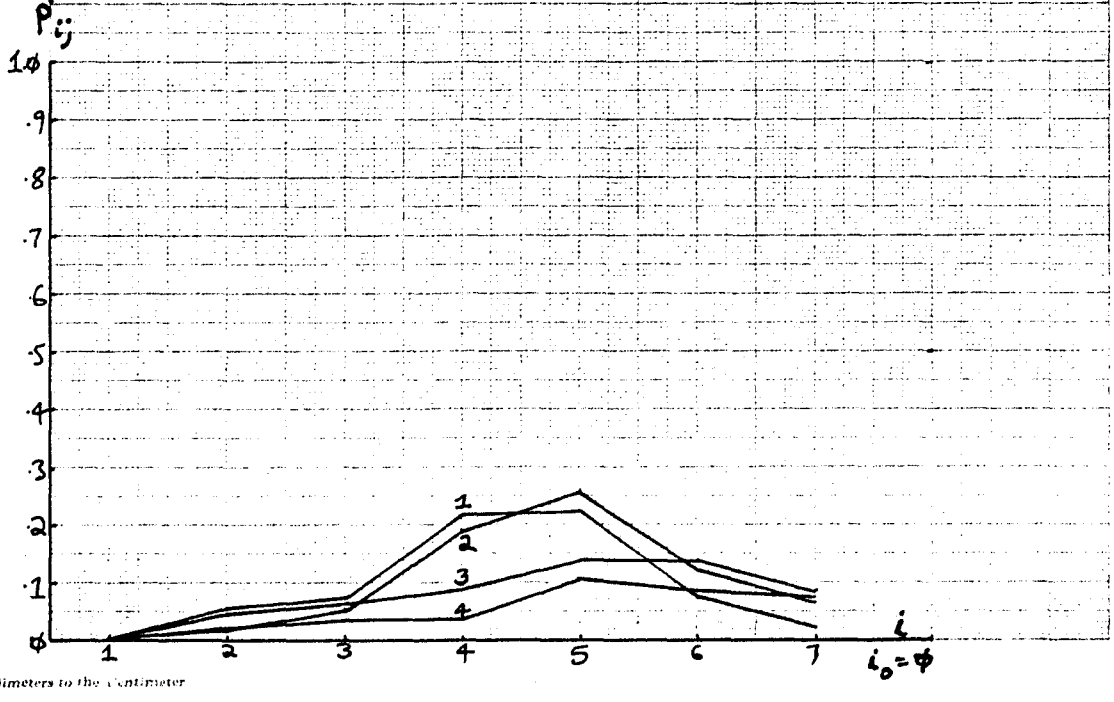
10 Millimeters to the Centimeter

FIG.14.p.10.

SUBJECT: G.L. CONDITION: RECALL 4 SQUARE AT 75 MSEC

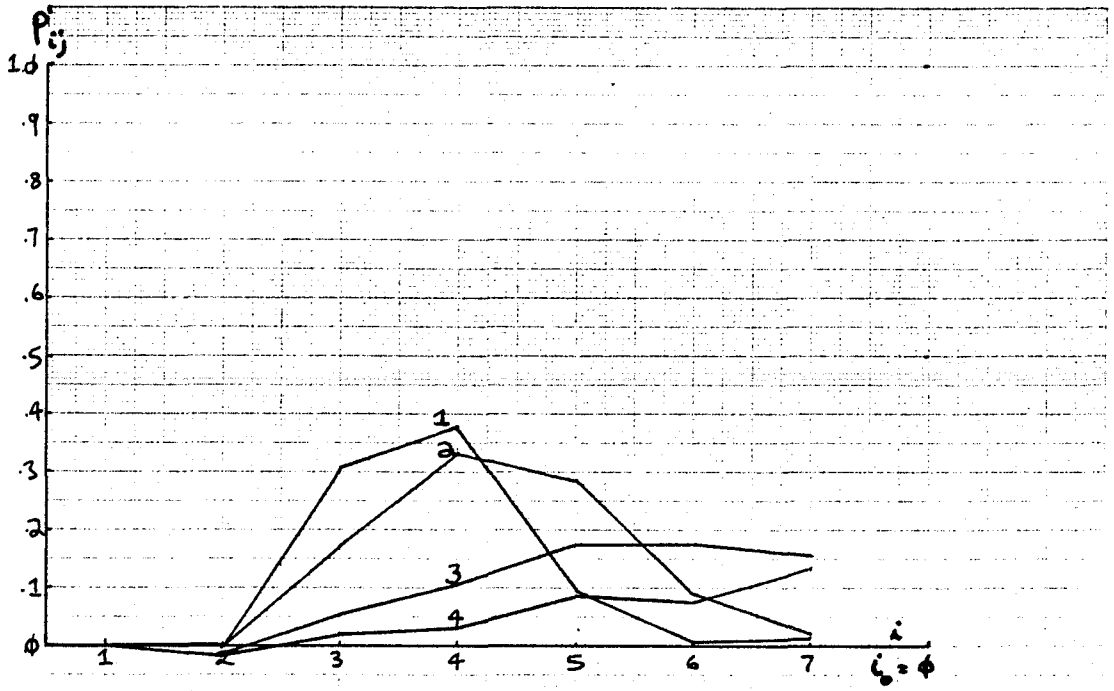


RECALL 4 ARROW AT 75 MSEC

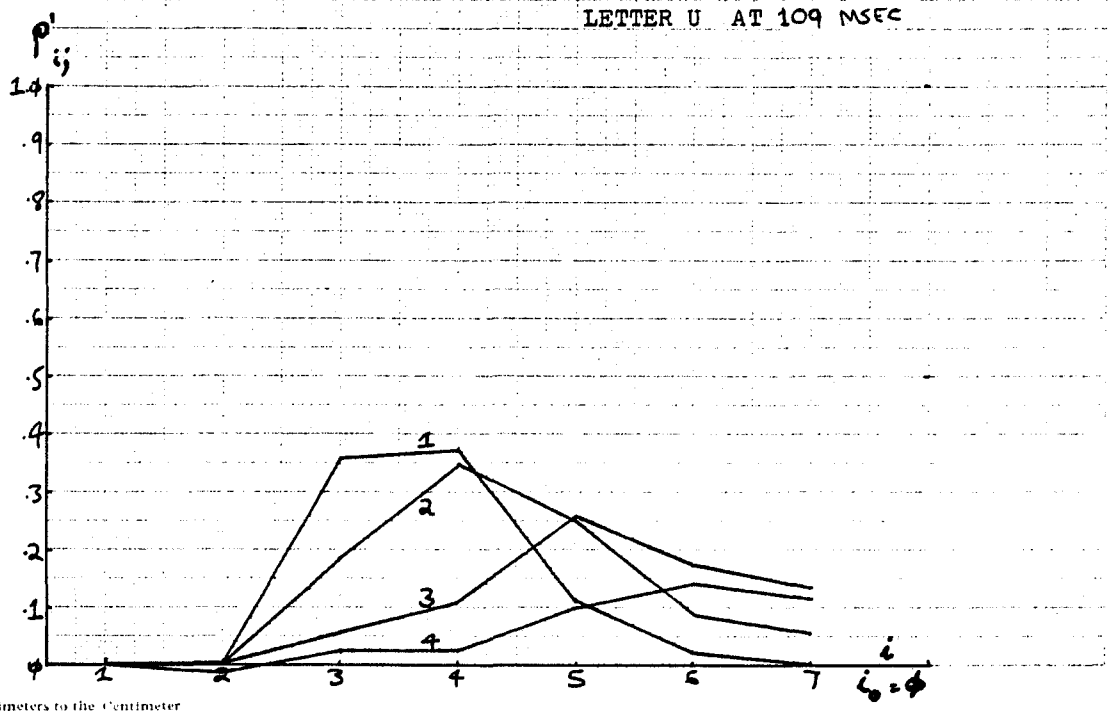


10 Millimeters to the Centimeter

SUBJECT: G.L. RECALL 4. LETTER C AT 109 MSEC. FIG. 14. p. 11.

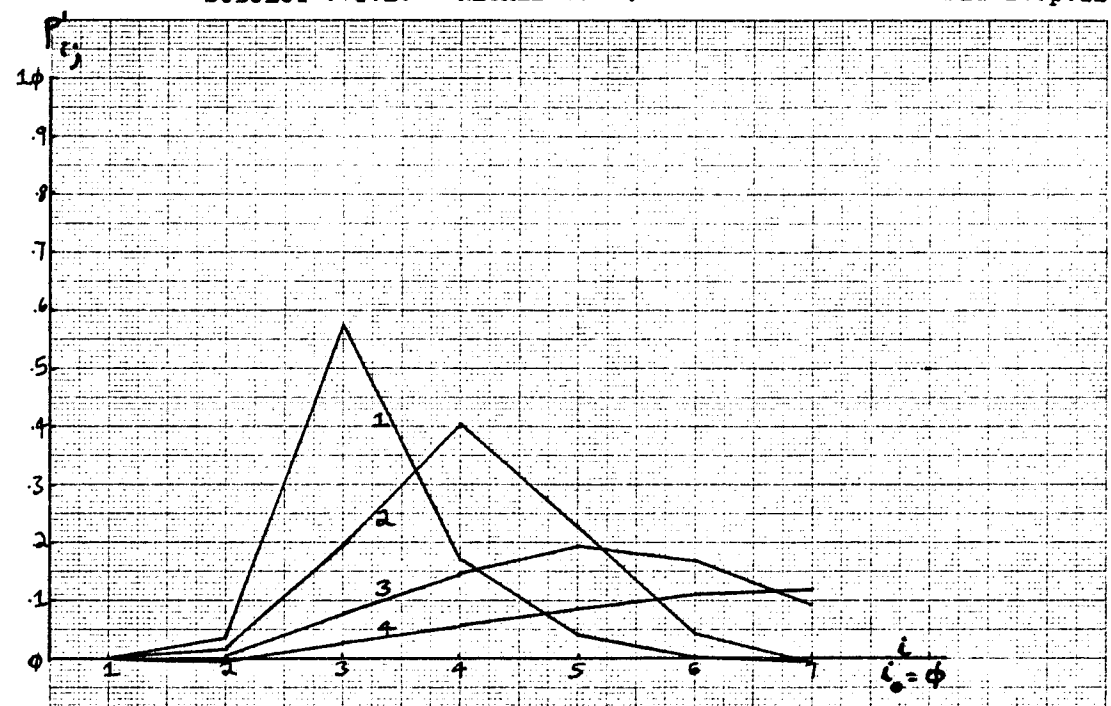


LETTER U AT 109 MSEC

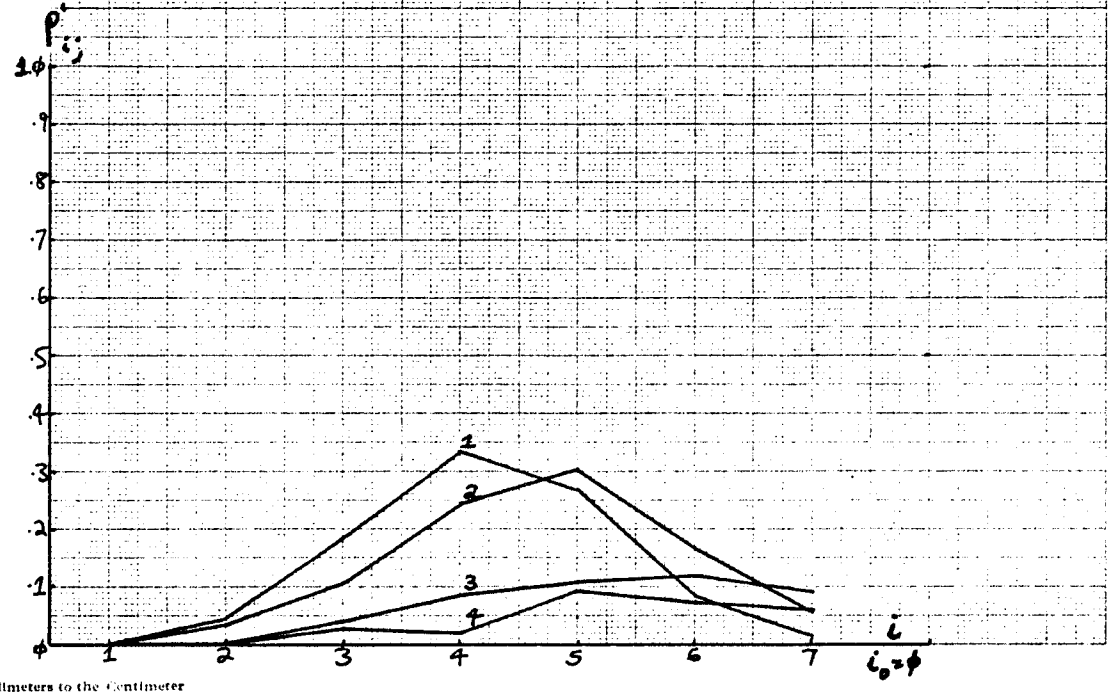


10 Millimeters to the Centimeter

SUBJECT : G.L. RECALL 4. SQUARE AT 109 MSEC . FIG.14.p.12.

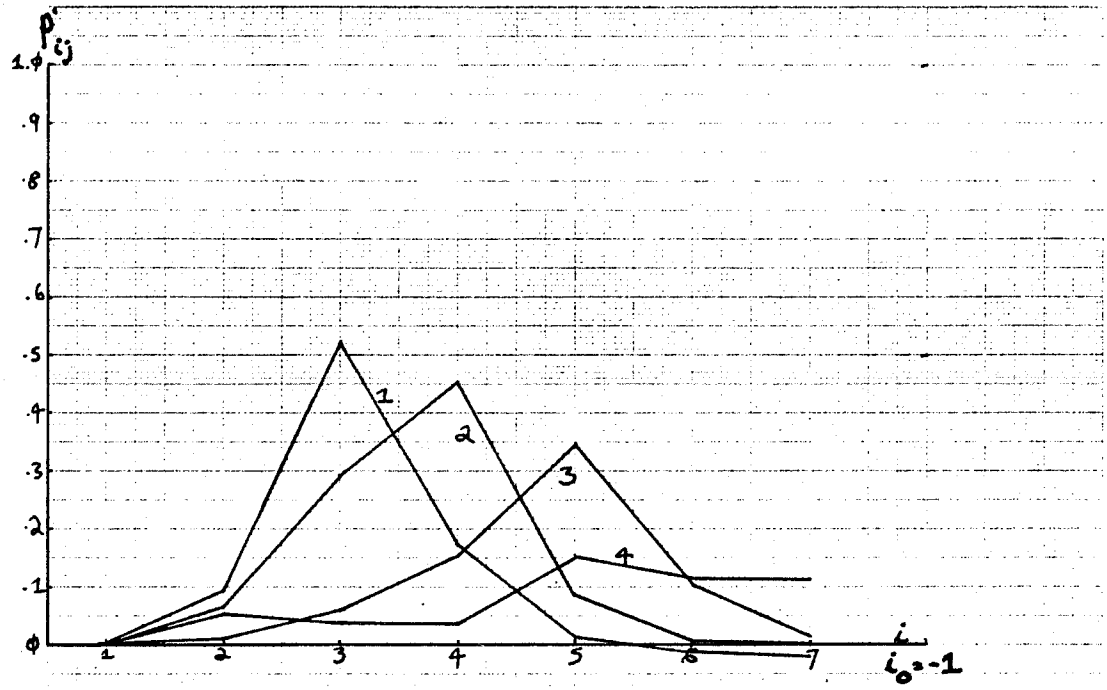


RECALL 4. ARROW AT 109 MSEC

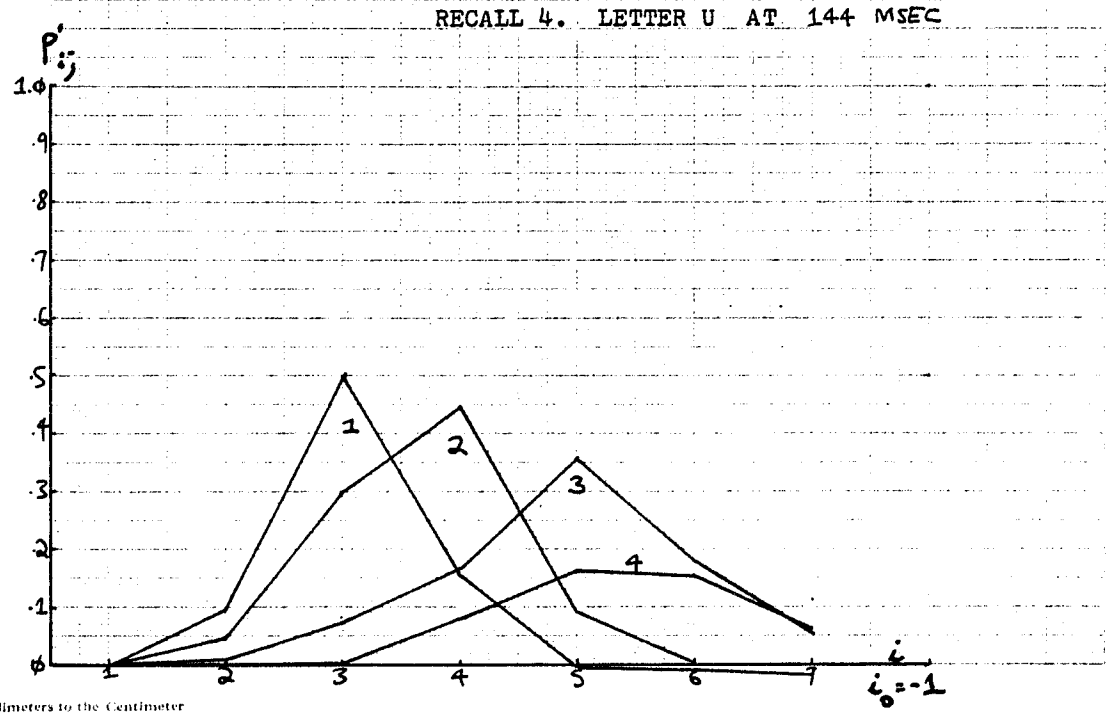


10 Millimeters to the Centimeter

SUBJECT: G.L. RECALL 4. LETTER C AT 144 MSEC. FIG.14.p.13.

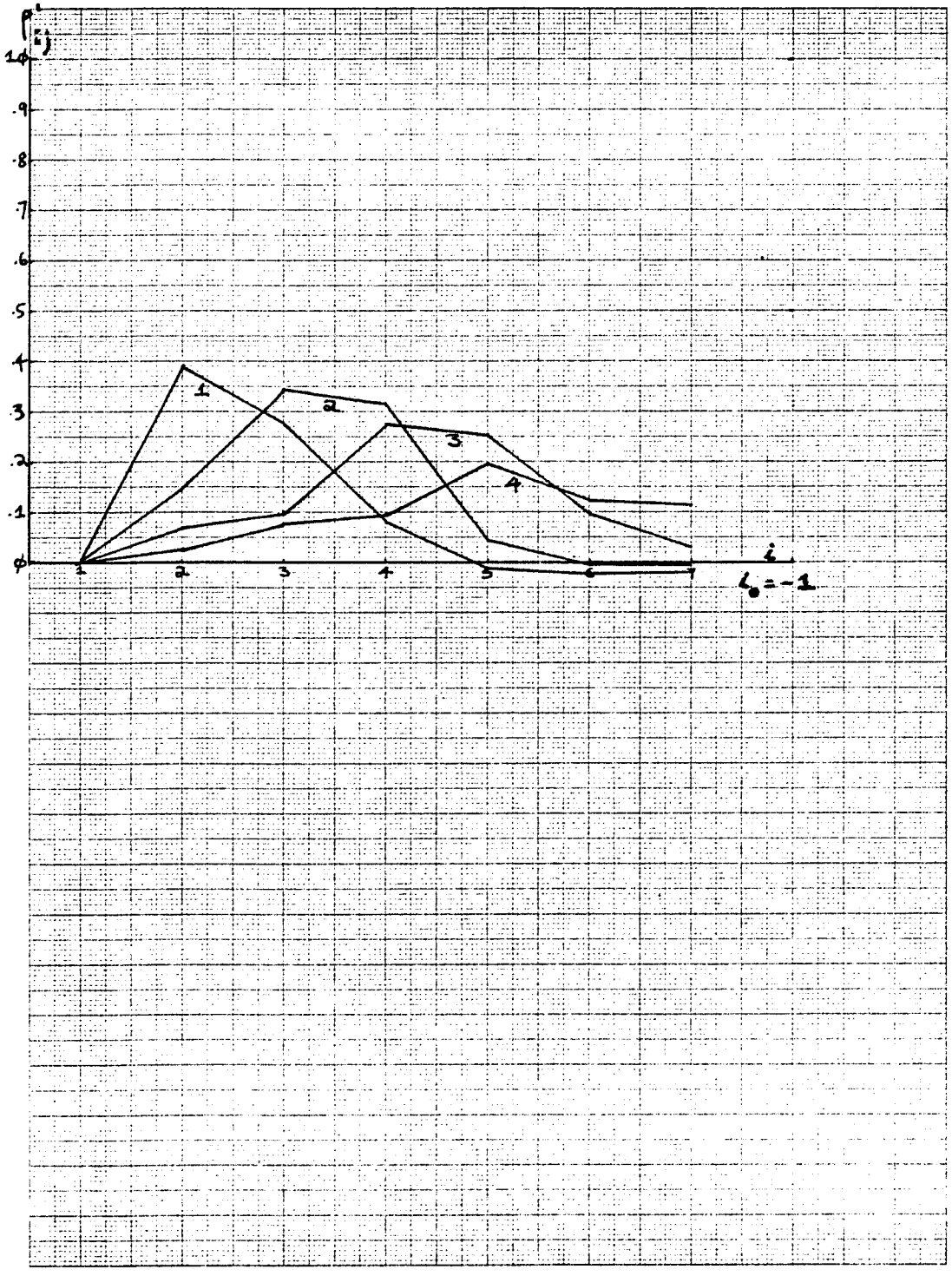


RECALL 4. LETTER U AT 144 MSEC



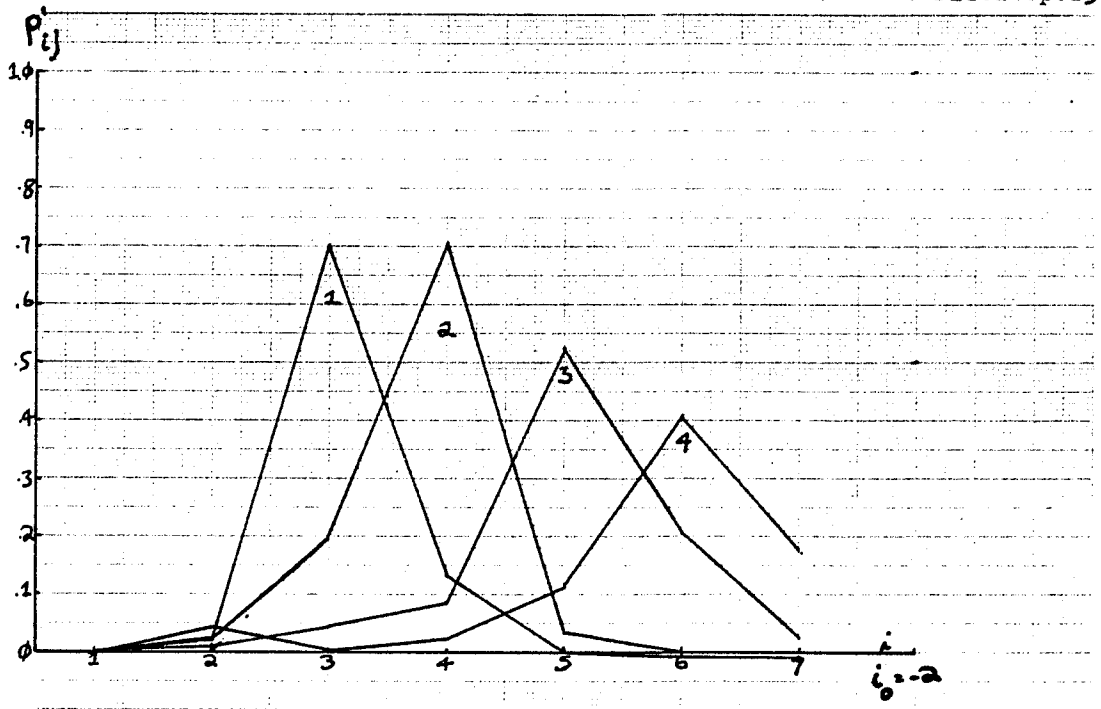
10 Millimeters to the Centimeter

SUBJECT: G.L. RECALL 4. SQUARE AT 144 MSEC. FIG.14.p.14.

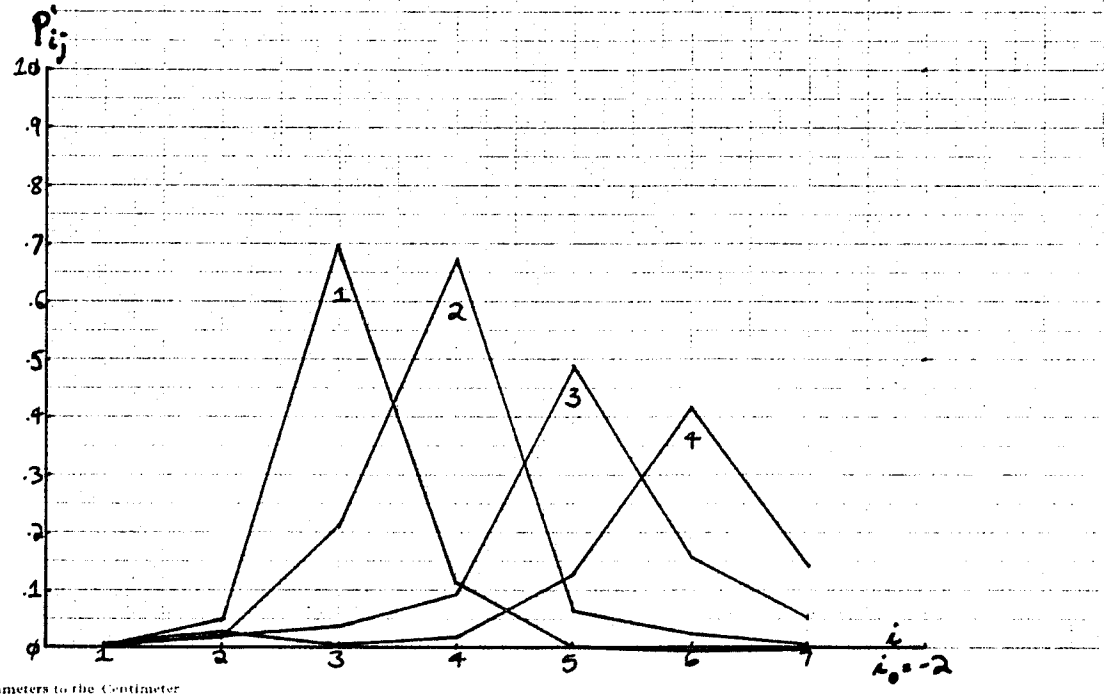


10 Millimeters to the Centimeter

SUBJECT: G.L. RECALL 4. LETTER C AT 214 MSEC. FIG.14.p.15.

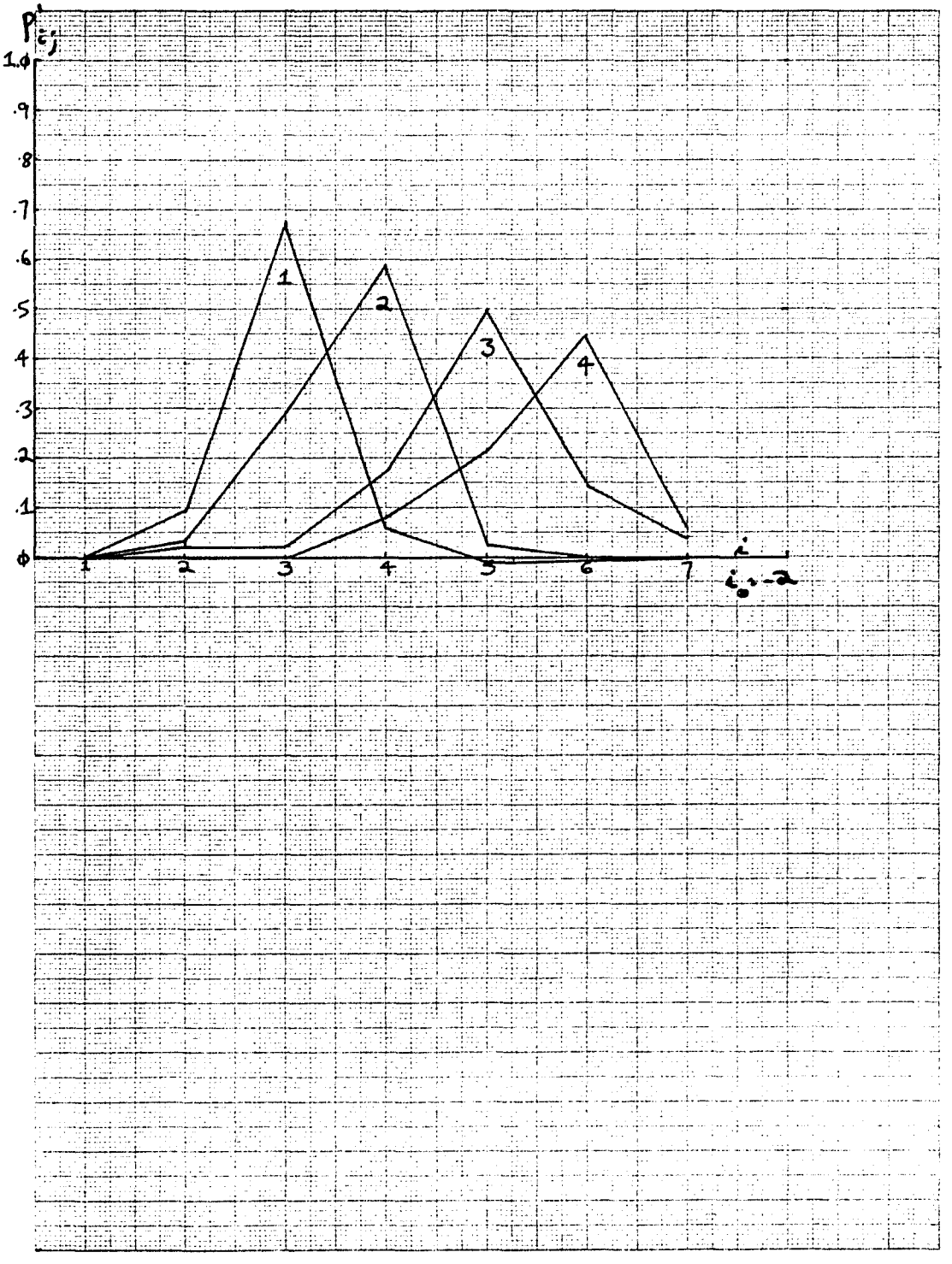


RECALL 4. LETTER U AT 214 MSEC.



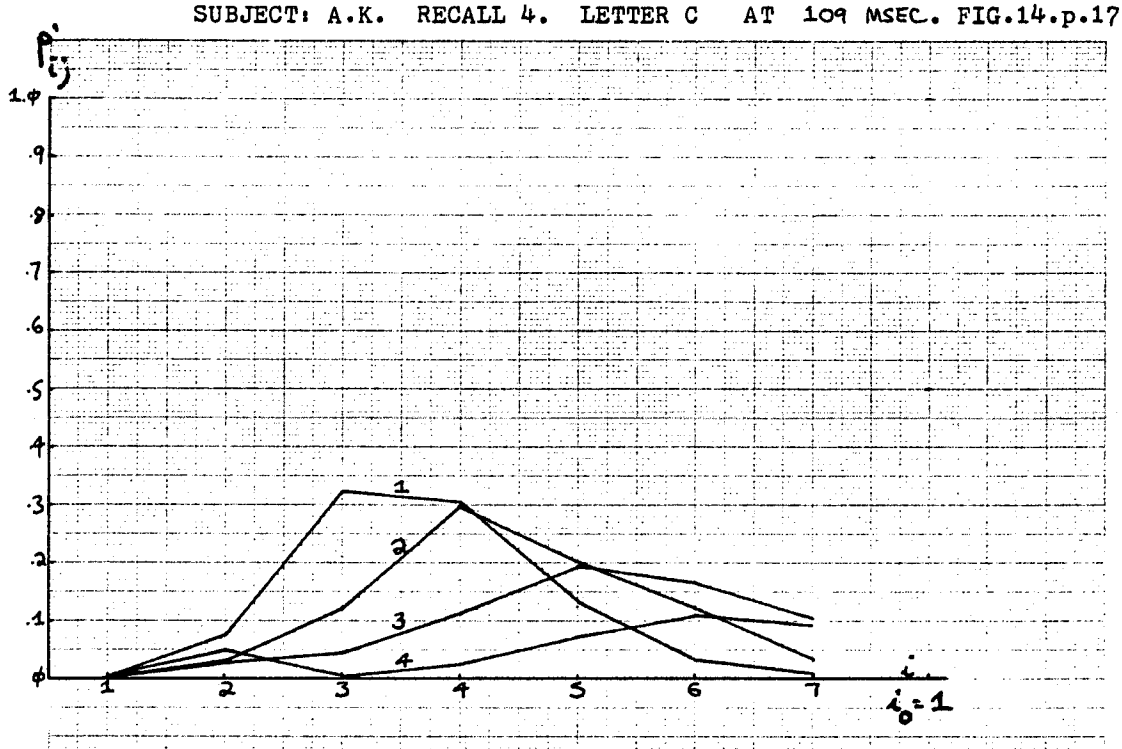
10 Millimeters to the Centimeter

SUBJECT: G.L. RECALL 4. SQUARE AT 214 MSEC. FIG.14.p.16.

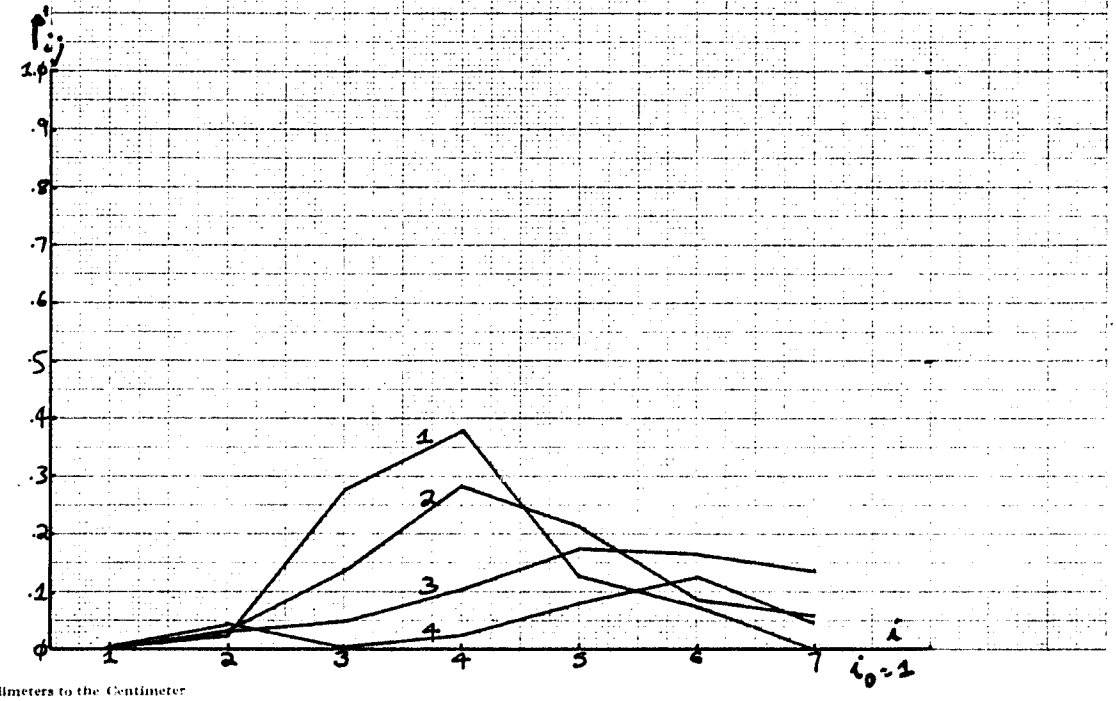


10 Millimeters to the Centimeter

SUBJECT: A.K. RECALL 4. LETTER C AT 109 MSEC. FIG.14.p.17.

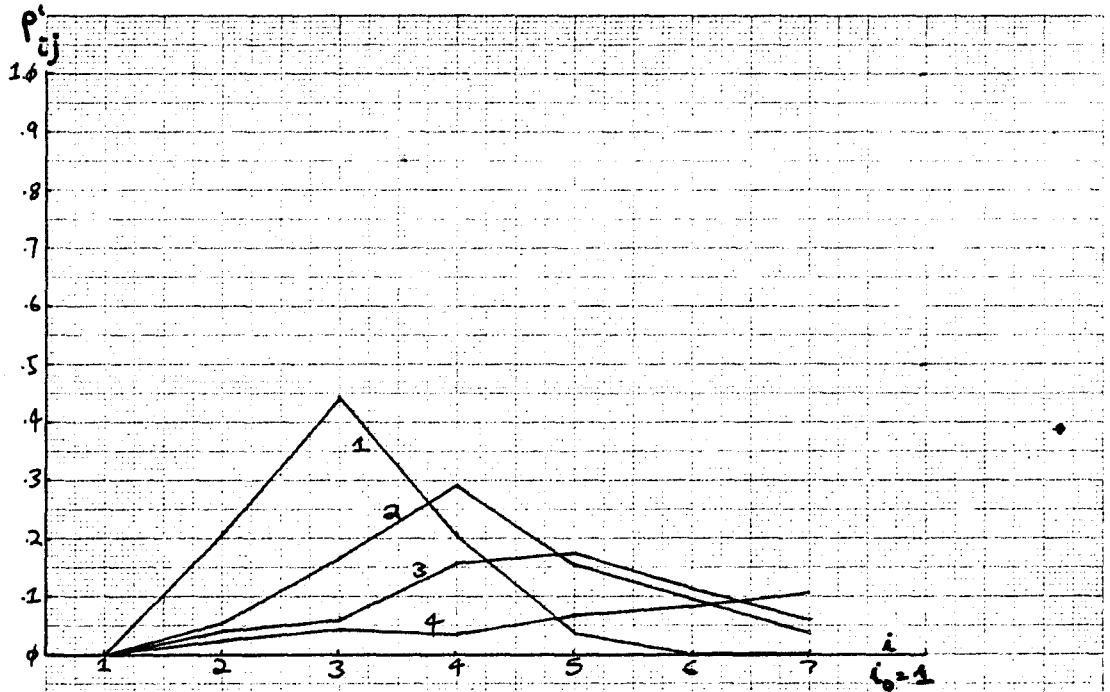


RECALL 4. LETTER U AT 109 MSEC

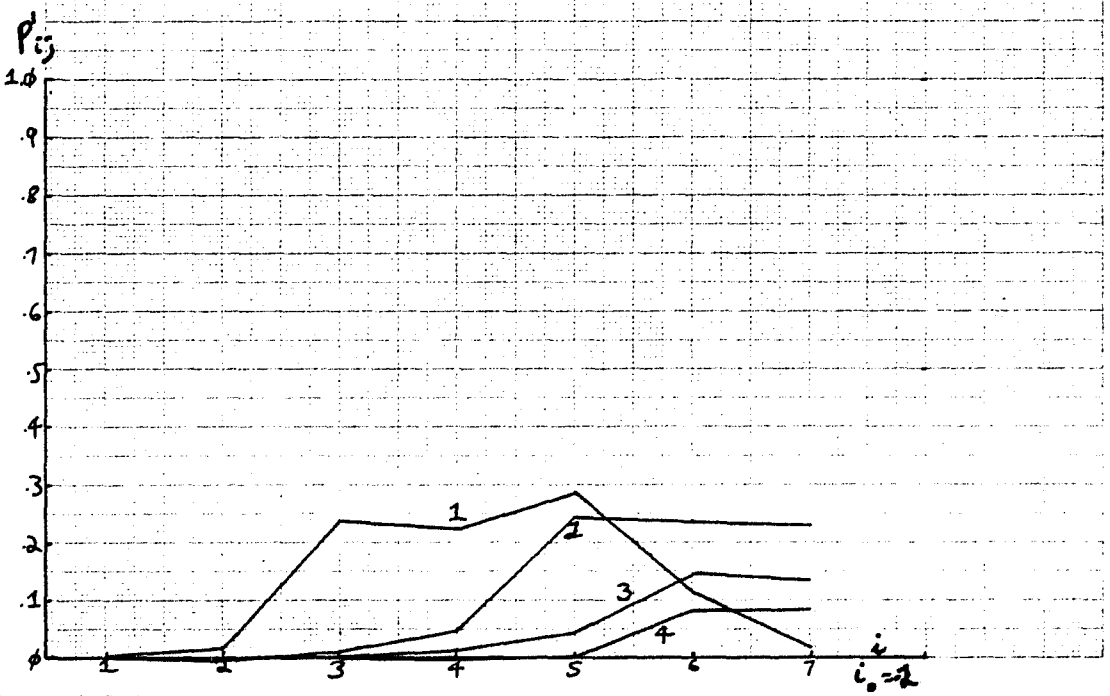


10 Millimeters to the Centimeter

SUBJECT: A.K. RECALL 4. SQUARE AT 109 MSEC. FIG.14.p.18.

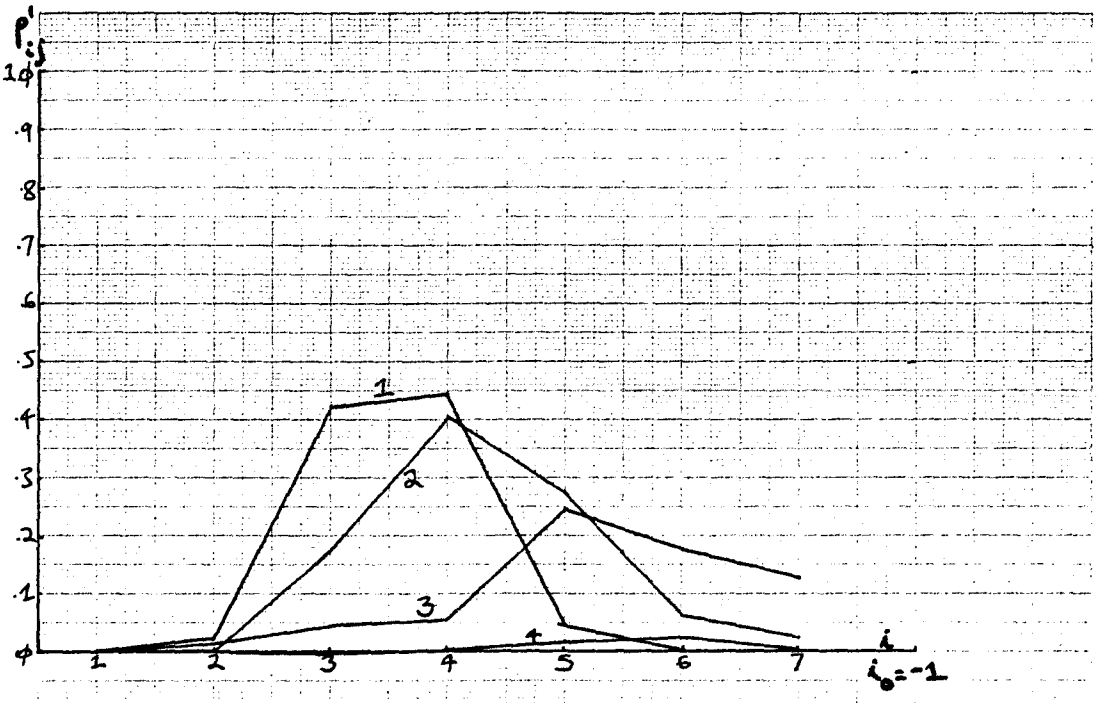


RECALL 4. ARROW AT 109 MSEC

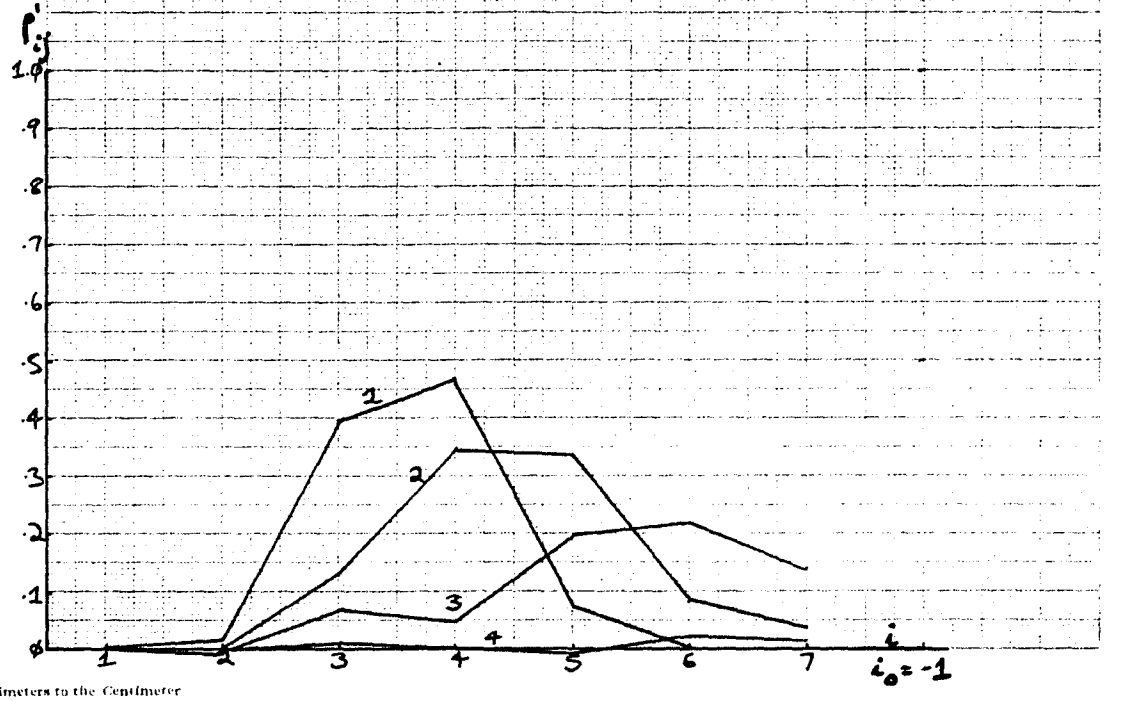


10 Millimeters to the Centimeter

SUBJECT: A.K. RECALL 4. LETTER C AT 144 MSEC. FIG.14.p.19.

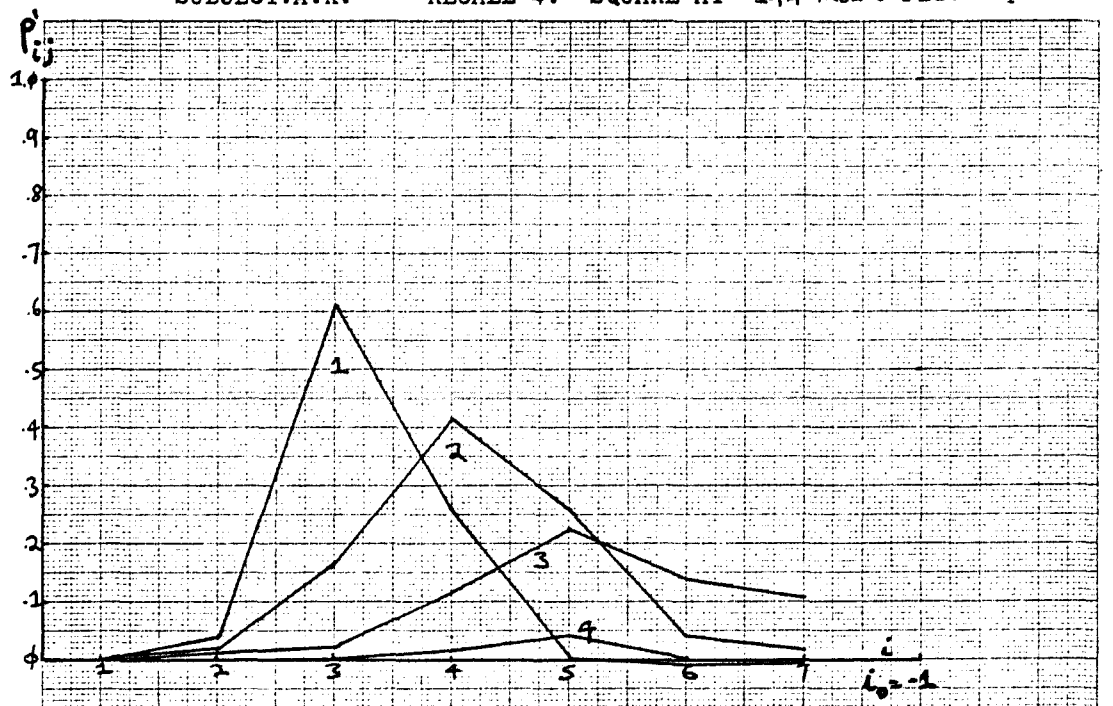


RECALL 4. LETTER U AT 144 MSEC

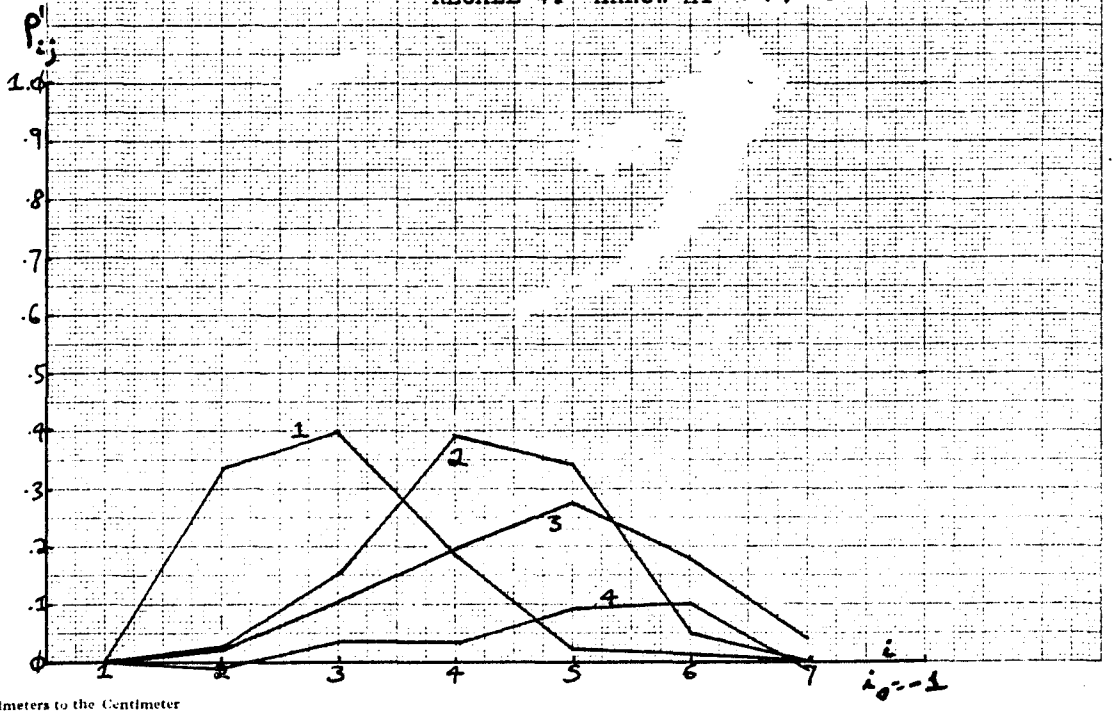


10 Millimeters to the Centimeter

SUBJECT:A.K. RECALL 4. SQUARE AT 144 MSEC. FIG.14.p.20.

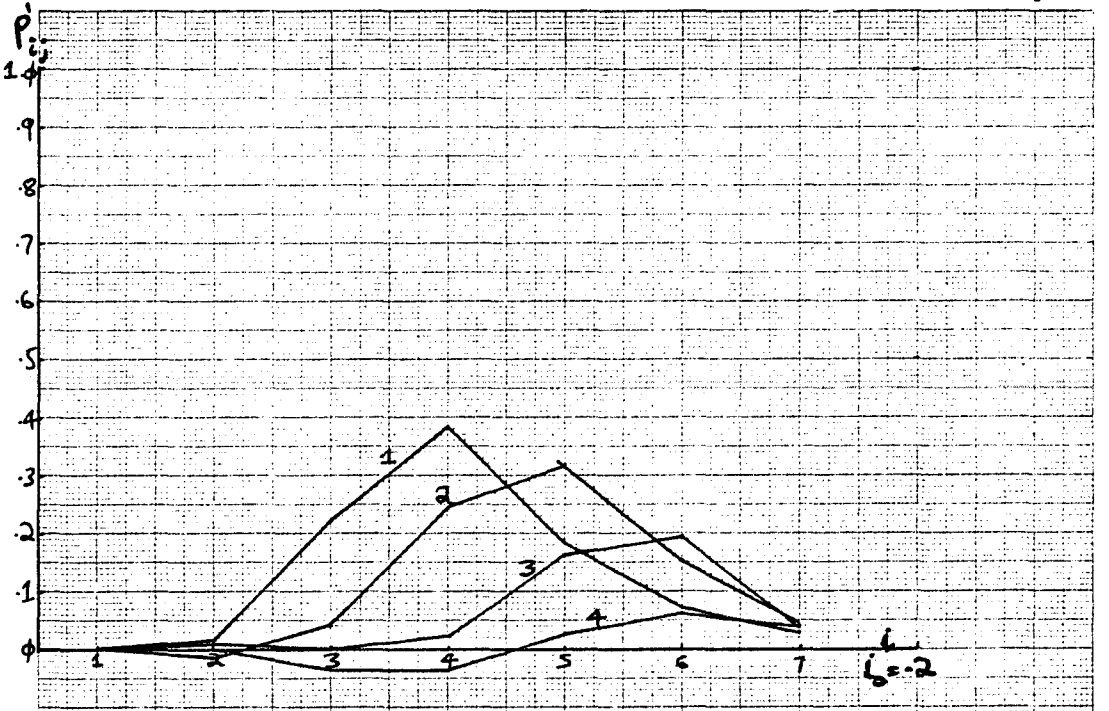


RECALL 4. ARROW AT 144 MSEC

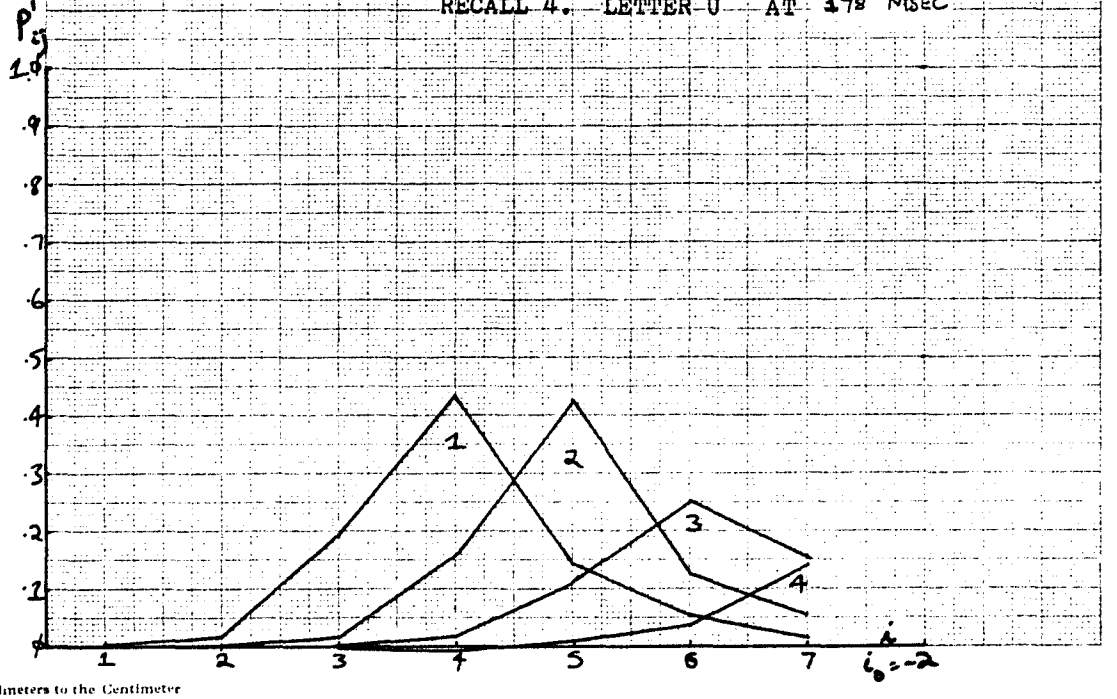


10 Millimeters to the Centimeter

SUBJECT: A.K. RECALL 4. LETTER C AT 178 MSEC. FIG. 14. p. 21.

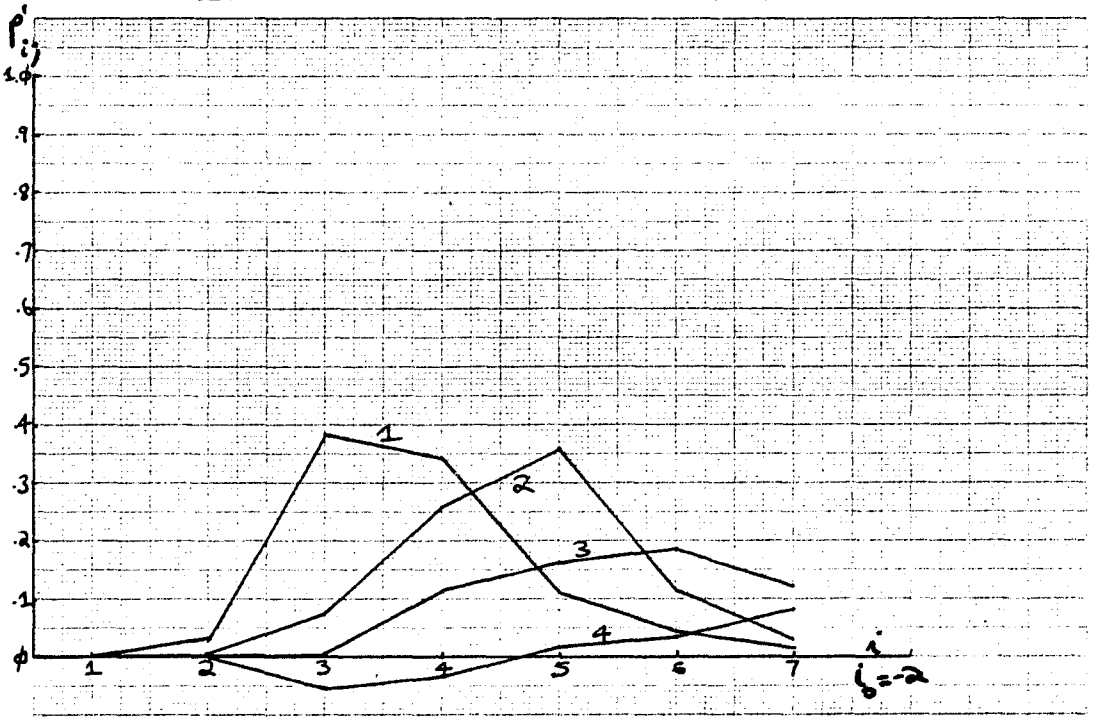


RECALL 4. LETTER U AT 178 MSEC



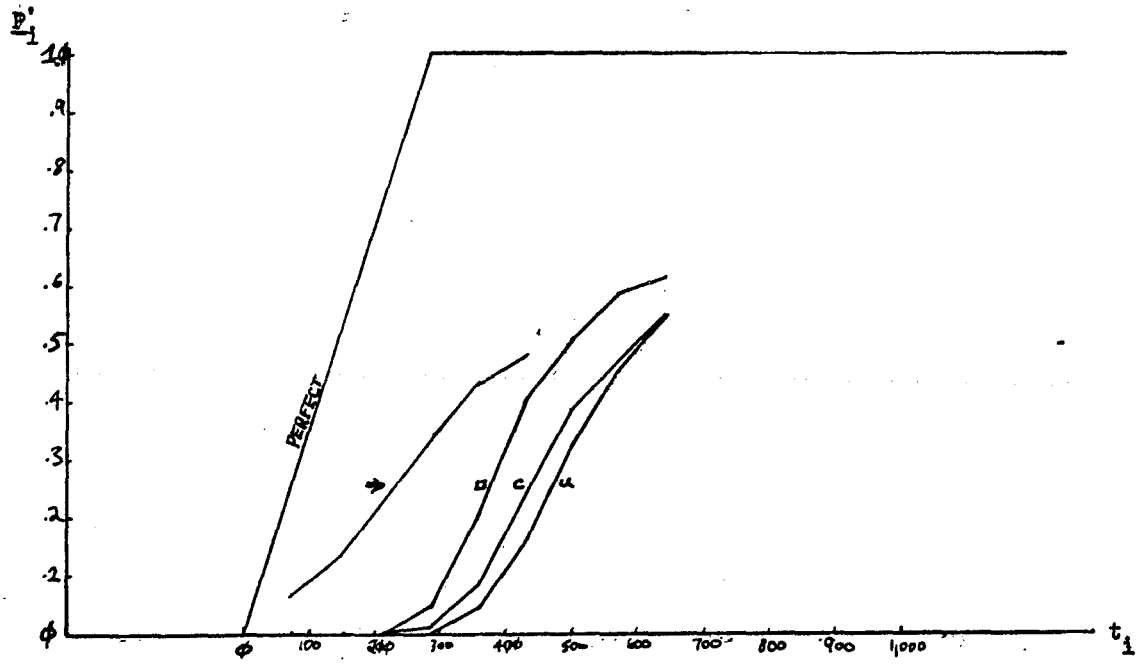
10 Millimeters to the Centimeter

SUBJECT: A.K. RECALL 4. SQUARE AT 178 MSEC. FIG.14. p.22.

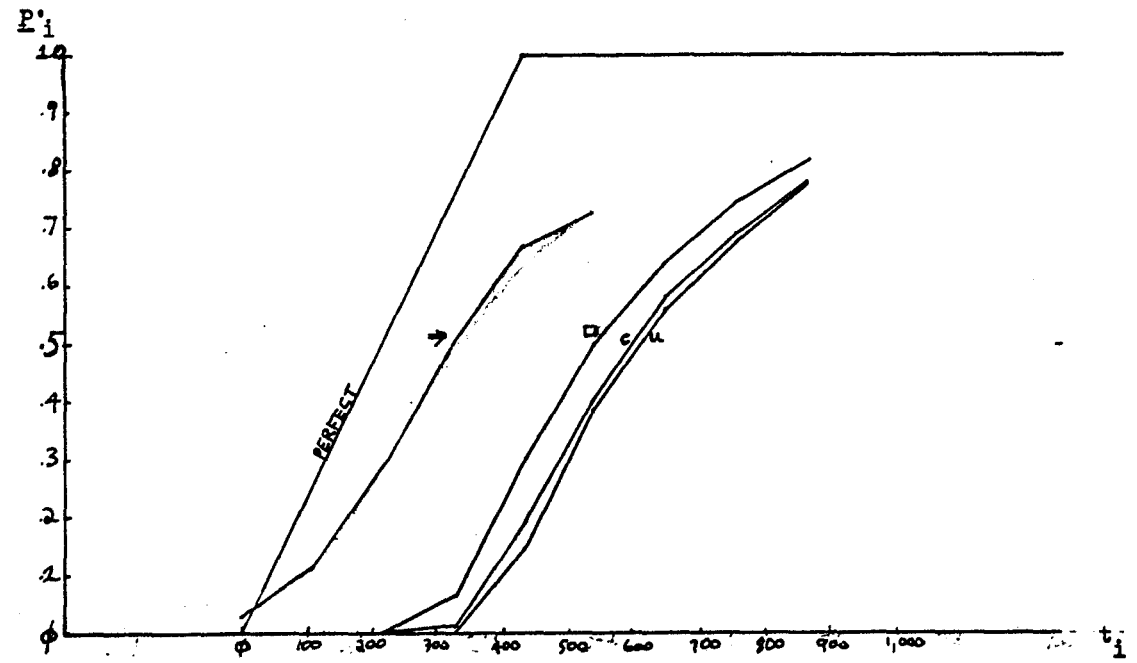


10 Millimeters to the Centimeter

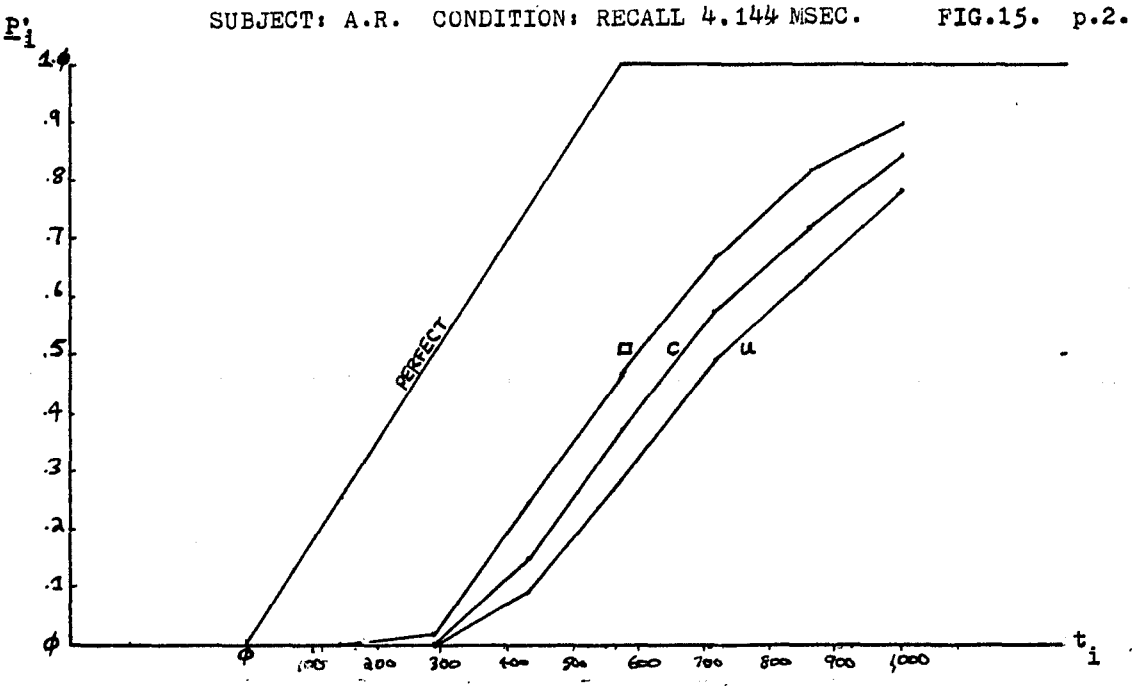
SUBJECT: A.R. CONDITION: RECALL 4. 75 MSEC. FIG. 15. p.1.



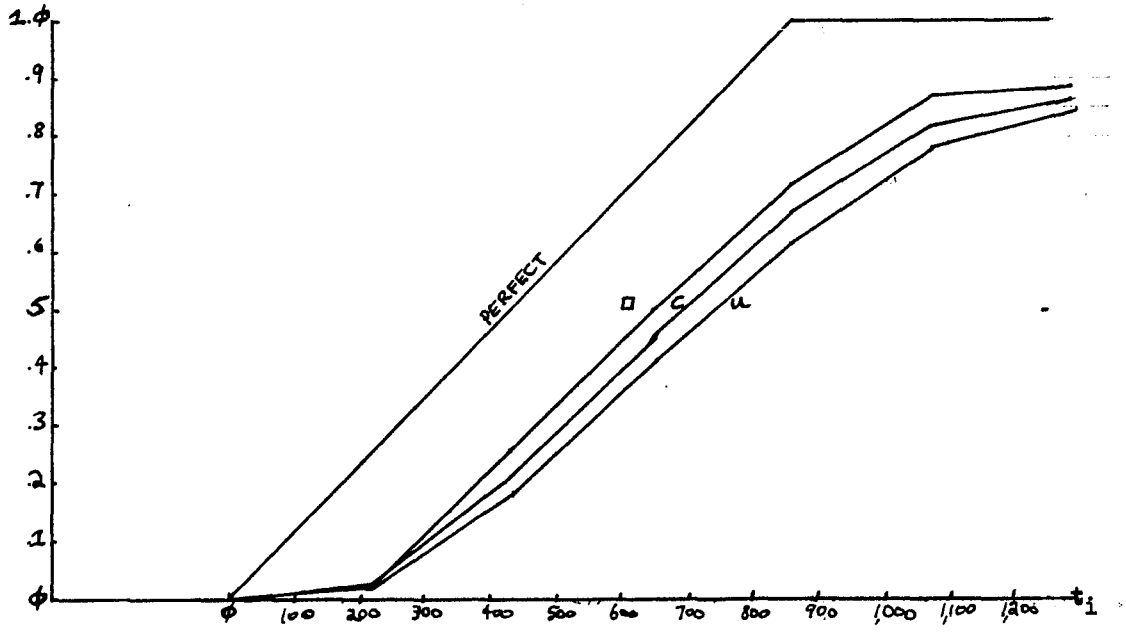
SUBJECT: A.R. CONDITION: RECALL 4. 109 MSEC.



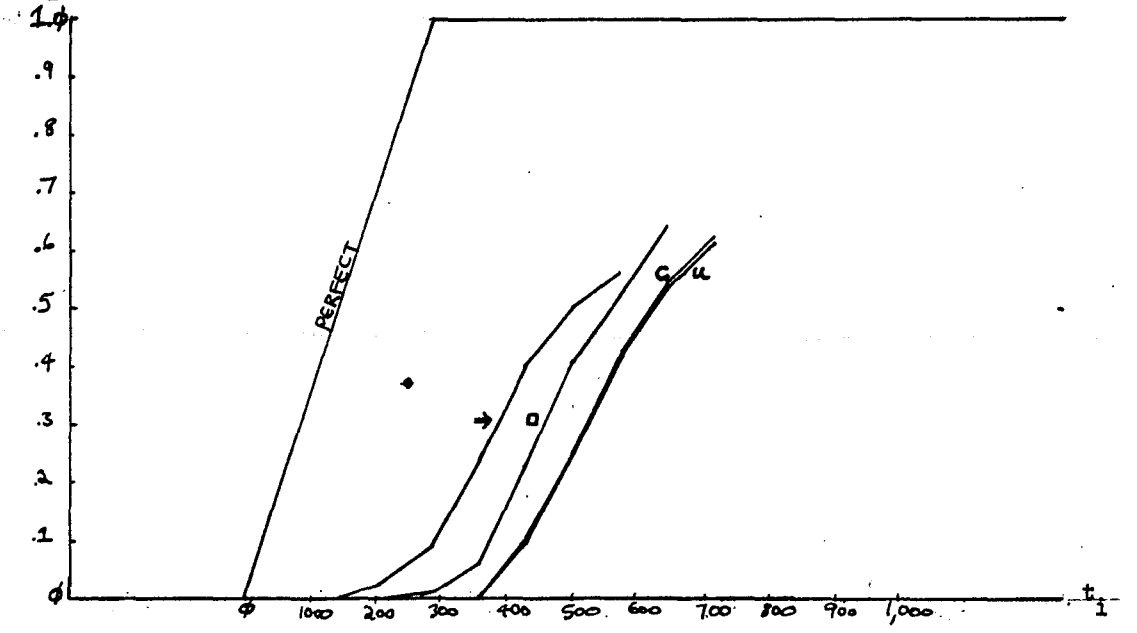
SUBJECT: A.R. CONDITION: RECALL 4.144 MSEC. FIG.15. p.2.



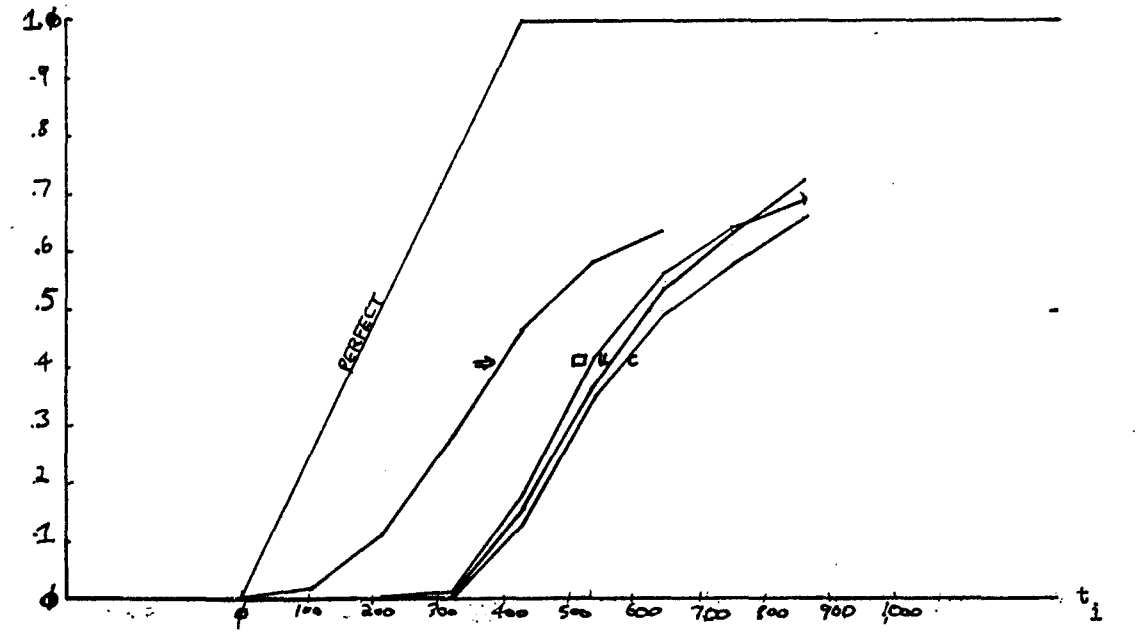
SUBJECT: A.R. CONDITION: RECALL 4. 214 MSEC.



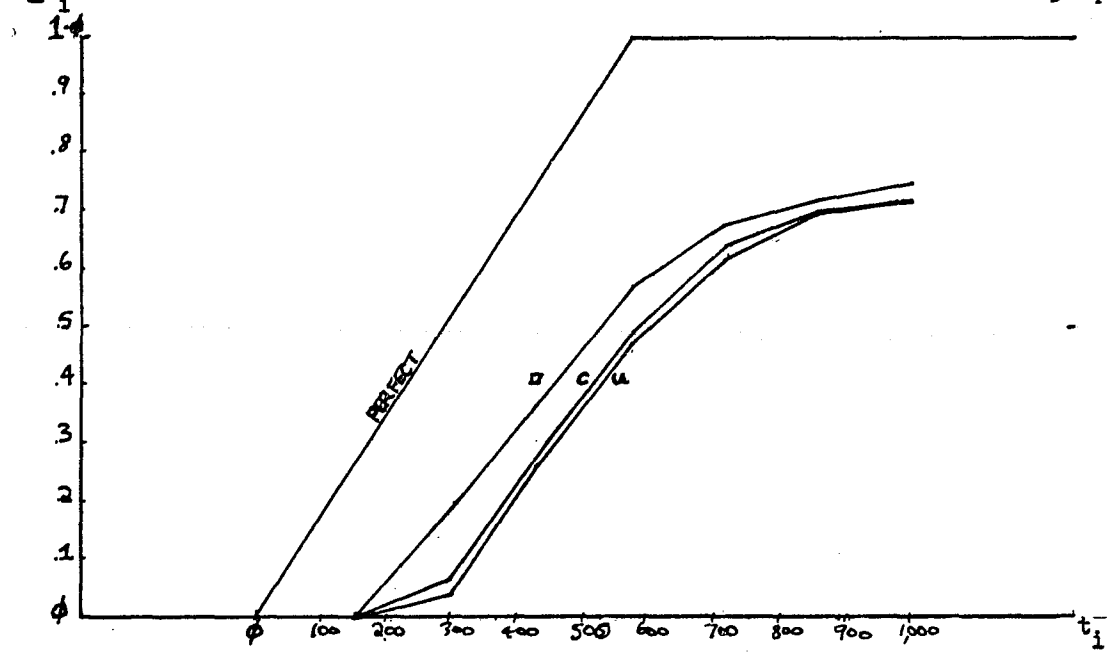
SUBJECT G.L. CONDITION: RECALL 4. 75 MSEC. FIG.15. p.3.



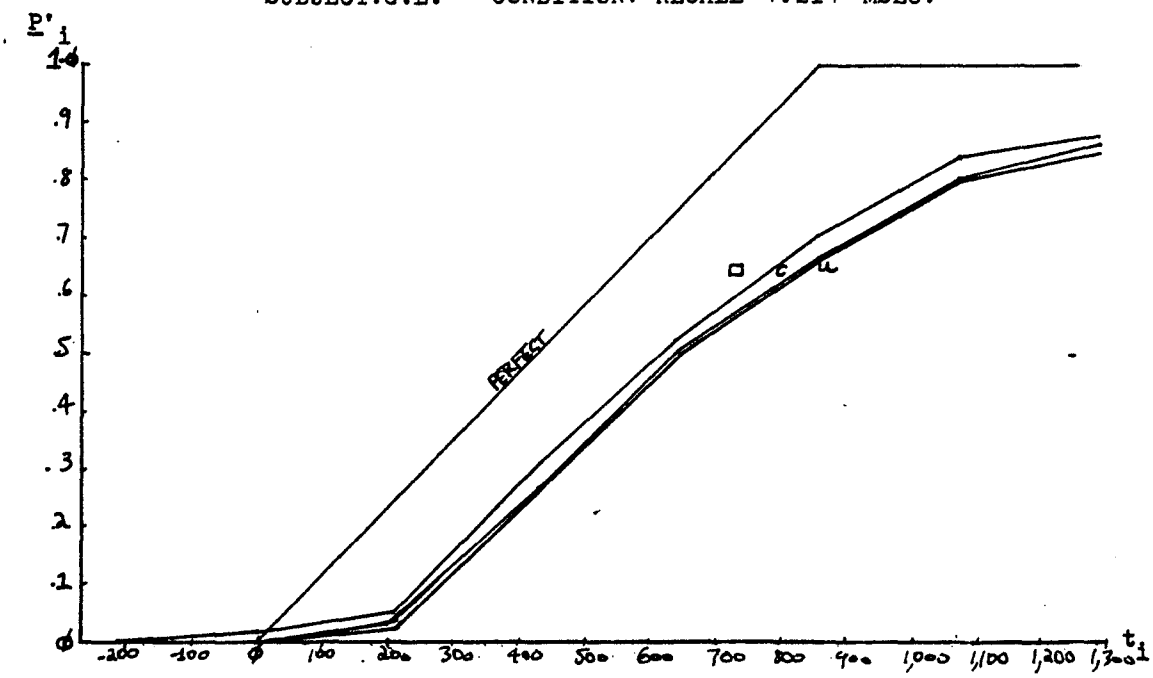
SUBJECT:G.L. CONDITION: RECALL 4. 109MSEC.



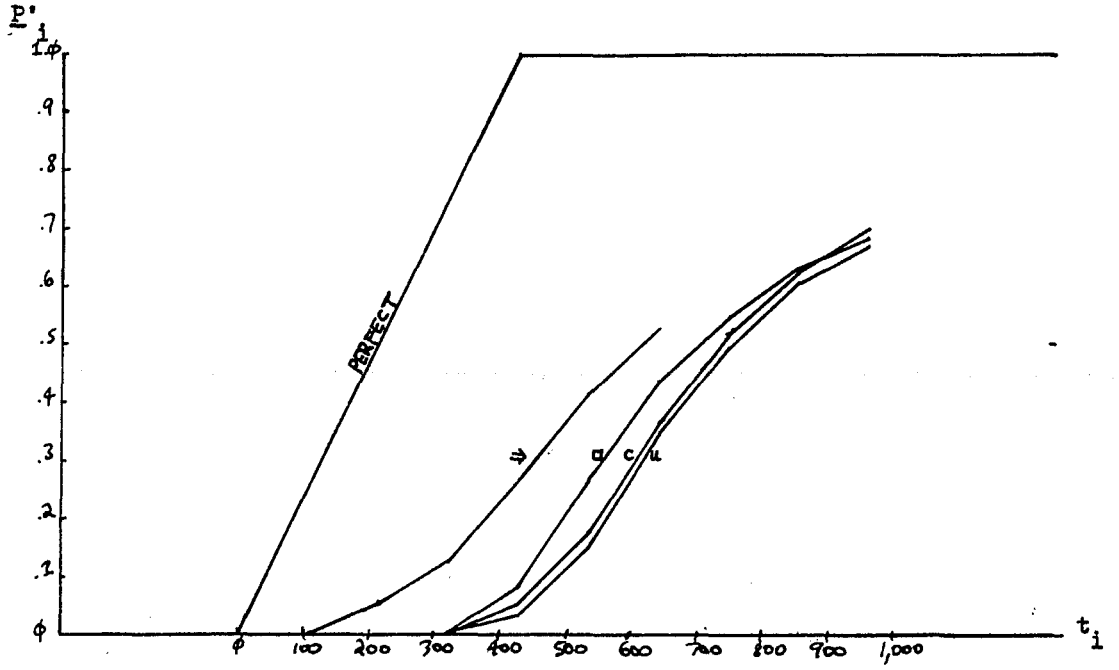
SUBJECT: G.L. CONDITION: RECALL 4.144 MSEC. FIG.15. p.4.



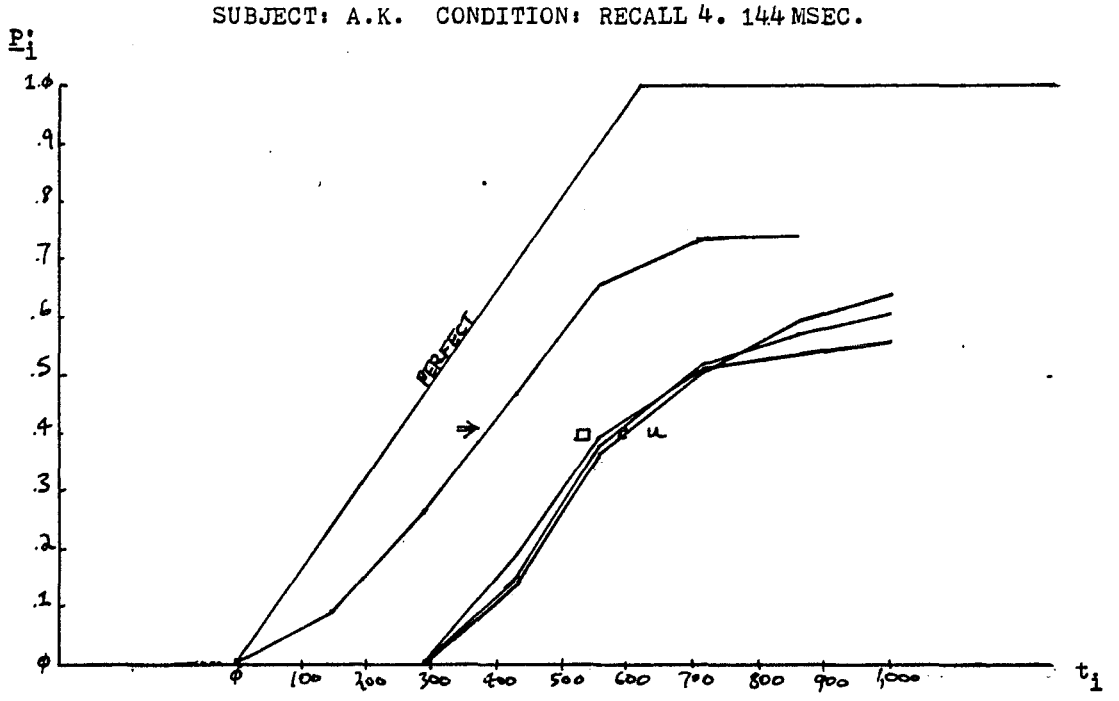
SUBJECT:G.L. CONDITION: RECALL 4.214 MSEC.



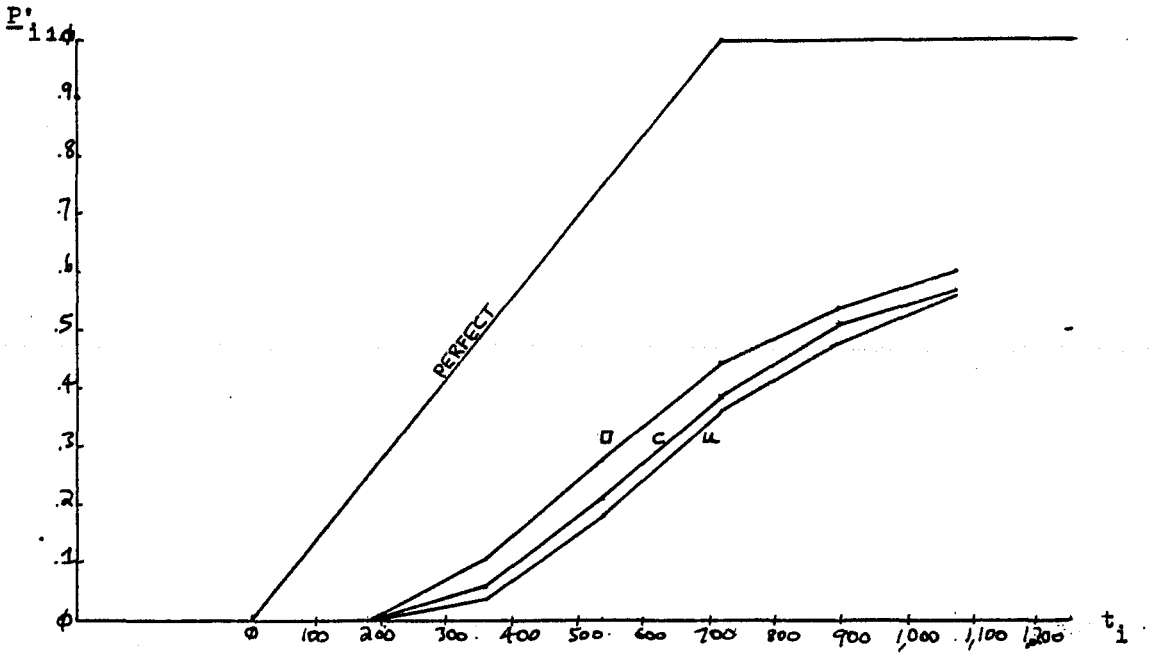
SUBJECT: A.K. CONDITION: RECALL 4.109 MSEC. FIG.15. p.5.



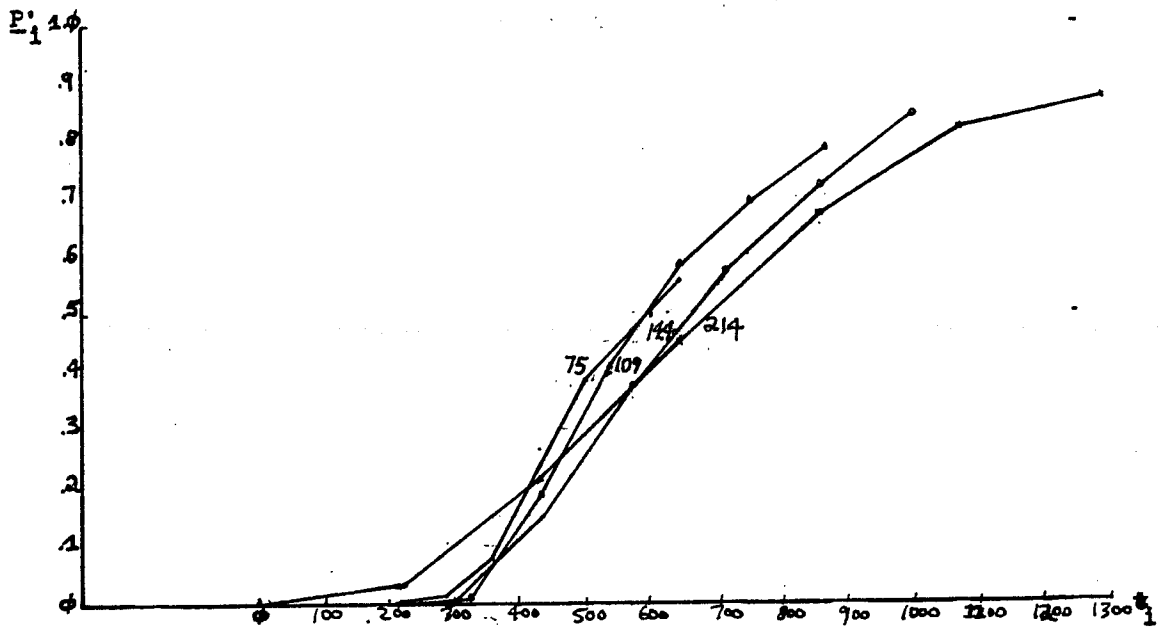
SUBJECT: A.K. CONDITION: RECALL 4. 144 MSEC.



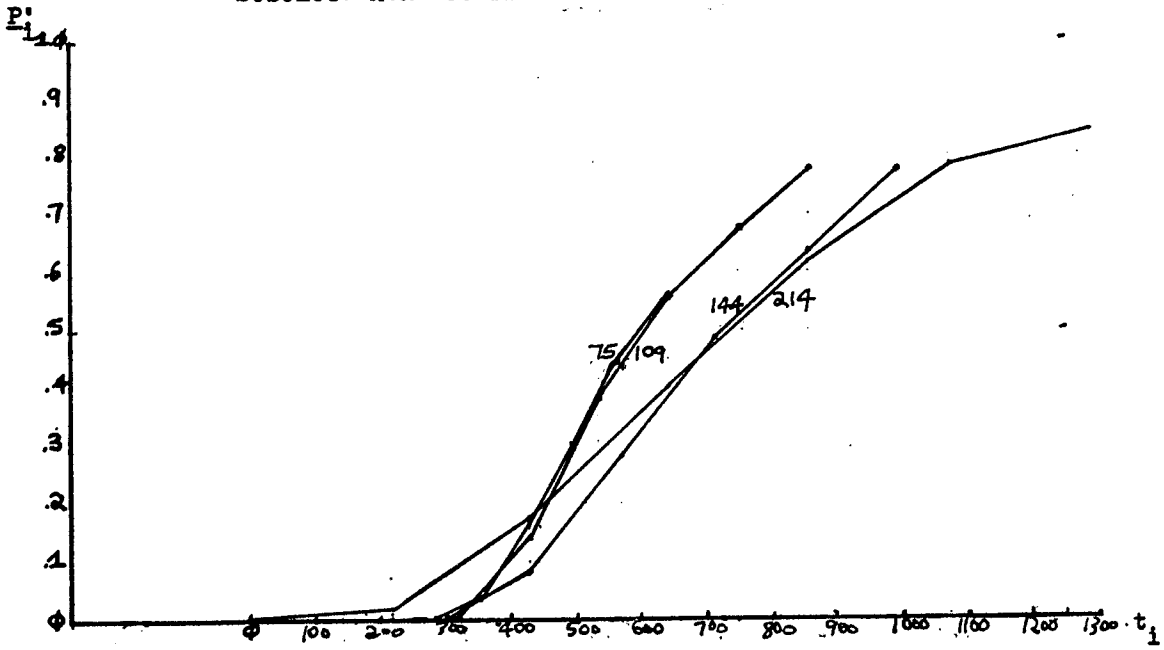
SUBJECT: A.K. CONDITION: RECALL 4.178 MSEC. FIG. 15.p.6.



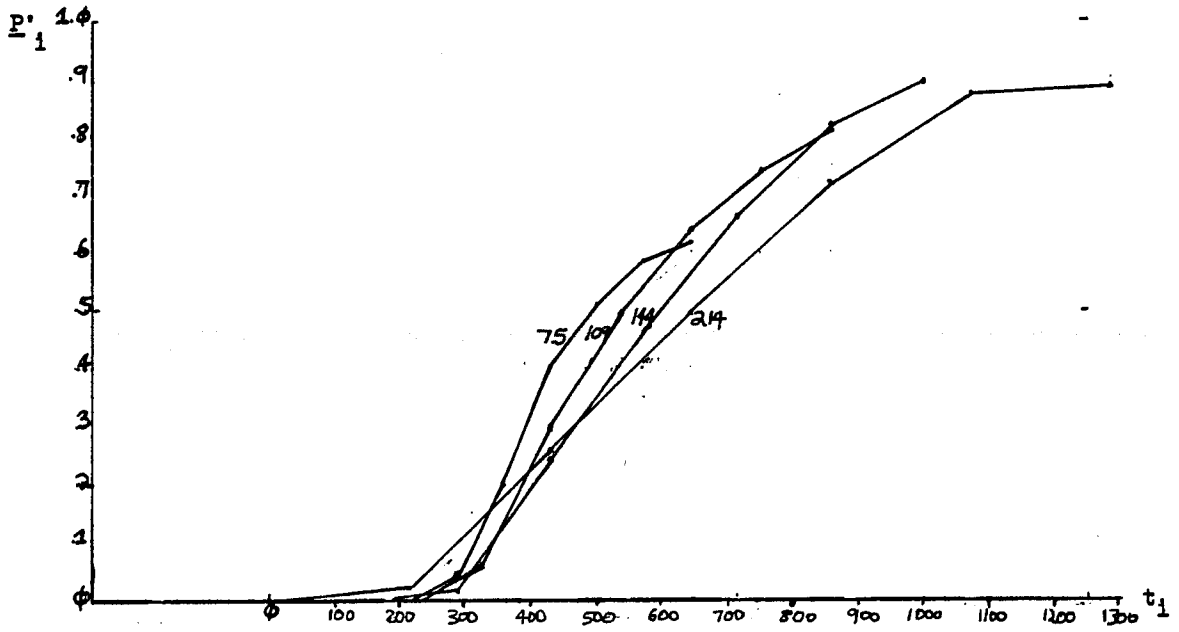
SUBJECT: A.R. CONDITION: RECALL 4. LETTER C. FIG. 16 p.1.



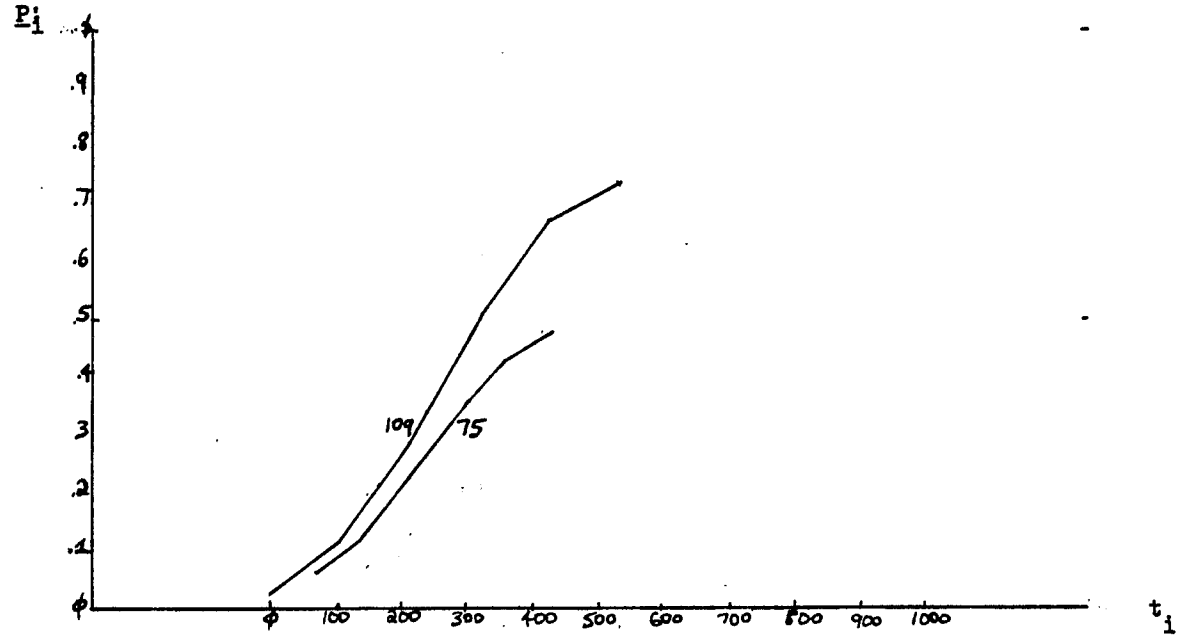
SUBJECT: A.R. CONDITION: RECALL 4. LETTER U.



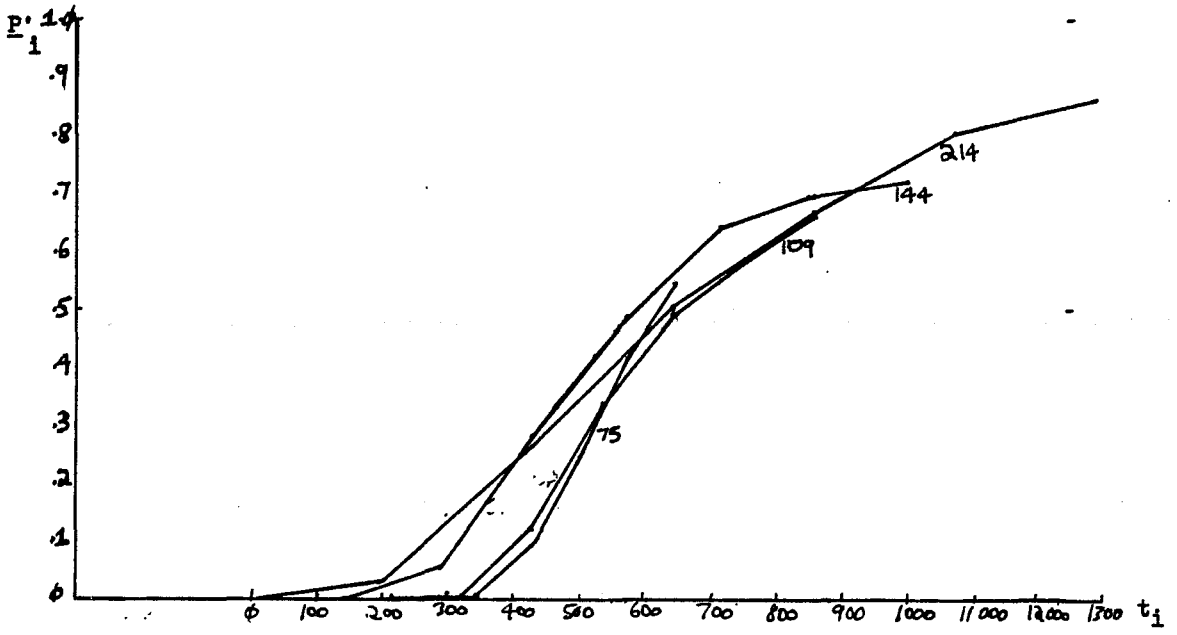
SUBJECT: A.R. CONDITION: RECALL 4. SQUARE. FIG. 16. p.2.



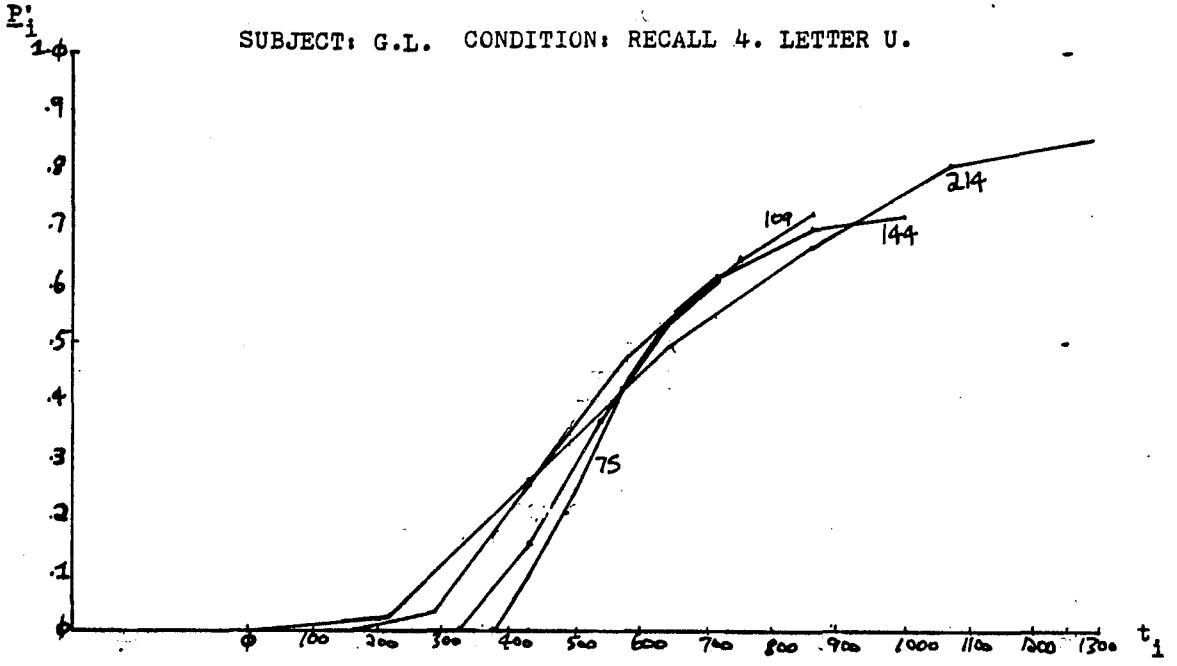
SUBJECT: A.R. CONDITION: RECALL 4.. ARROW.



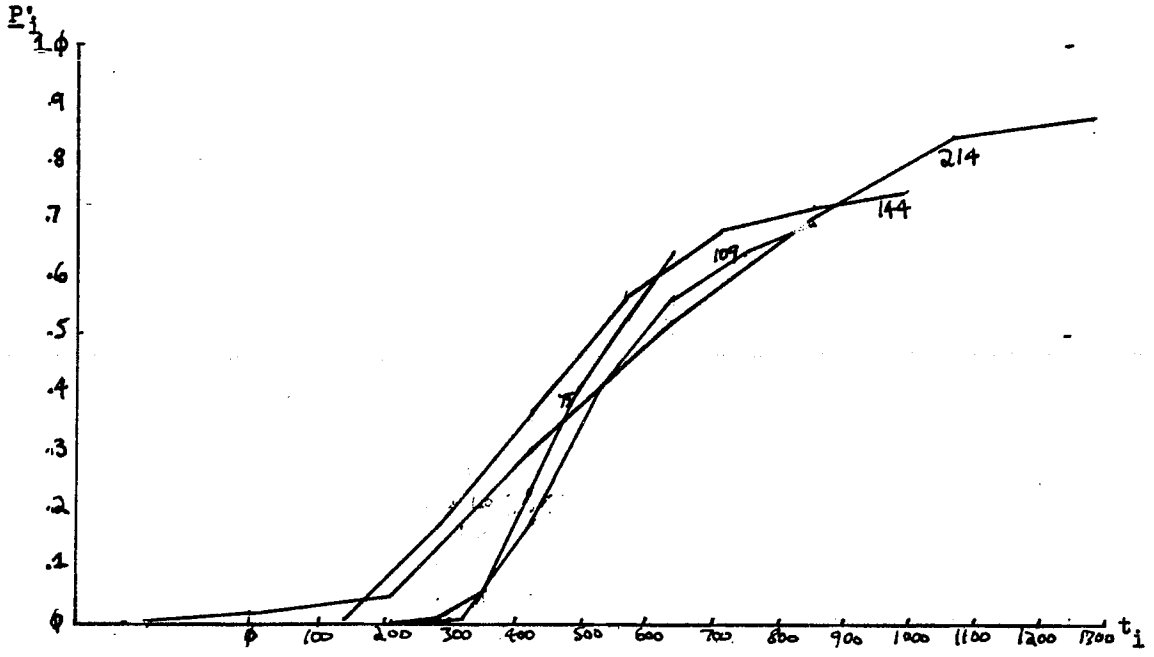
SUBJECT: G.L. CONDITION: RECALL 4. LETTER C. FIG.16. p.3.



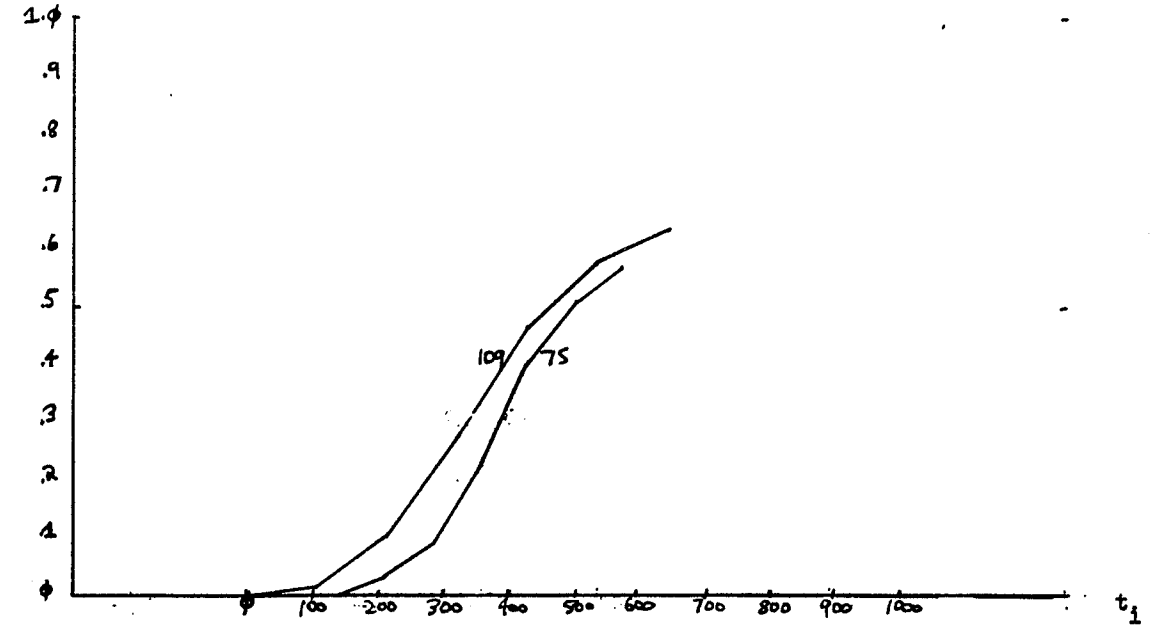
SUBJECT: G.L. CONDITION: RECALL 4. LETTER U.



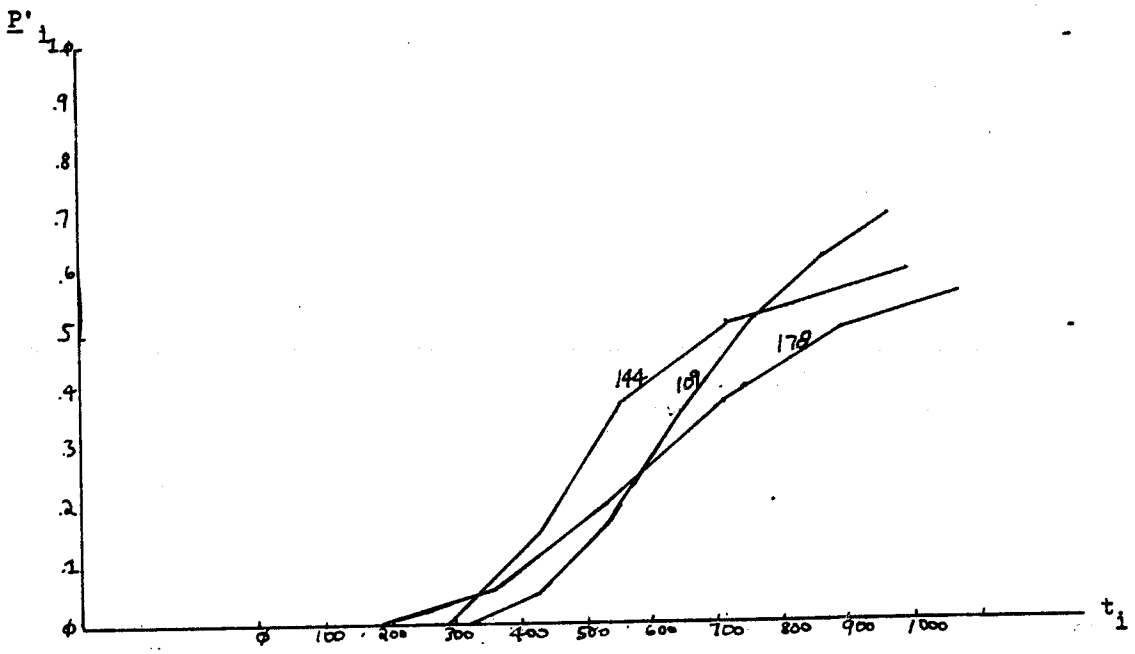
SUBJECT: G.L. CONDITION: RECALL 4. SQUARE. FIG.16. p.4.



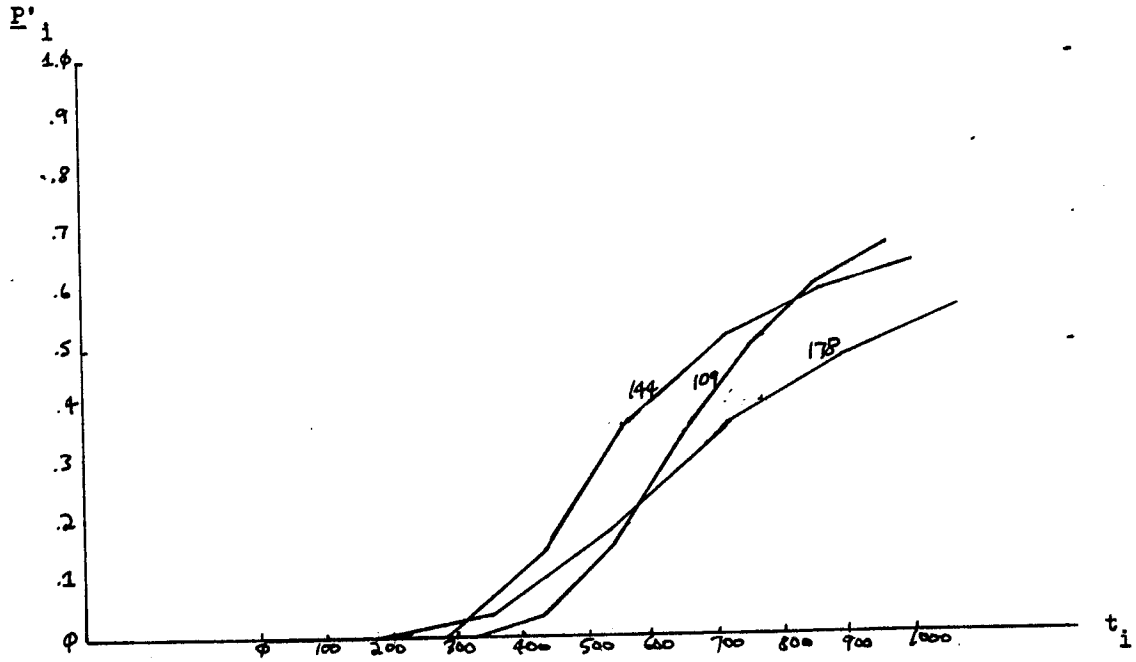
SUBJECT:G.L. CONDITION: RECALL 4. ARROW.



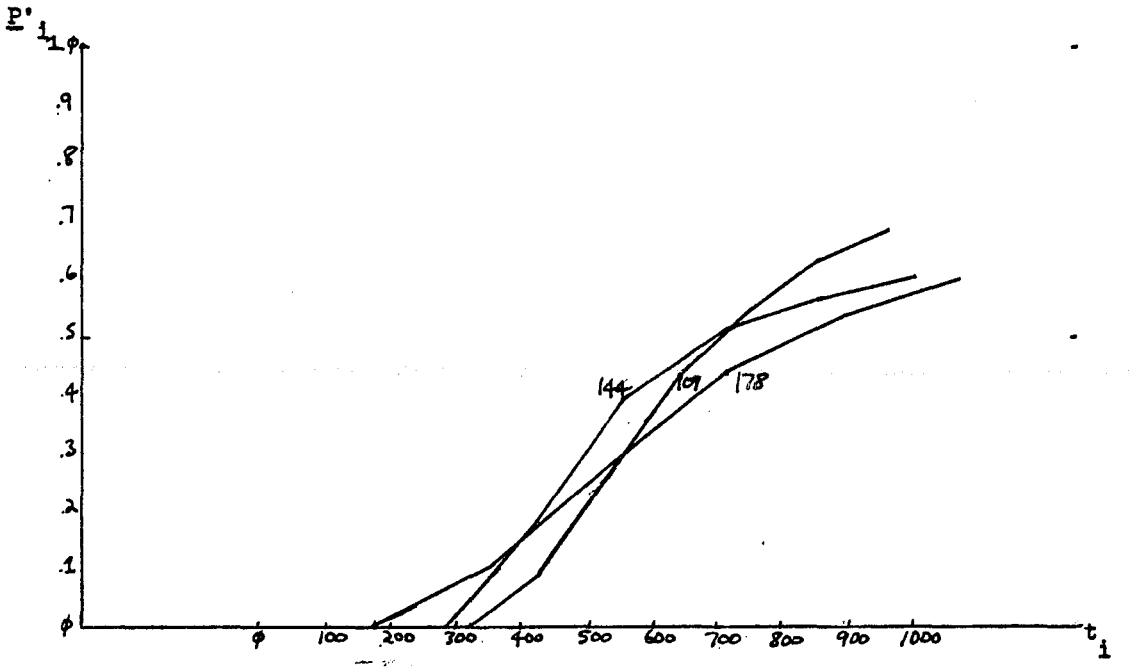
SUBJECT: A.K. CONDITION: RECALL 4. LETTER C. FIG. 16.p.5.



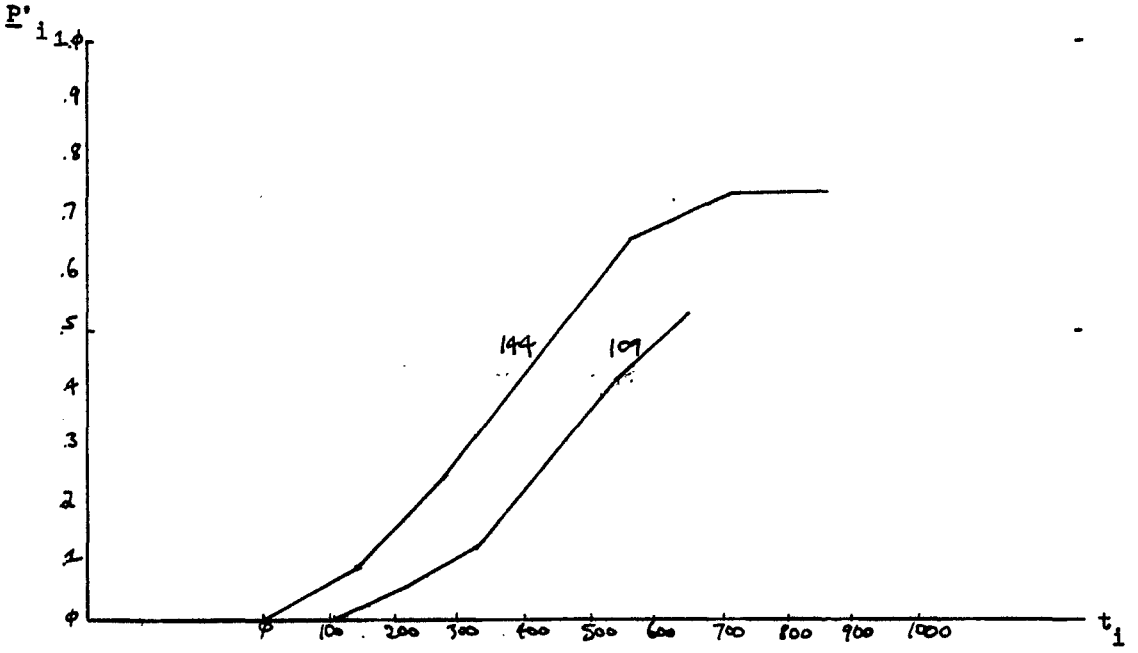
SUBJECT: A.K. CONDITION: RECALL 4. LETTER U.



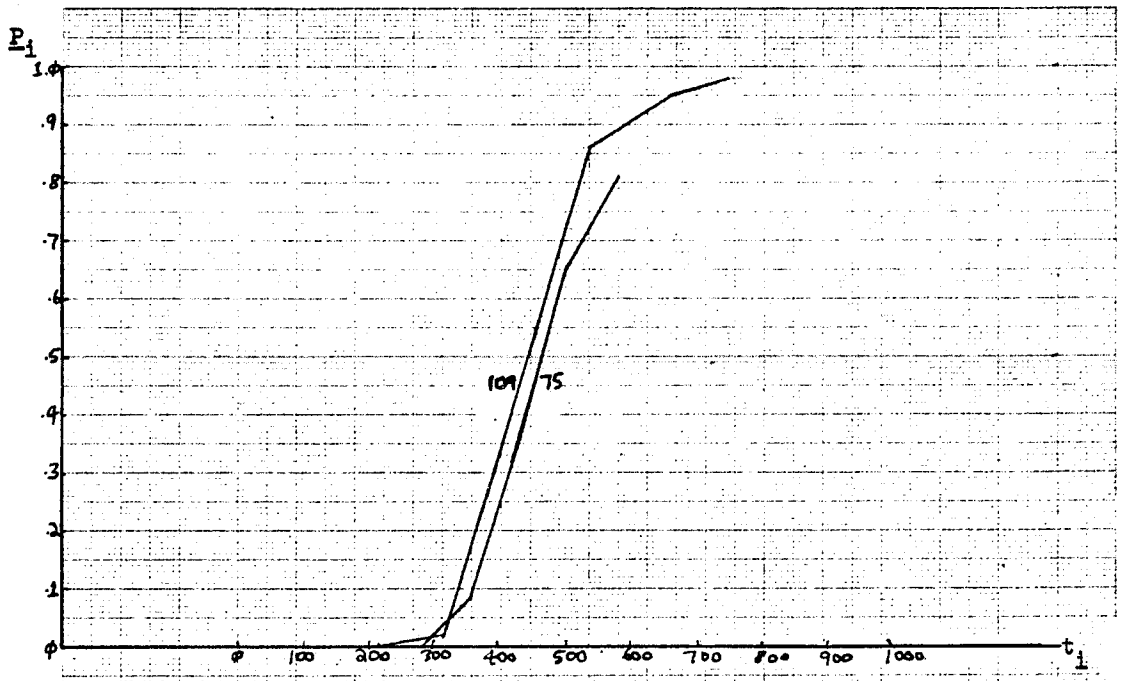
SUBJECT: A.K. CONDITION: RECALL 4. SQUARE. FIG. 16.p.6.



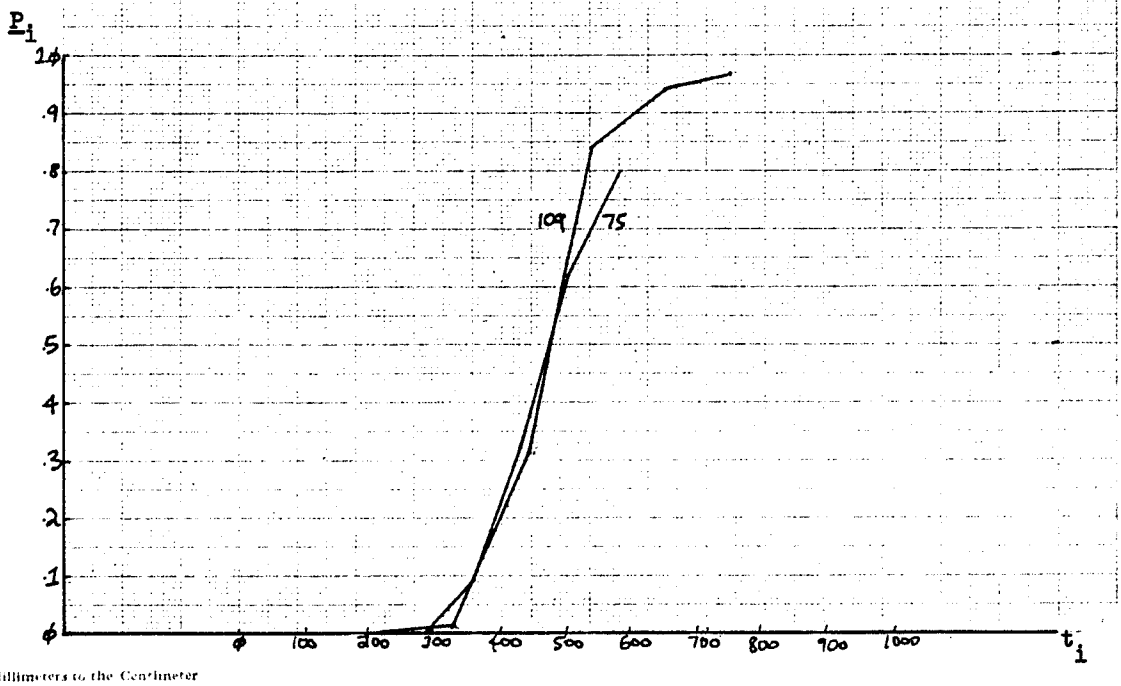
SUBJECT: A.K. CONDITION: RECALL 4. ARROW.



SUBJECT:A.R. CONDITION: RECALL 1 LETTER C FIG.17. p.1.

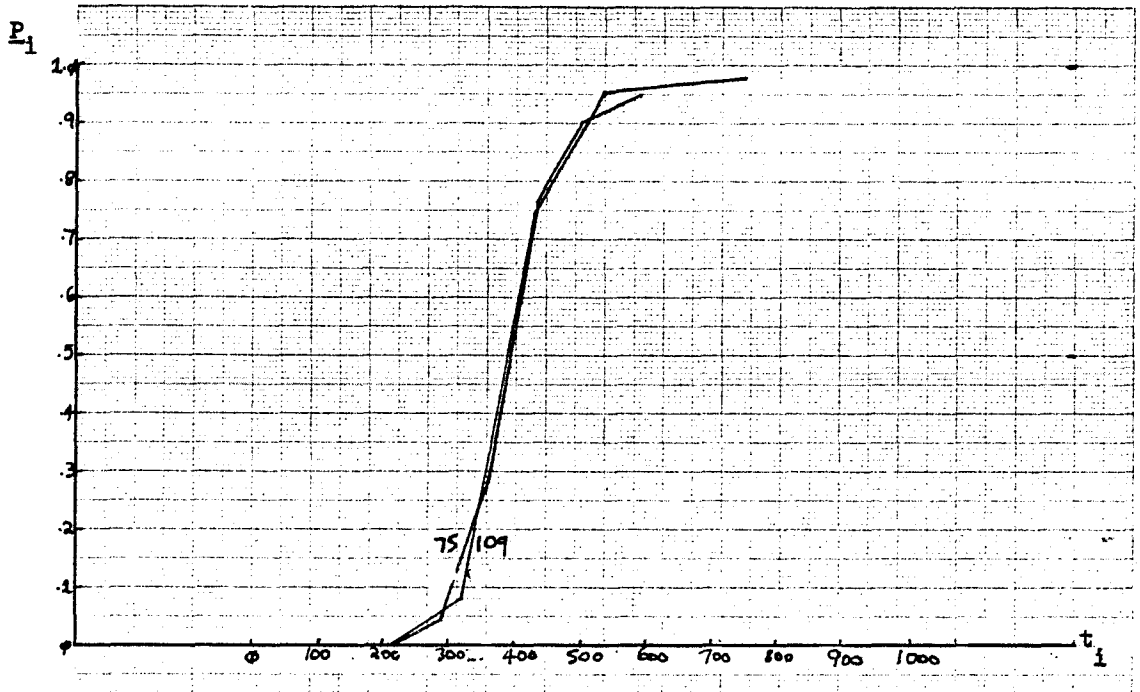


SUBJECT:A.R. CONDITION: RECALL 1 LETTER U

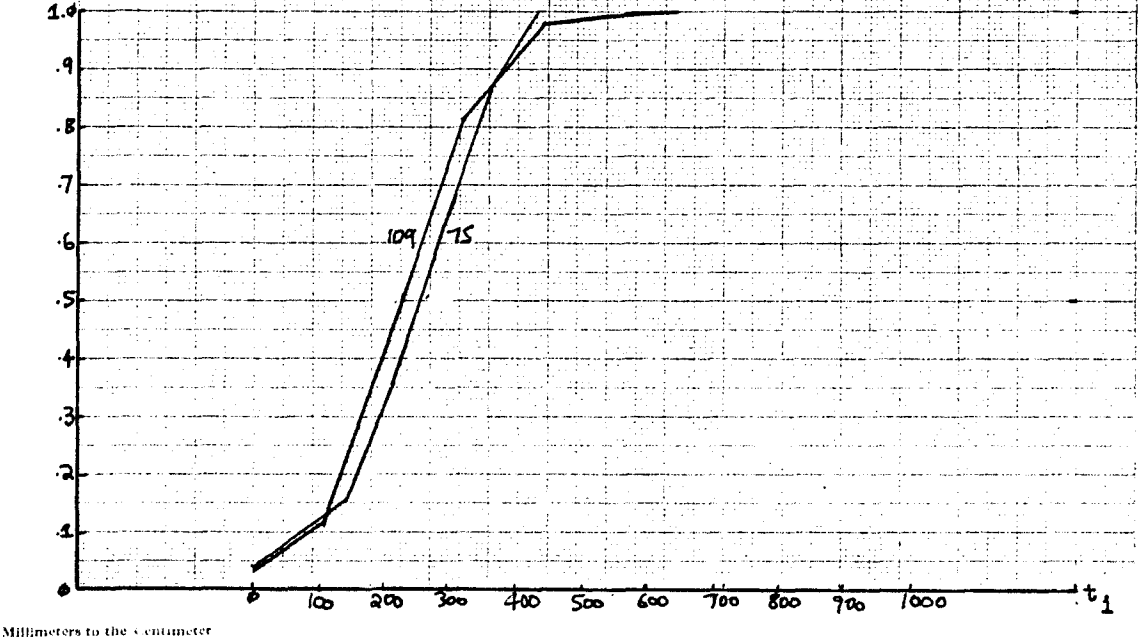


10 Millimeters to the Centimeter

SUBJECT:A.R. CONDITION: RECALL 1 SQUARE FIG. 17. p.2.

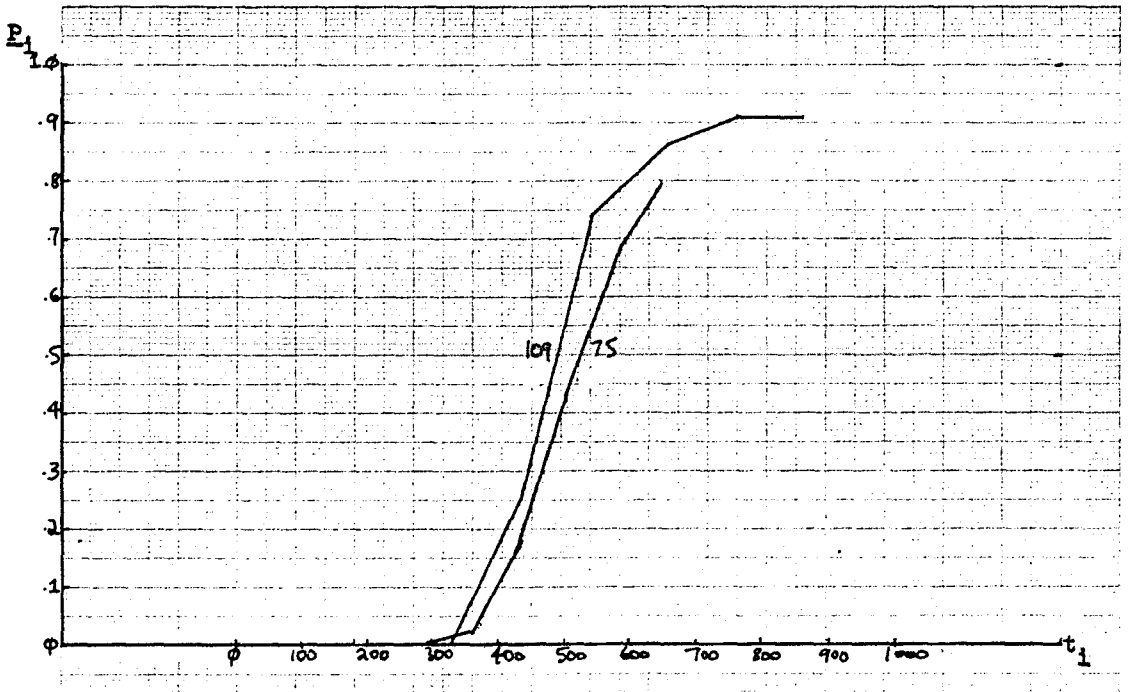


SUBJECT: A.R. CONDITION: RECALL 1 ARROW

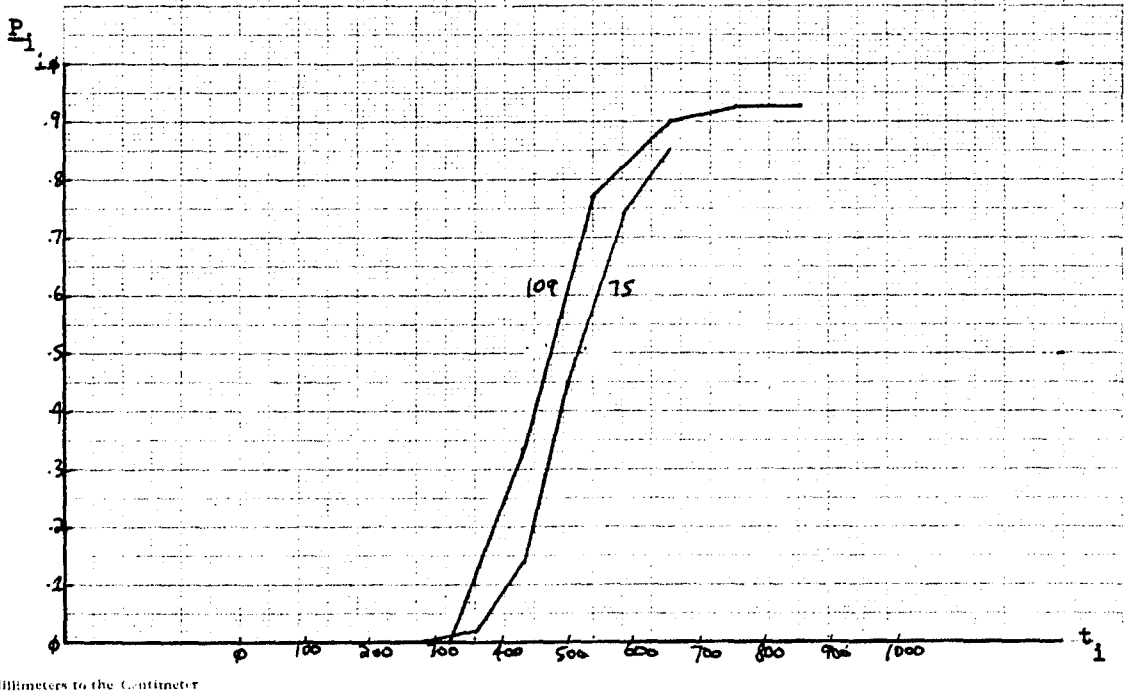


10 Millimeters to the centimeter

SUBJECT:G.L. CONDITION: RECALL 1 LETTER C FIG.17. p.3.

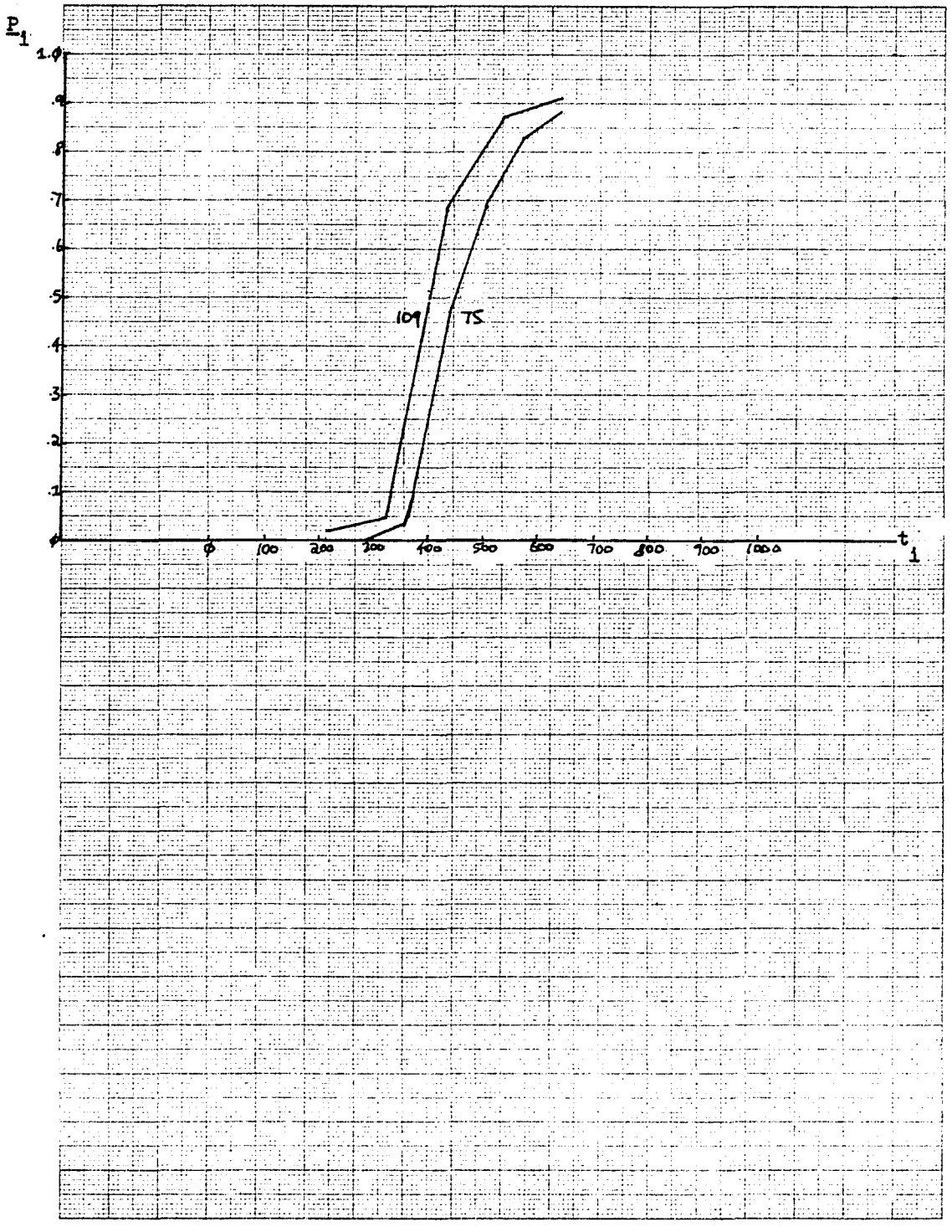


SUBJECT:G.L. CONDITION: RECALL 1 LETTER U



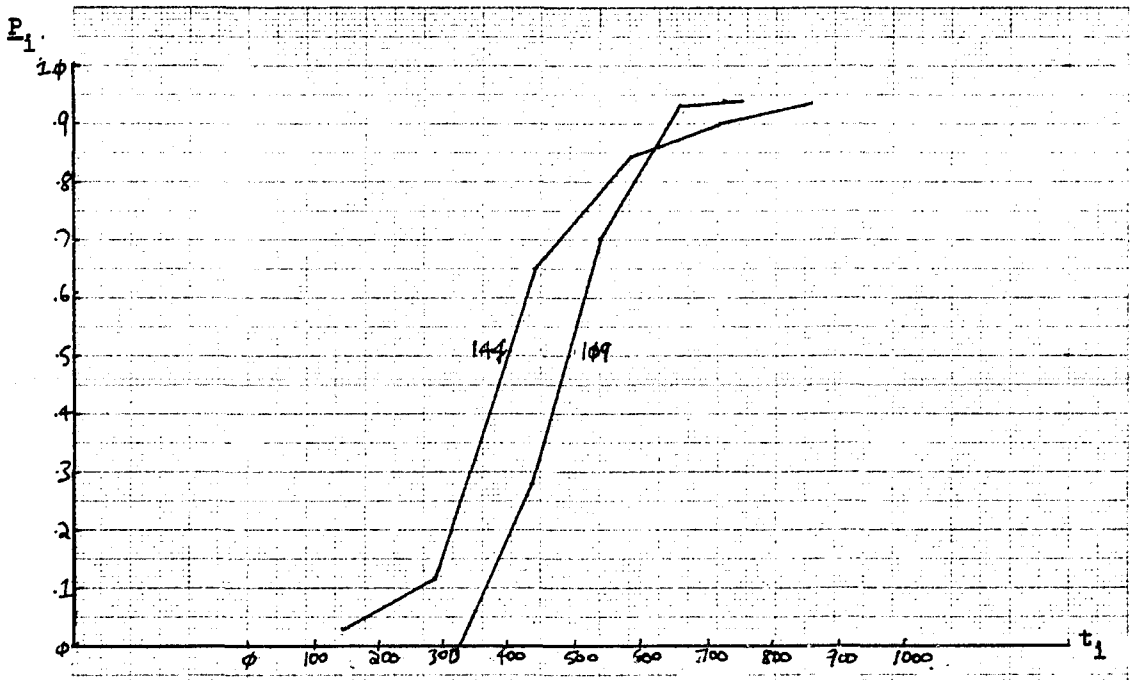
10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 SQUARE FIG.17. p.4.

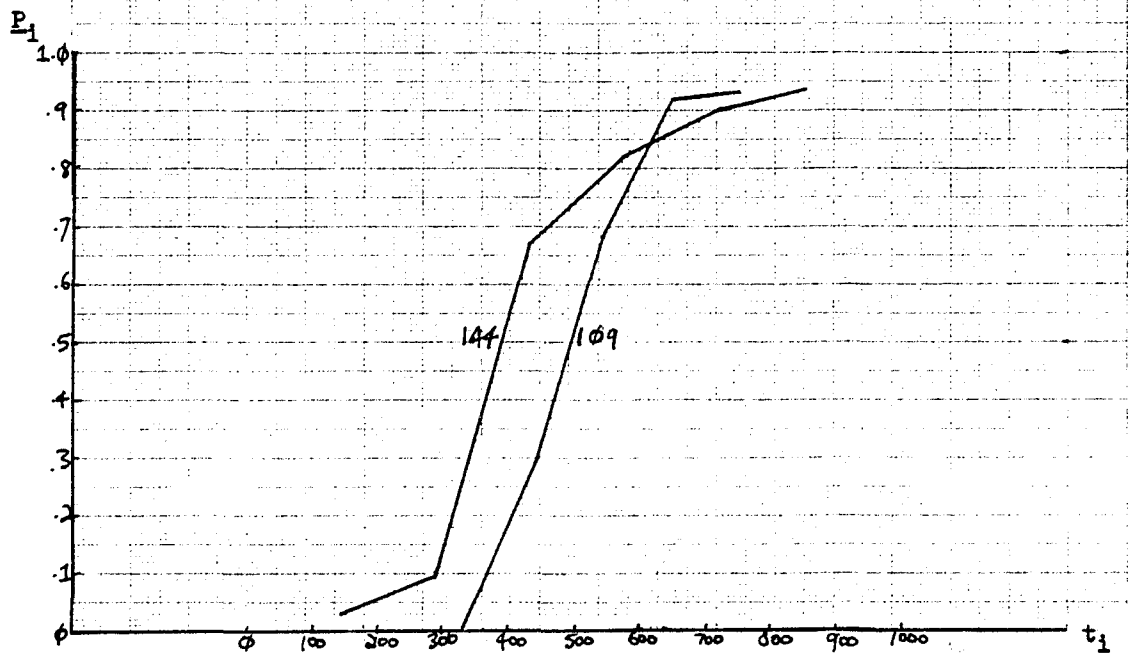


10 Millimeters to the Centimeter

SUBJECT:A.K. CONDITION: RECALL 1 LETTER C FIG.17. p.5.

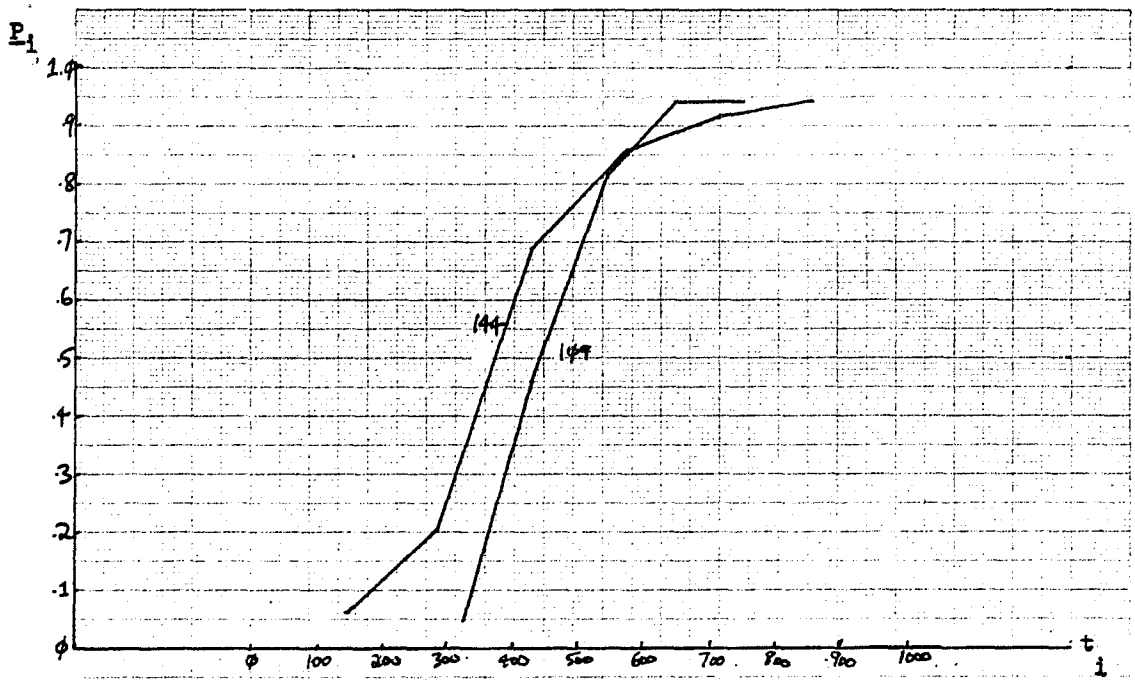


SUBJECT:A.K. CONDITION: RECALL 1 LETTER U



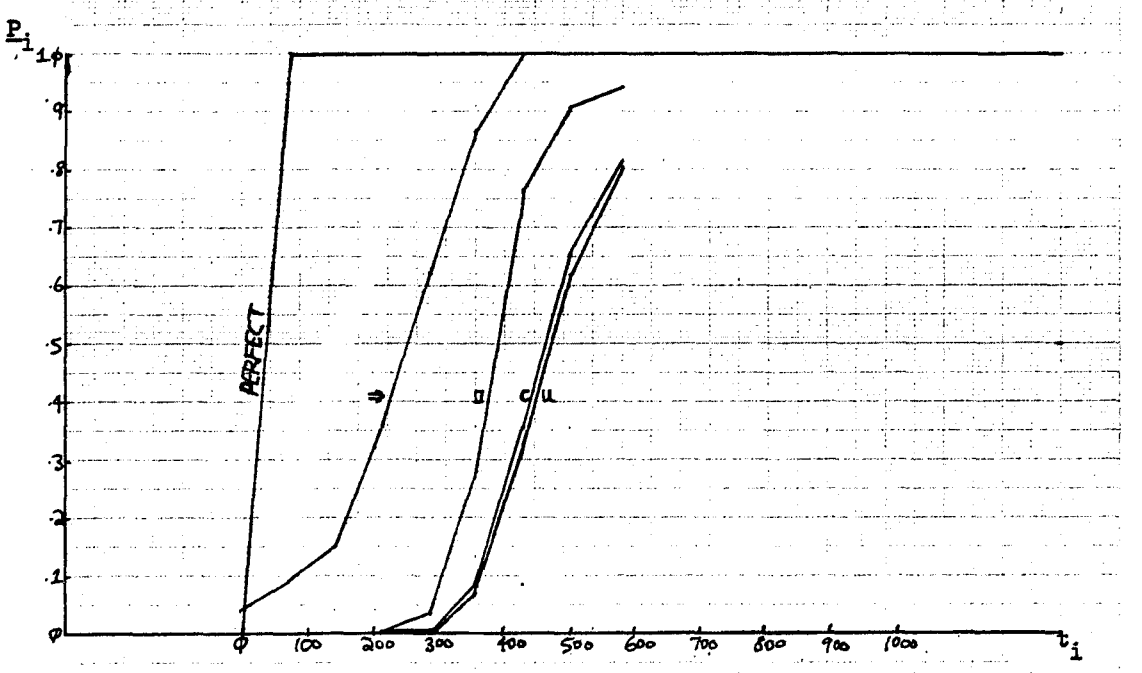
10 Millimeters to the Centimeter

SUBJECT: A.K. CONDITION: RECALL 1 SQUARE FIG.17. p.6.

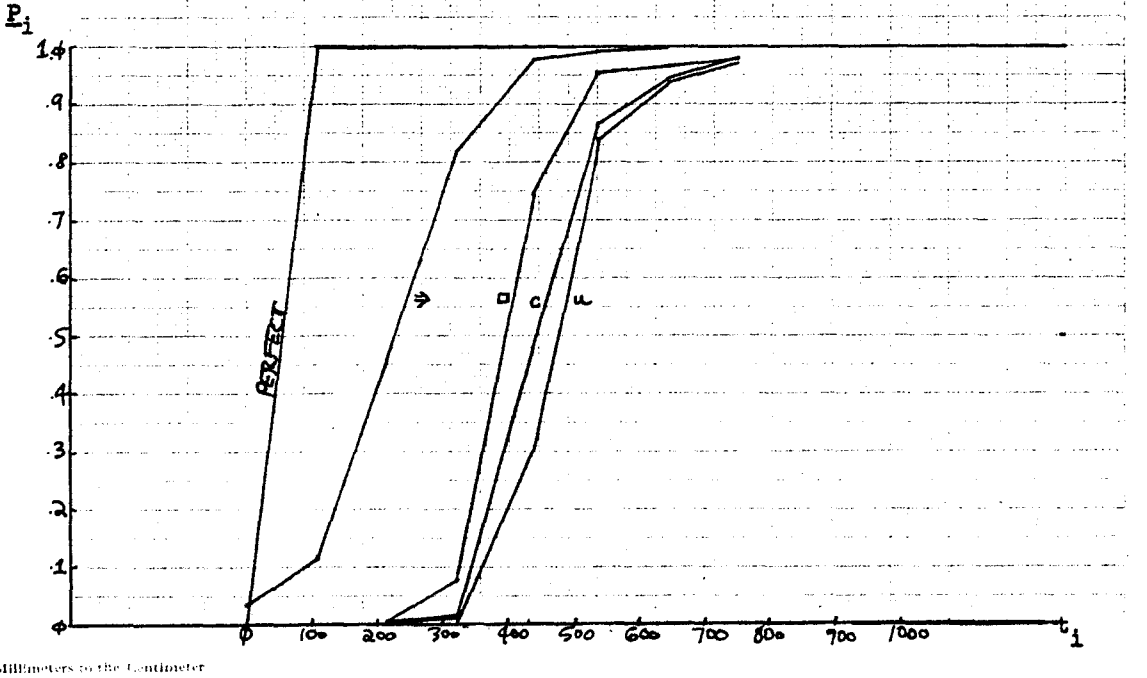


10 Millimeters to the Centimeter

SUBJECT:A.R. CONDITION: RECALL 1 AT 75 MSEC. FIG.18.p.1.

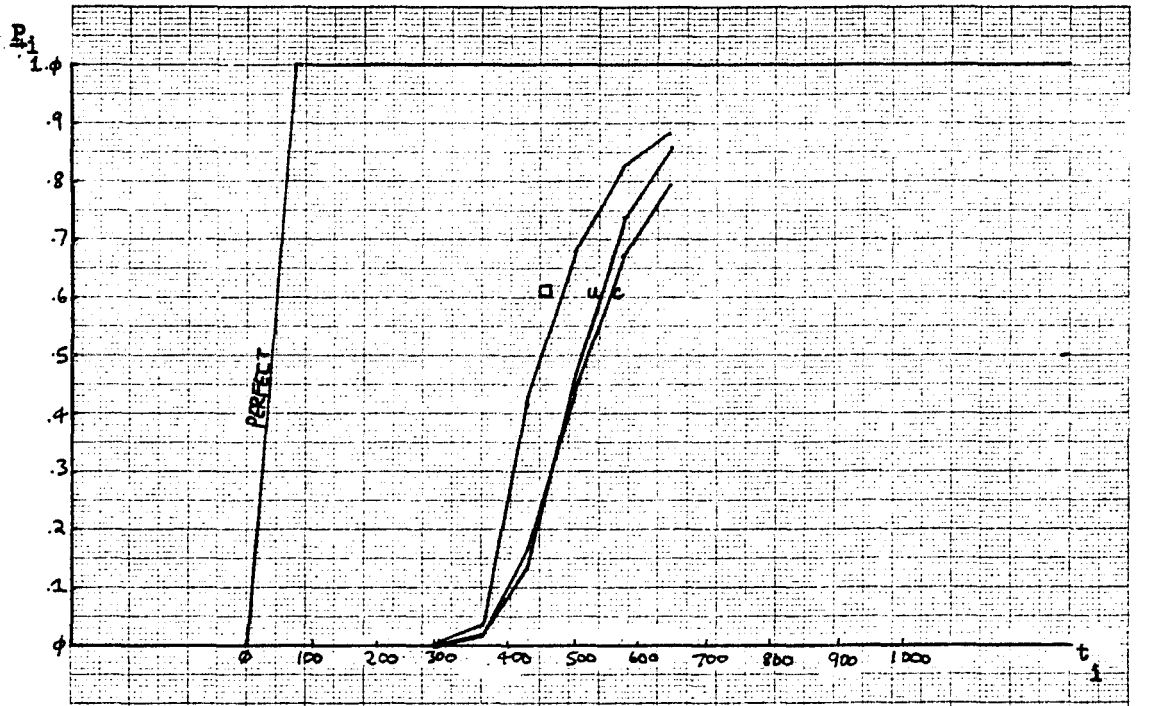


SUBJECT:A.R. CONDITION: RECALL 1 AT 109 MSEC.

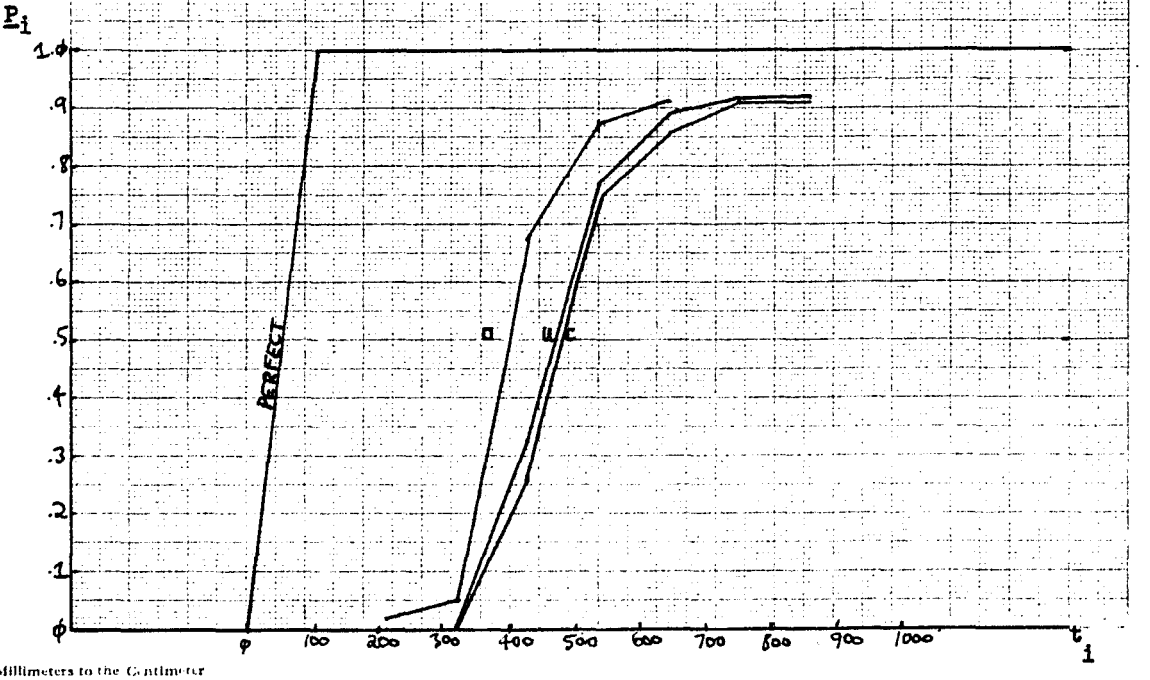


10 Millimeters to the Centimeter

SUBJECT:G.L. CONDITION: RECALL 1 AT 75 MSEC. FIG.18.p.2.



SUBJECT:G.L. CONDITION: RECALL 1 AT 109 MSEC



10 Millimeters to the Centimeter

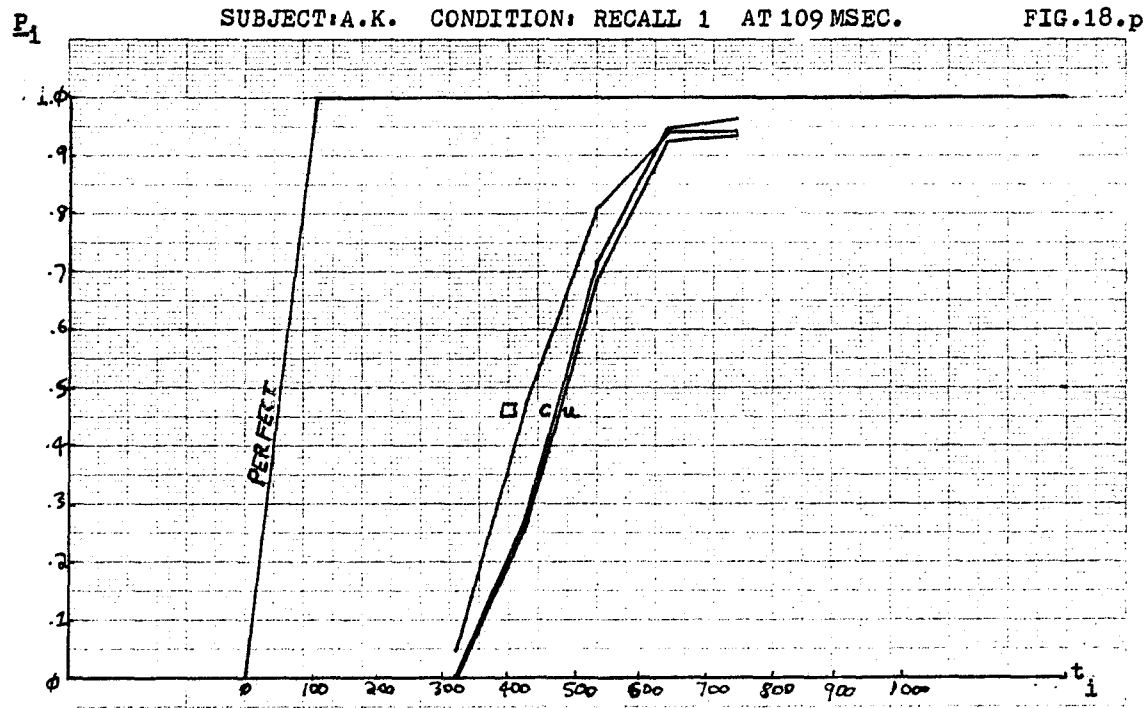
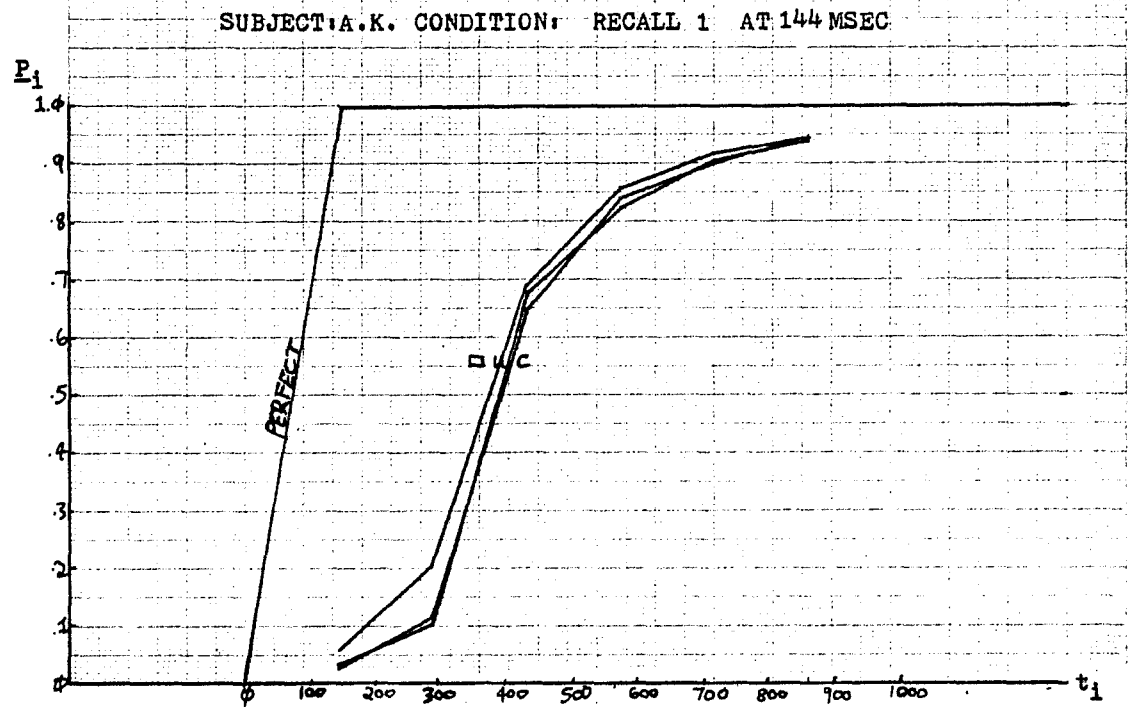
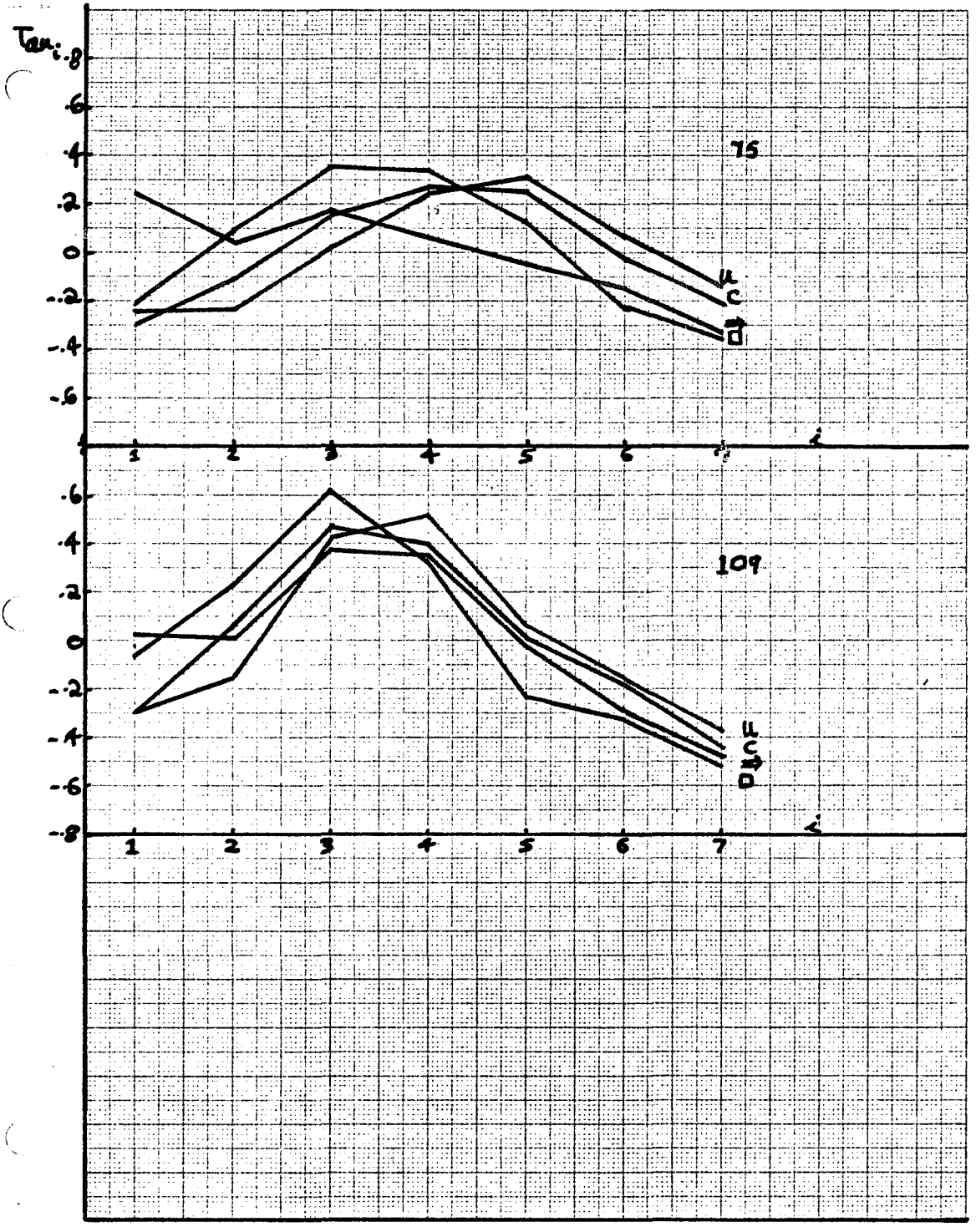


FIG.18.p.3.



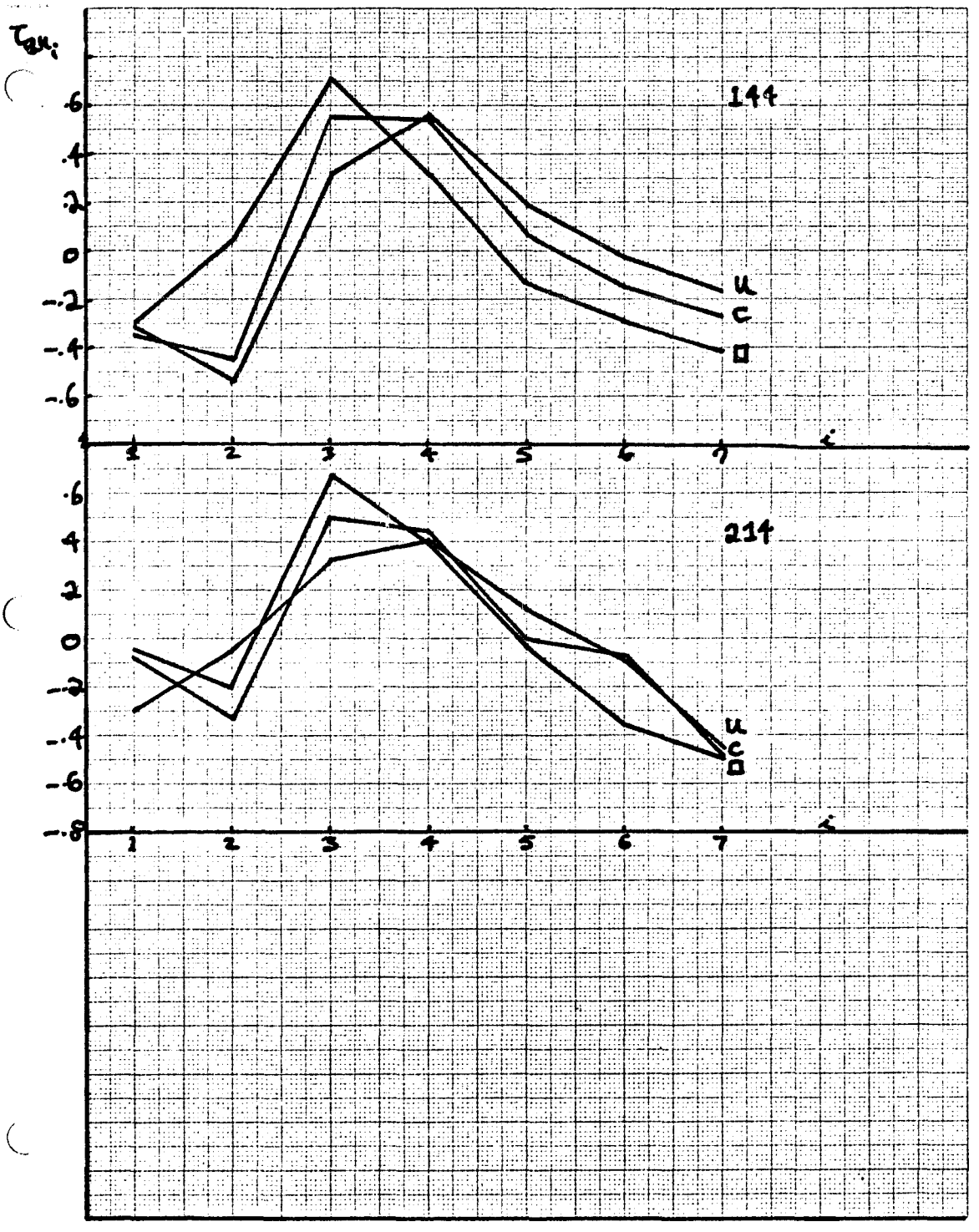
10 Millimeters to the Centimeter

TAU$_i$ BY I. SUBJECT: A.R. FIG. 19 .p.1.



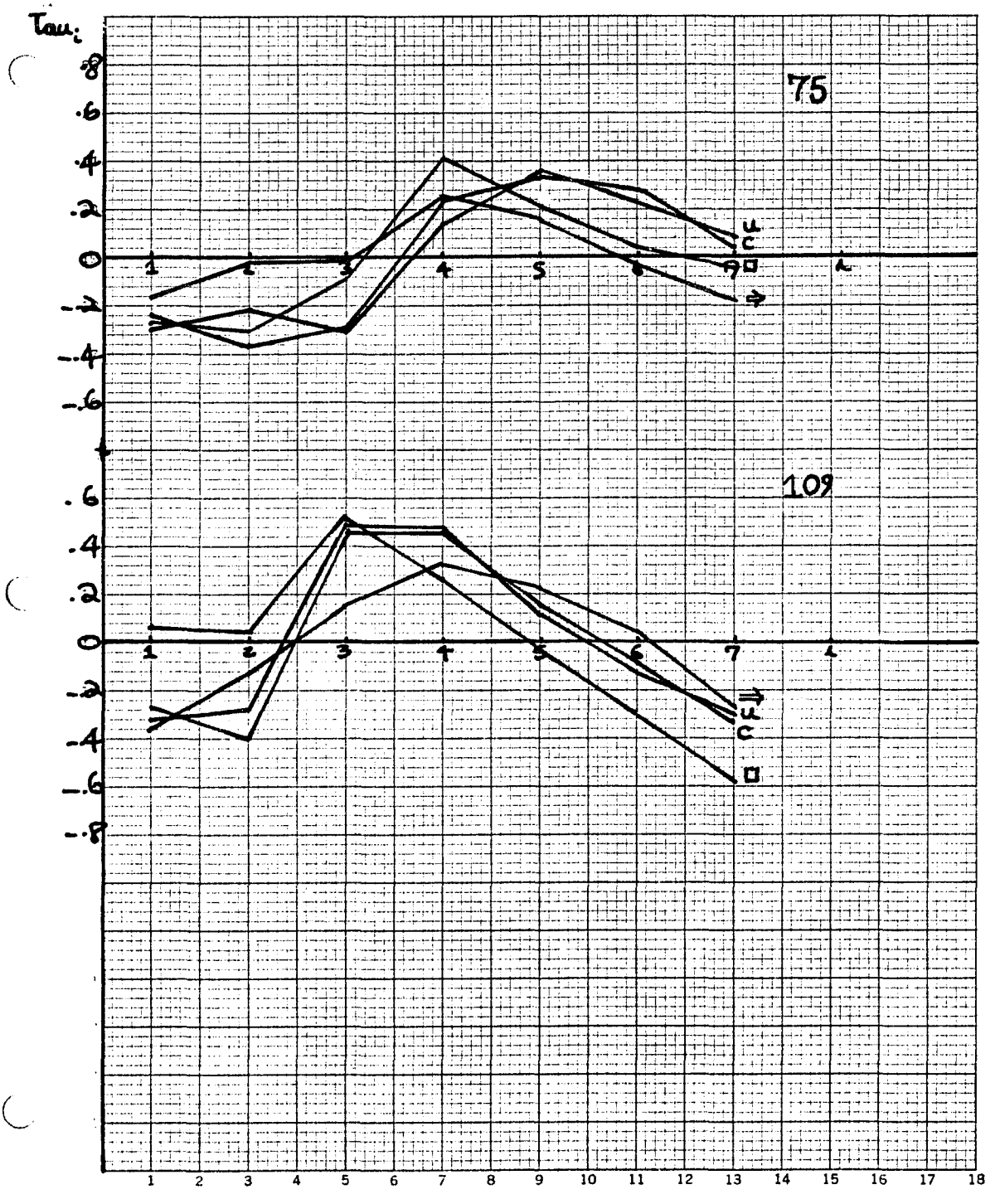
10 Millimeters to the Centimeter

TAU$_i$ by I. SUBJECT: A.R. FIG.19. p.2.



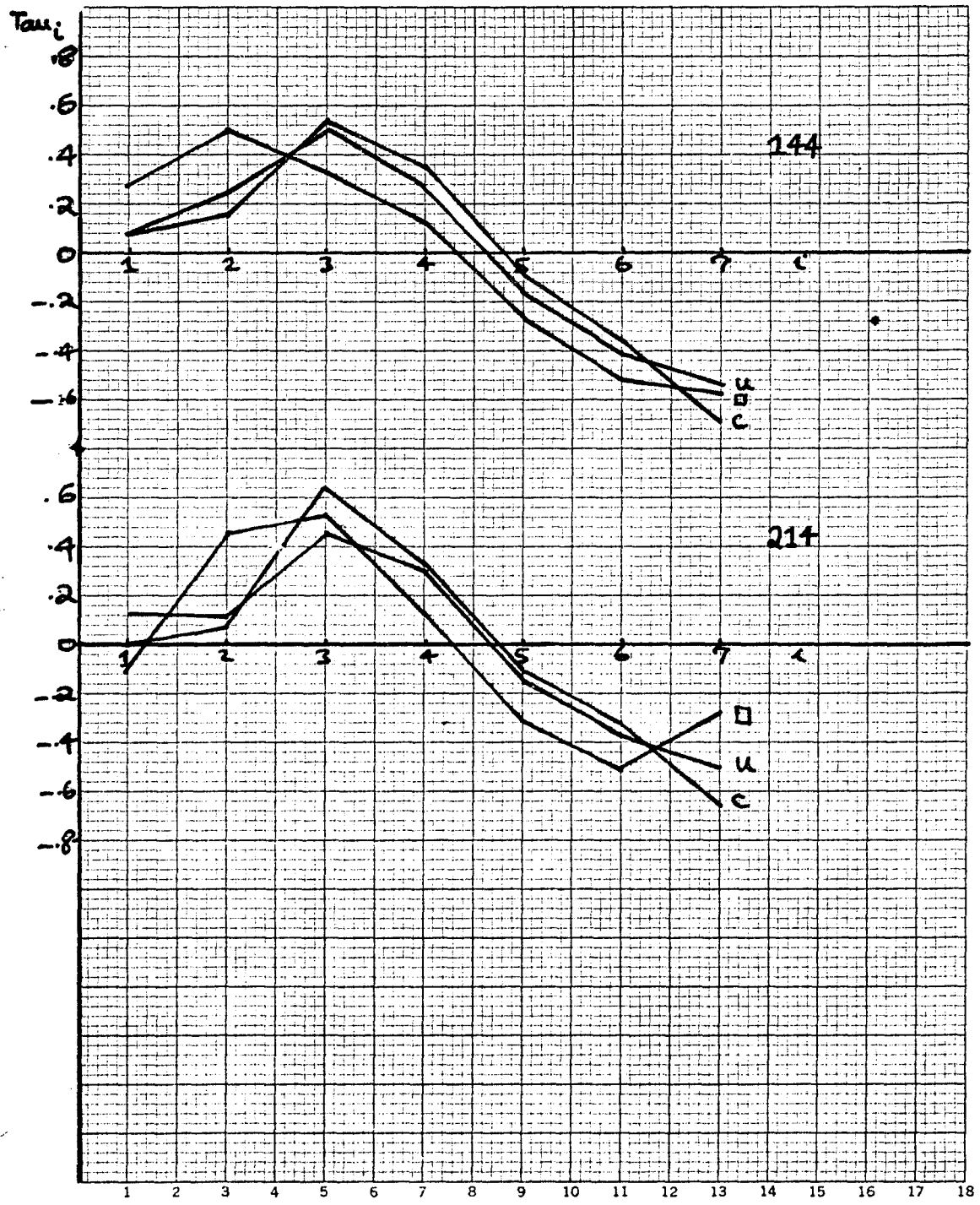
10 Millimeters to the Centimeter

TAU_i by I. SUBJECT: G.L. FIG.19. p.3.



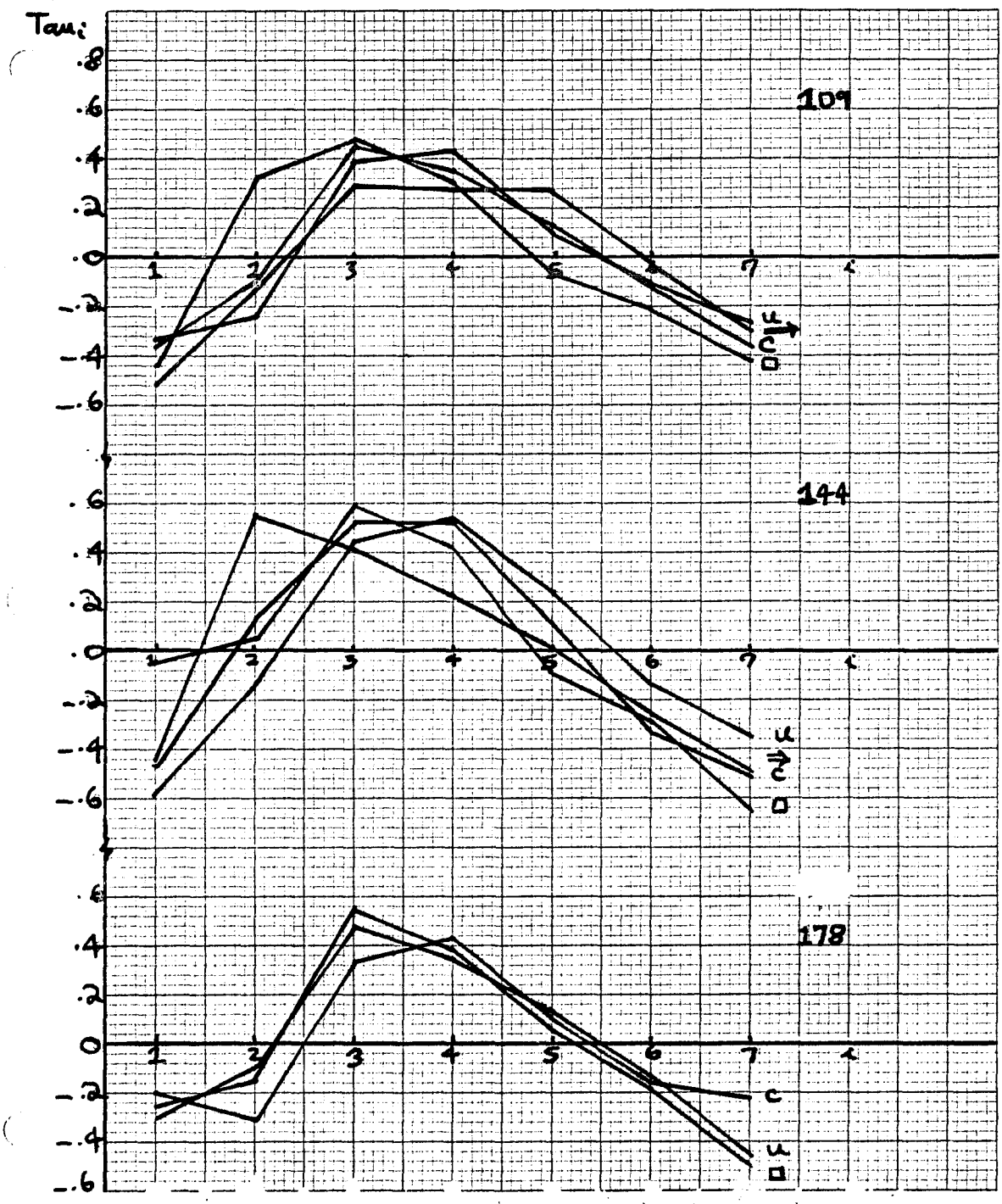
5 Squares to the Centimeter

TAU_i by I. SUBJECT: G.L. FIG.19. p.4.



5 Squares to the Centimeter

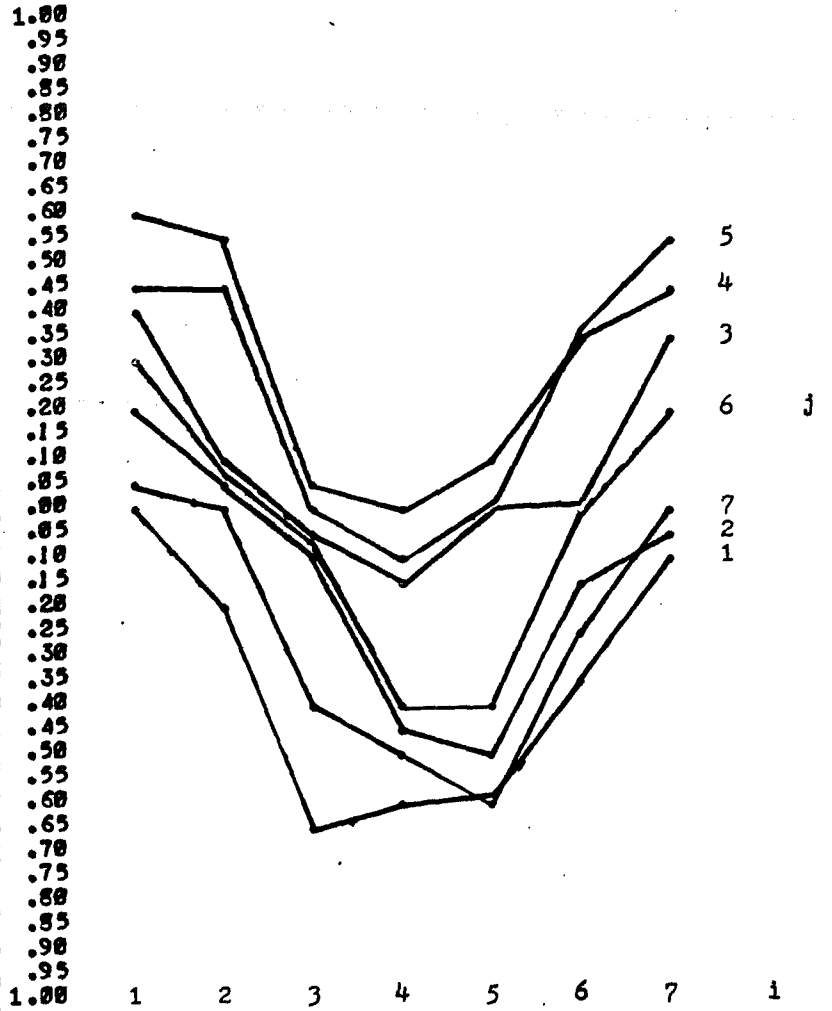
TAU_i by I. SUBJECT: A.K. FIG.19. p.5.



5 Squares to the Centimeter

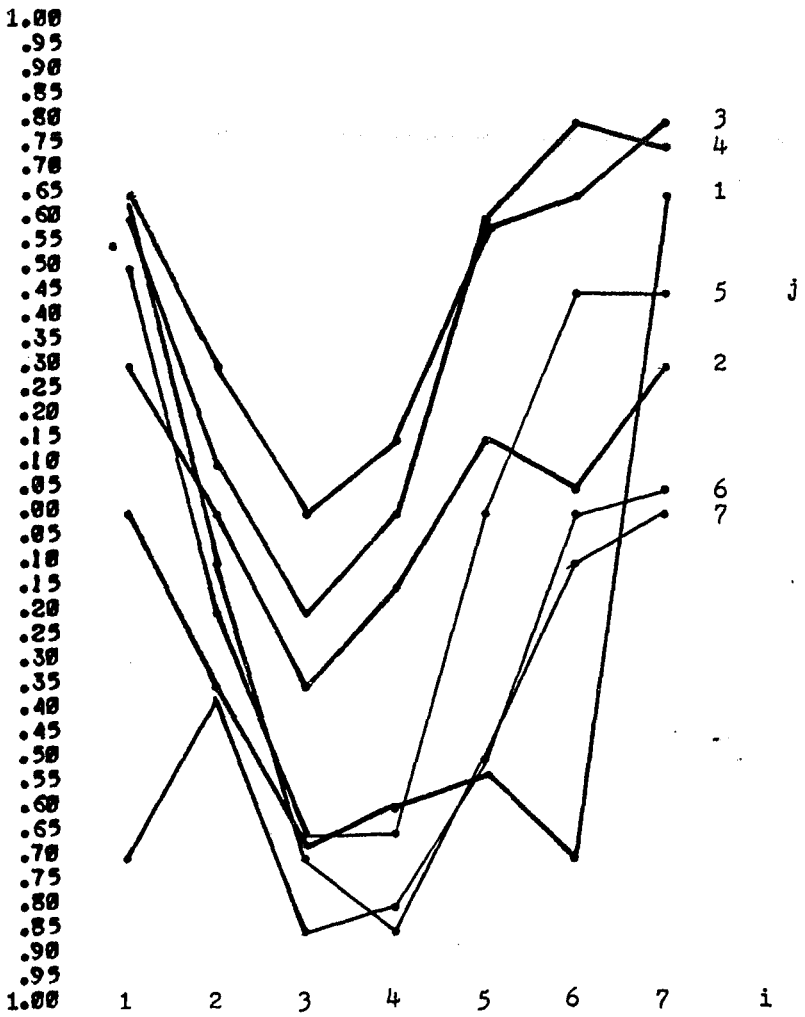
CONDITION : RECALL 4. SUBJECT: A.R. $\underline{TAU}_{ij}$. FIG.20. p.1.

75 MSEC. LETTER C .



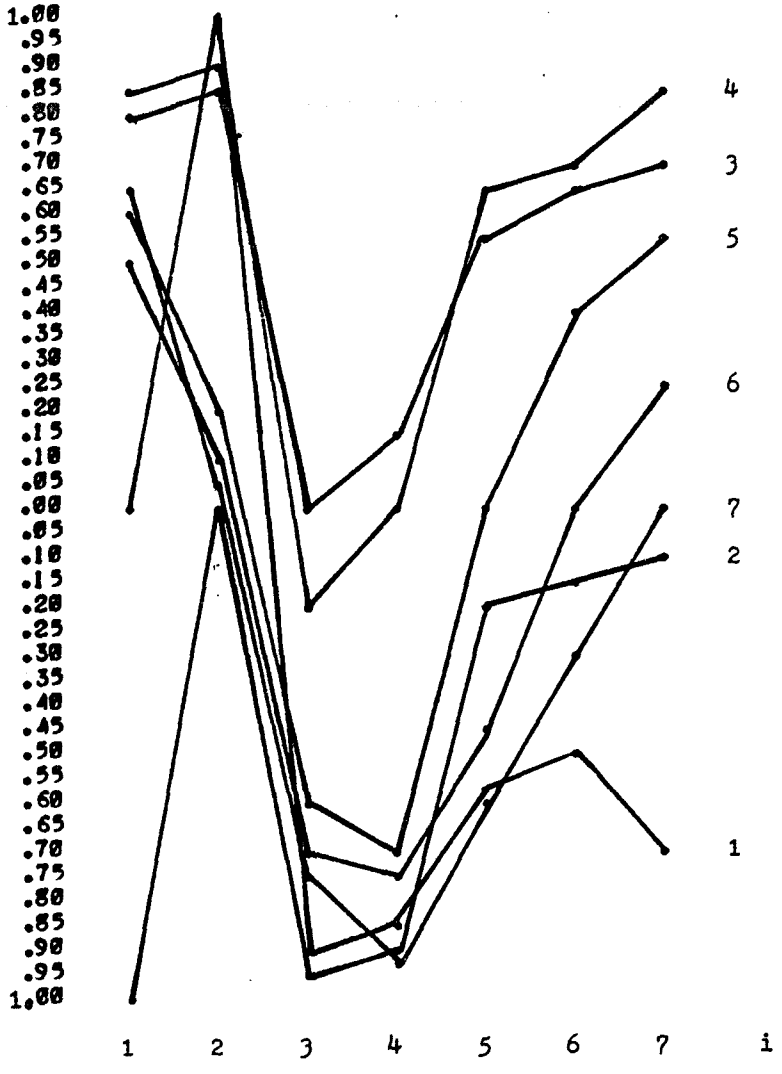
CONDITION: RECALL 4. SUBJECT: A.R. $\underline{TAU}_{ij}$. FIG.20. p.2.

109 MSEC. LETTER C.



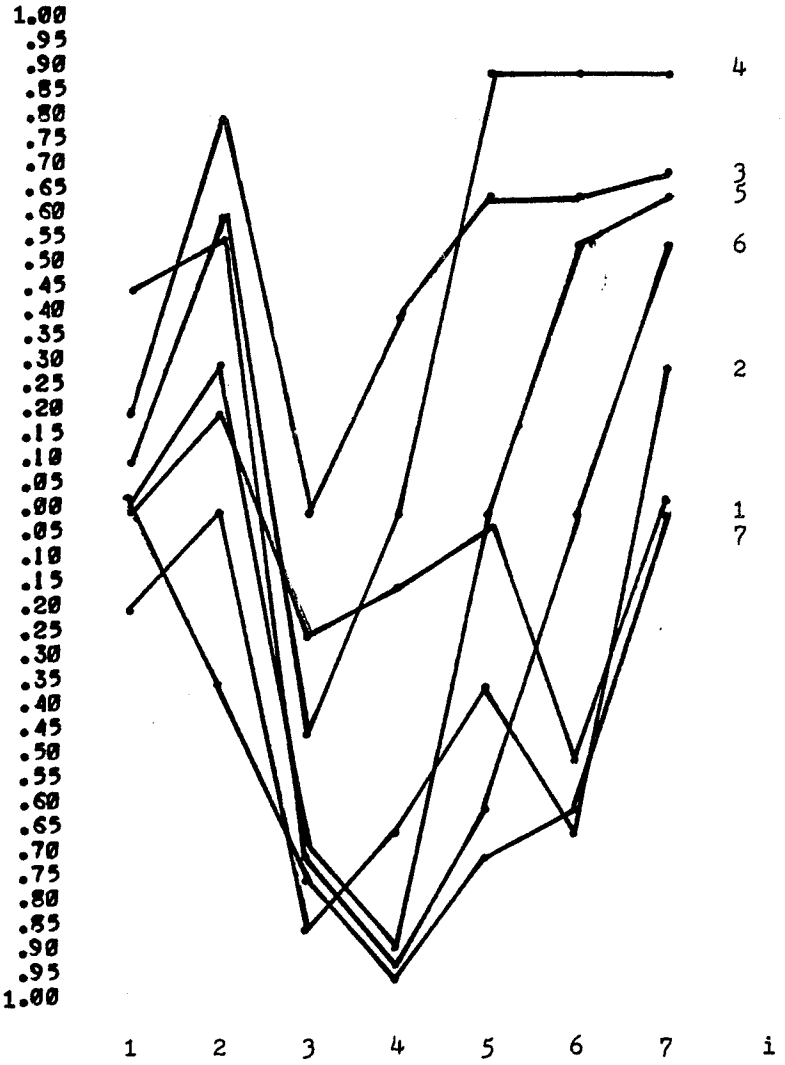
CONDITION : RECALL 4. SUBJECT: A.R. $\underline{TAU}_{ij}$. FIG.20. p.3.

144 MSEC. LETTER C.



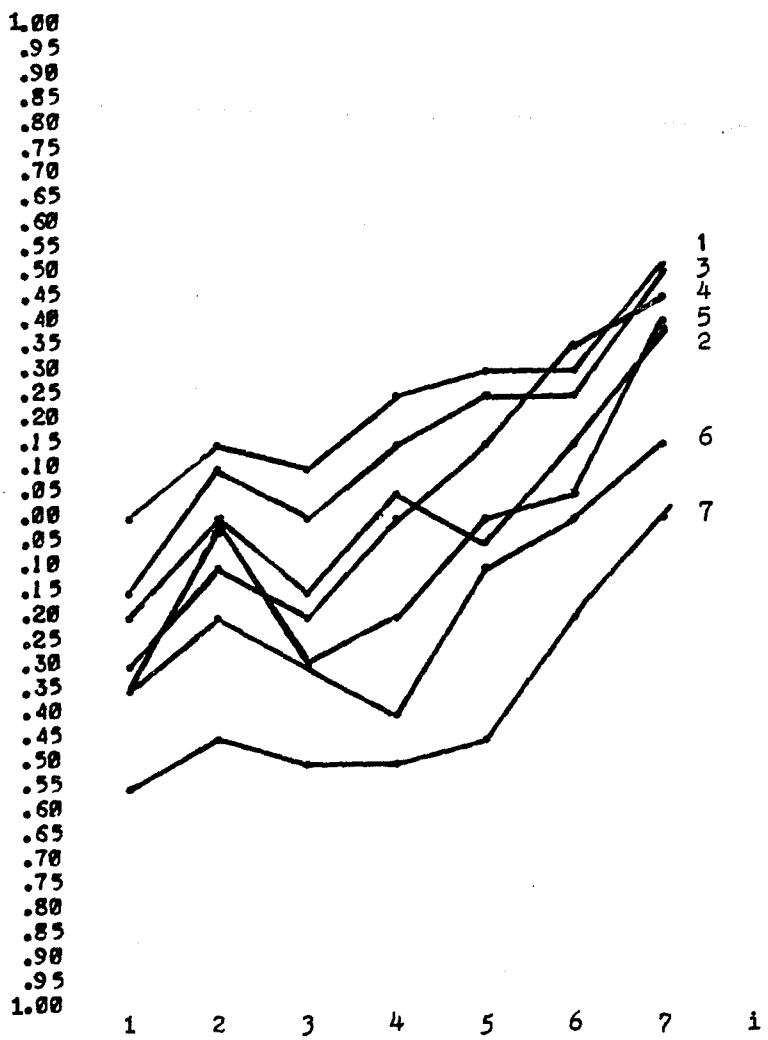
CONDITION : RECALL 4. SUBJECT : A.R. $\underline{TAU}_{ij}$. FIG.20. p.4.

214 MSEC. LETTER C.



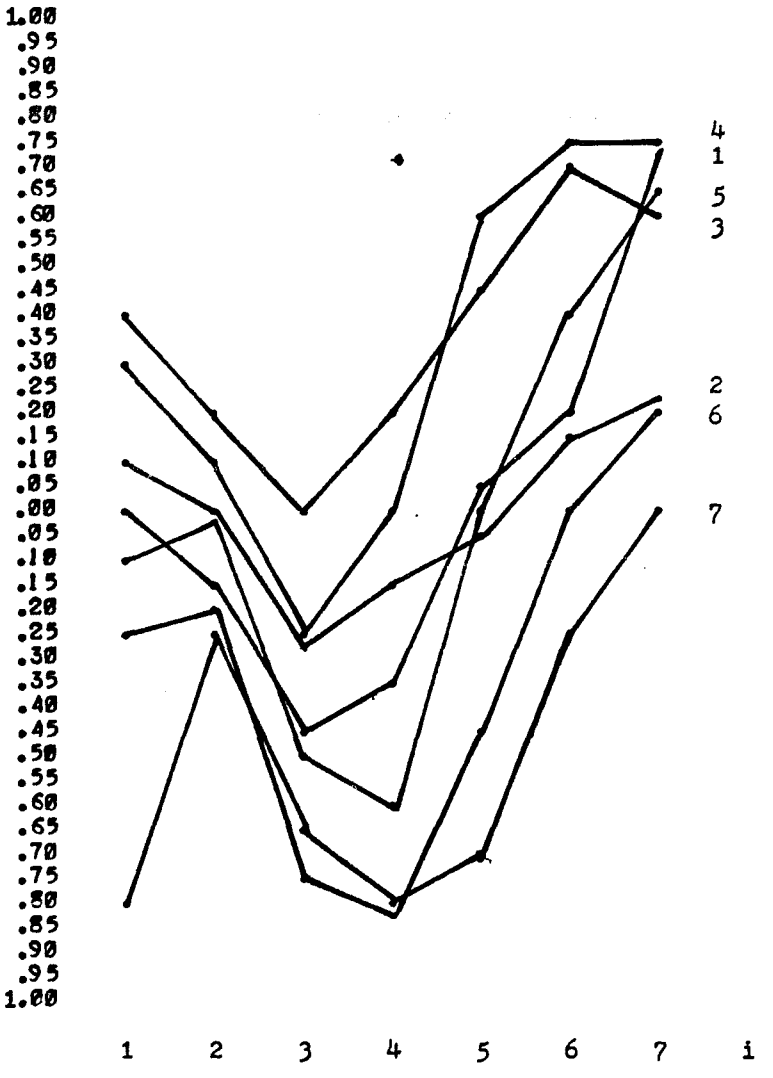
CONDITION : RECALL 4. SUBJECT: AR. $\underline{TAU}_{ij}$. FIG.20, p.5.

75 MSEC. ARROW.

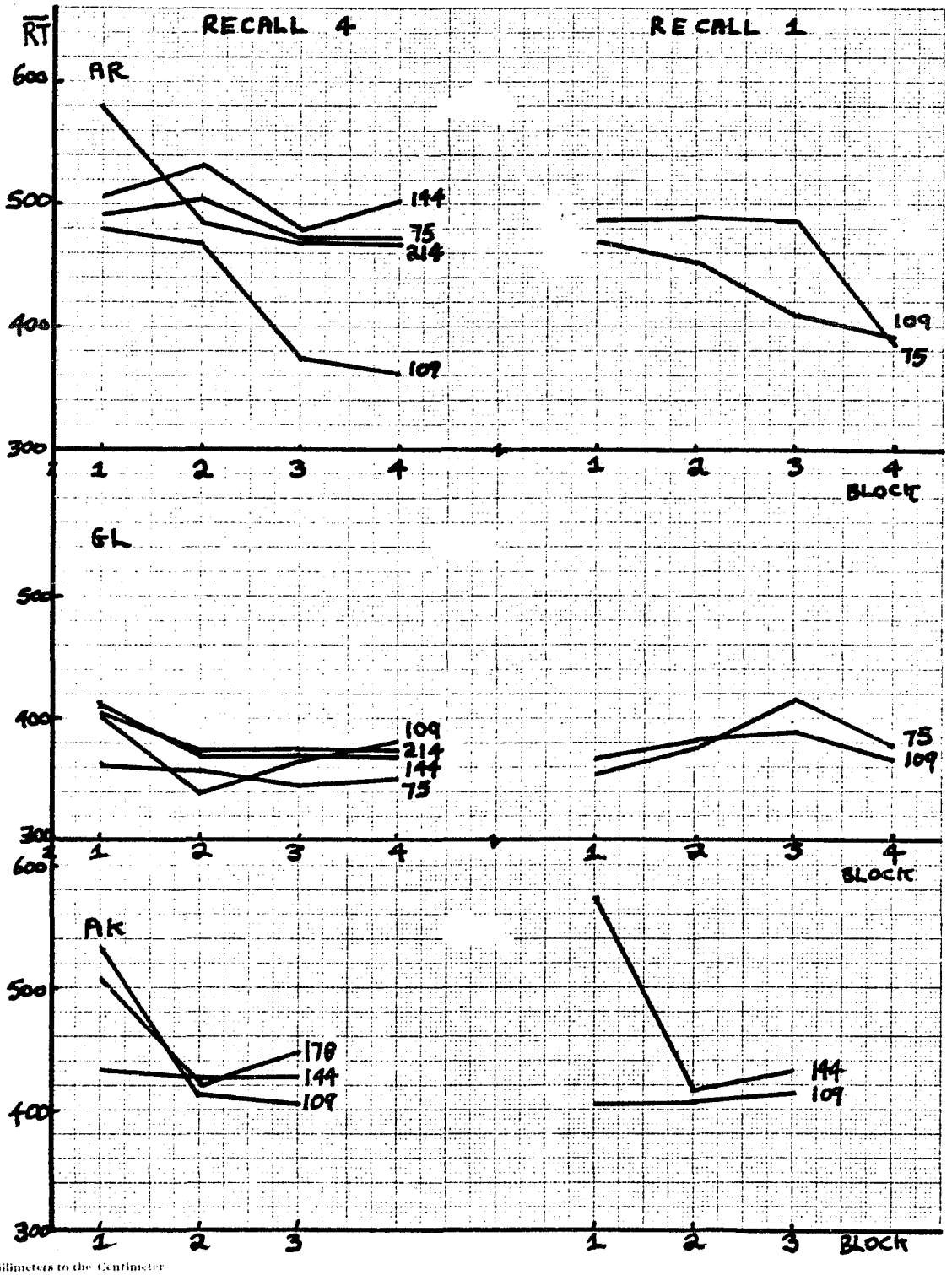


CONDITION : RECALL 4 SUBJECT: A.R. TAU_{ij} FIG.20 p. 6.

109 MSEC. ARROW

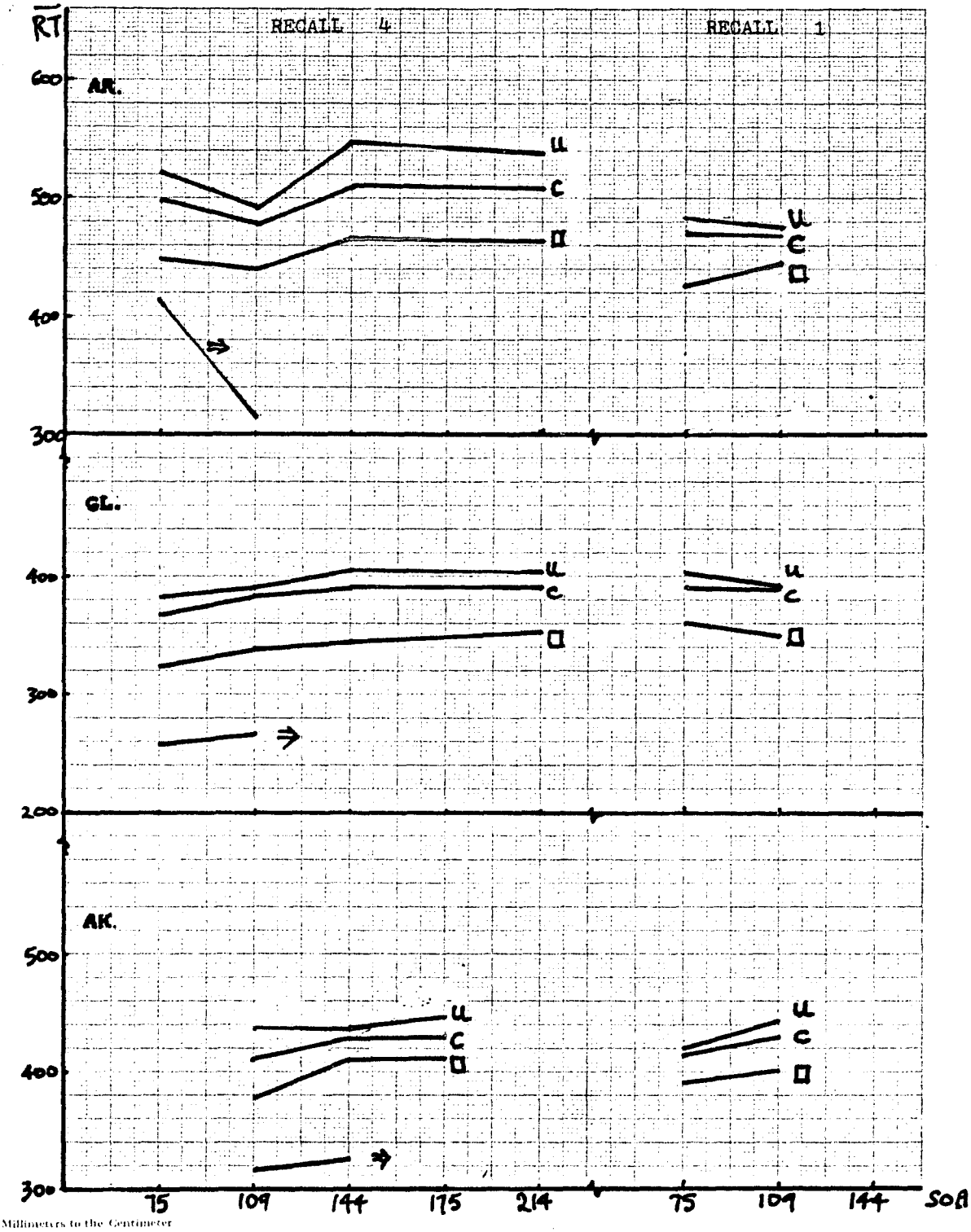


MEAN REACTION TIME BY BLOCK OF 300 TRIALS. FIG. 21



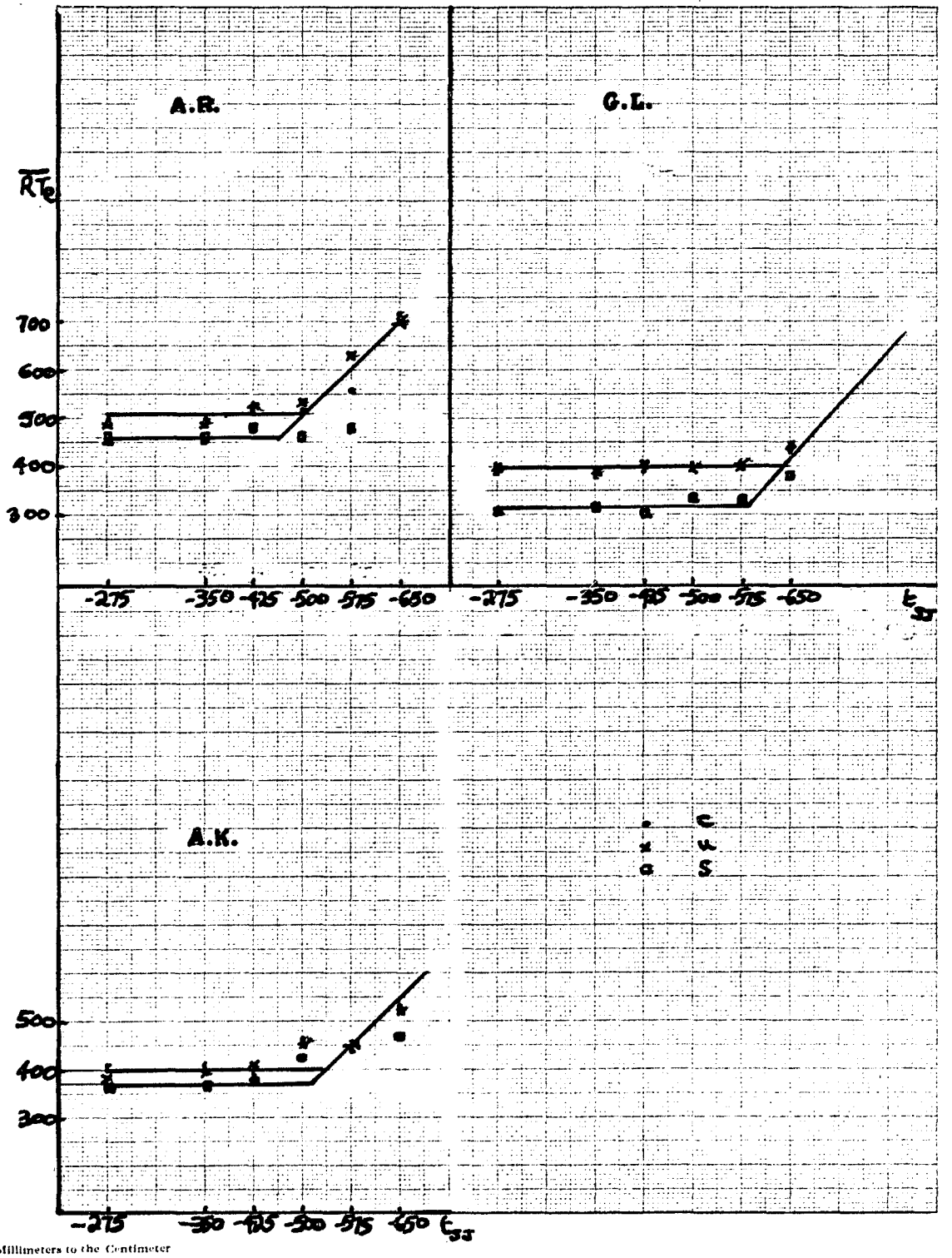
10 Millimeters to the Centimeter

MEAN REACTION TIME, CORRECTED FOR SESSION. FIG. 2a



(1) Millimeters to the Centimeter

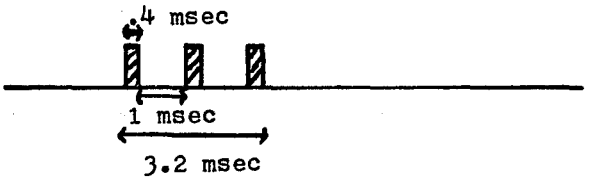
$\overline{RT}$ by GROUPED $t_{e.}$ IN RECALL 4. FIG. 23



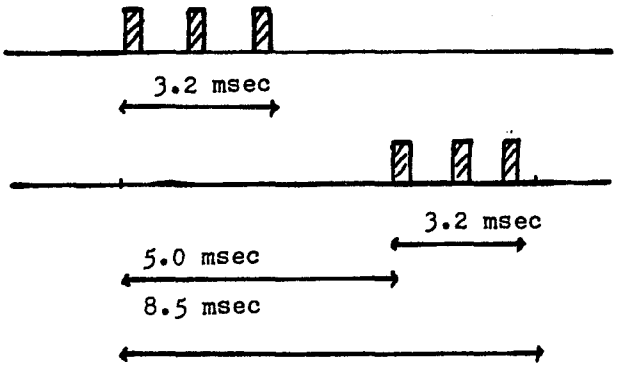
10 Millimeters to the Centimeter

STIMULUS TIMING. FIG. 24

Panel A: Presentation of a single character.

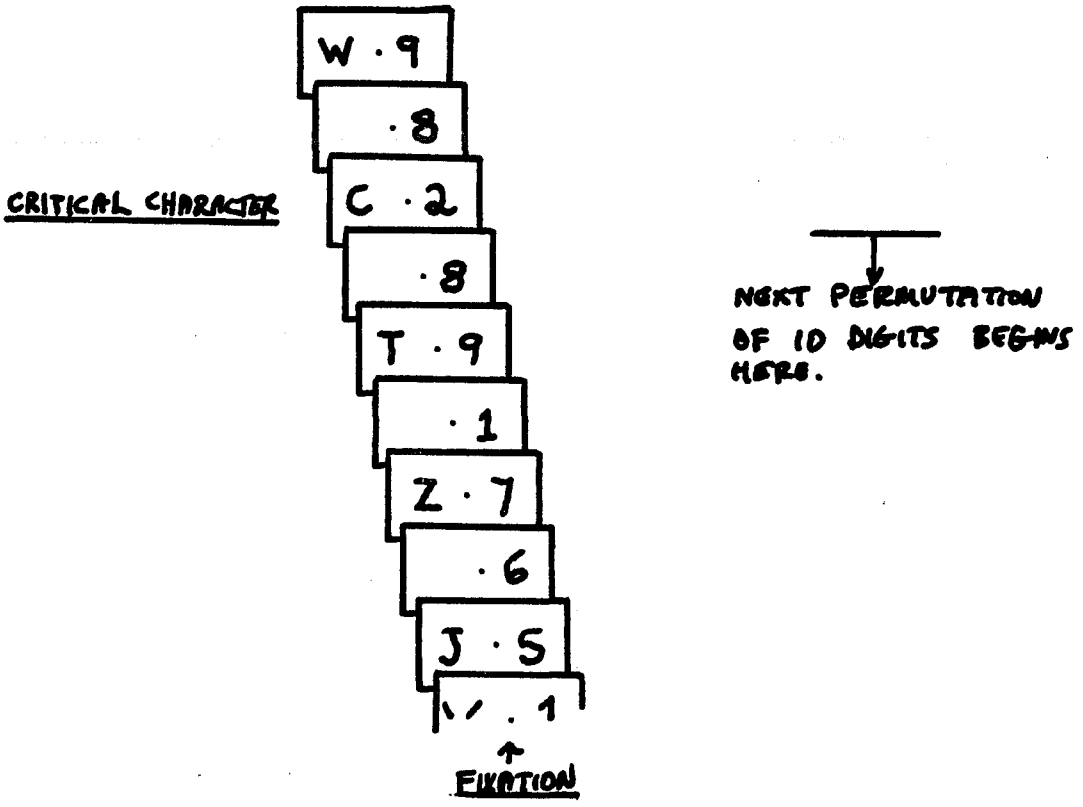


Panel B: Presentation of two 'simultaneous' characters.

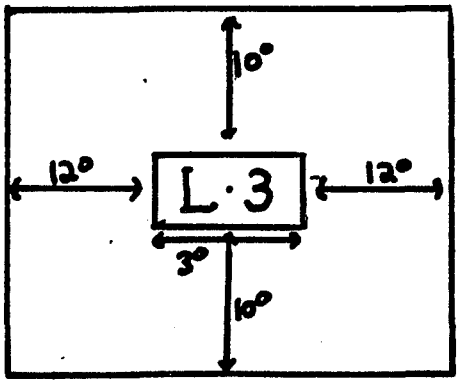


DISPLAY SEQUENCE FIG. 25

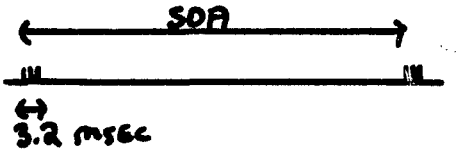
The Figure represents a condition such as 109 msec, in which letter SOA = twice number SOA. S is searching for the letter C. He reports the number appearing simultaneous with the C.



DISPLAY IN DEGREES OF VISUAL ANGLE.



DISPLAY TIMING.



INDEXING OF DIGIT POSITIONS

KEY: L - LETTER STREAM WITH SOA = 214 msec
D_1 - DIGIT STREAM WITH SOA = 214 msec
D_2 - DIGIT STREAM WITH SOA = 75 msec

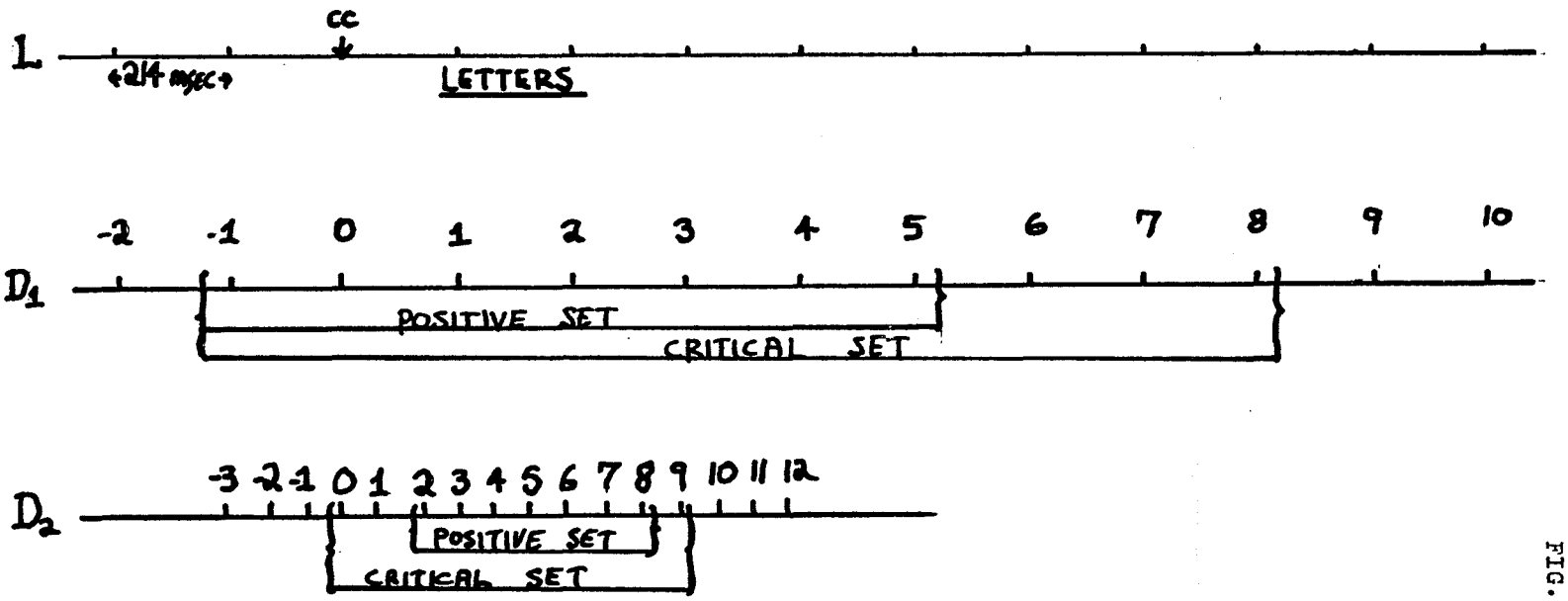


FIG. 26

Photographs of the Stimuli

FIG.27



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GLOSSARY

A: Arrow: a CC. Also, A is the Set of Attended to Positions in Model 1.

A(t): Amount of Attention paid at time t, in Model 4.

b: Number of positions attended to in Model 2.

c: A particular CC.

CC: Critical Character.

C_{ij}: Concordance of stimuli i and j.

$\bar{C}$: Mean C_{ij}.

C: Letter C: a CC.

Cov_{ij}: Covariance of stimuli i and j.

D(x,y): The Difference between x and y. A particular definition of D is given for each use.

d: Digit SOA.

E(X): Expectation (mean) of X.

EP: Earliest Position: EP= Min (R).

F: Psychophysical function in the Introduction. Also, F is the Strength function, in Model 4.

f_i: Switching distribution, in Model 1.

G: Guessing function, in Models 1 and 2. G is also the Arrival time function, in Model 4.

g_i: Amount of guessing in position i (as a proportion).

H: Saturation function, in Model 4. H is also the Permutation function, in Model 1.

i: Position in the Positive Set.

i_o: The position of the positive set relative to the CC.

ISI: Inter-stimulus interval.

L_c: Identification latency of c (which is a CC).

M_j: Mean stimulus reported in response position j.

M^+_j: M_j averaged over positive set positions only.

: Grand Mean

$\underline{N}$: Number of trials used in data analysis, in Results.

N(x): Number of trials in which event x occurred.

N(M,V): Normal Distribution with mean M, variance V.

N(1): Normal $N(\bar{T},Var(T))$ fit to Response position 1 data P_{i1}.

NP: Noted Position = i, if R=(i,j,k,l).

P: Proportion (of data) or Probability (in Model): P(X)=P(event X).

P': P, analyzed in Model 2.

p": P, analyzed in Model 3.

$\underline{P}$: Cumulated P.

P_i: P(Report digit from position i) = P(Stimulus i).

$P_i(j)$: P(Stimulus i and position estimate j), in Recall 1.

P_{ij}: P(Stimulus i in response position j).

$P_{i,j}$: P(Stimulus i and stimulus j).

$P_{i<j}$: P(Stimulus i and stimulus j, with i reported before j in R.

$\bar{P}_i$: Mean stimulus reported = $_i i.P_i$.

$\bar{P}_j(j)$: Mean stimulus reported with position estimate j.

P(+): P(Stimulus reported from +ve set).

PE: Position Estimate in Recall 1.

R: Digit response, coded into positive set positions. R=(i,j,k,l).

R*: R*= i,j,k,l .

R'*: Set of unguessed responses in Model 2.

$\underline{R}$: Matrix of stimulus-response probabilities P_{ij}.

R_o: Residual RT in the Latency models.

RT: Reaction Time.

$r_{x,y}$: Correlation of x and y.

S: An outline square: a CC.

$\underline{S}$: Subject.

s: Forms plural (e.g.: RTs): s forms genitive.

S_d: Switch time in Latency Model 2.

S.D. or s.d.: standard deviation.

SJ: Simultaneity Judgement.

SOA: Stimulus onset asynchrony: The digit SOA = d.

T: Time of the Attention switch ($T=S_d + L_d$ in latency Model 2.

T_o: Time of Attention switch away from the digit stream.

T_{EP}: T measured from EP.

T_{NP}: T measured from NP.

t_i: Onset time of stimulus i.

T(X): Time of event X (e.g., $t(NP) = d.(NP=i_o)$).

Tau_{ij}: Kendal's Tau, computed for stimuli i and j.

$Tau_{i\bar{j}}$: Tau_{ij} averaged over j.

TOJ: Temporal Order Judgement.

U: Letter U: a CC.

V(i): Position preference for position i in Model 4.

V'_c and V''_c: are variable components of latency in the second latency model.

v_c: A fixed component of latency in the second latency model.

Var(X): The variance of X.

W: The perceived stimuli in Model 1, in order: W* is the set of such.

Additional Symbols

$\#_k(X)$: The first k positions in the vector X: $(\#_2(R)=(i,j))$.

X: Predicted X value (usually a probability).

$\underline{P}$: Cumulated P value.

$\overline{X}$: Mean of X.

X|Y: X conditioned on Y.

X*: The set of elements obtained from a vector X: (R* = i,j,k,l).

[x]: The integer part of x.