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ENCODING OF FREQUENCY OF OCCURRENCE, TEMPORAL ORDER, AND SPATIAL LOCATION INFORMATION BY CLOSED HEAD INJURED AND ELDERLY SUBJECTS: IS IT AUTOMATIC?

City University of New York PH.D. 1985

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by

ELIYAHU VAKIL

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

1985

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

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Abstract

by

Eliyahu Vakil

Advisor: Professor J. R. Tweedy

Recently several theories have attempted to explain amnesia in terms of a distinction in contemporary memory theory between encoding processes that are automatic (use minimal attention) and those that are effortful (require attention). Evidence has been obtained which indicates that for normal subjects, information regarding the temporal or spatial conditions of an item, or its frequency of occurrence, accumulates in memory via automatic processes which are unaffected by age, education, or instructional variables.

Memory for these different types of information was investigated in young adults recovering from closed head injuries (CHI), normal elderly and young adult controls. Every subject engaged in temporal, spatial, and frequency of occurrence judgment tasks applied to items previously presented as members of a single list.

Three hypotheses derived from Hasher and Zacks' (1979) model were evaluated. First, there should not be a difference between groups on any of the three tests.

Second, performance on judgment tasks should not be related to performance on effortful memory tasks. Third, being informed about the nature of the task requirements should not improve performance.

This paradigm also allows study of the relationships in performance between these three putative automatic tasks. The control and CHI groups showed a high correlation between performance on temporal and spatial tasks. The eldrly group showed a significant correlation between the temporal and the frequency tasks.

Analyzing the variability of each subject's judgment revealed that, relative to young controls, performance on the frequency and temporal tasks was impaired for CHI and elderly groups. When the subjects were given more than two alternatives in the spatial task, the CHI group also showed performance decrements. Being informed about the task never improved performance. In some cases it impaired judgment accuracy. These results raise serious questions concerning the validity of Hasher and Zacks' (1979) contention that performance on these judgment tasks is mediated by automatic processes.

This dissertation is dedicated to my wife, Tami, for her love and support through rough times, and to my daughters, Hila and Maya for their understanding and patience.

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Recently psychological theorists have distinguished between two basic types of mental operations: automatic and non-automatic processing (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). "Automatic" processes are defined as those requiring minimal attention and awareness, while non-automatic processes require the awareness, attention, and control of the individual. Non-automatic processes have been given different names: "conscious," (Posner & Snyder, 1975); "controlled," (Shiffrin & Schneider, 1977); and "effortful," (Hasher & Zacks, 1979). Each one of these names reflects a different aspect of the automatic - non-automatic dichotomy.

According to Posner and Snyder (1975) automatic processes occur: a) rapidly, b) without intention, c) without necessarily giving rise to awareness, and d) without interfering with other processes. Shiffrin and Schneider (1977) postulated some additional characteristics of the automatic processes: a) when activated, they run to completion, b) they are difficult to suppress once aroused, c) they do not on their own result in the storage of new information, and d) under certain circumstances, they improve with practice. Kellogg (1980) characterized automatic processes as a) failing to cause interference, b) occurring without intention, c) unconscious, and d) inaccessible to introspection.

Hasher and Zacks (1979) introduced a new distinction within the category of automatic processes. They characterize the automatic processes discussed so far as "learned." These processes require massive amounts of practice to become automatic. The other type of automatic processes they call "innate" or "inherited." These processes cannot be improved by additional practice or feedback, do not require intention or awareness to be performed, and can not be inhibited willfully. They require minimal amounts of attentional capacity and, in contrast to Kellogg, and Shiffrin and Schneider, Hasher and Zacks propose that knowledge gained from these automatic processes is accessible to consciousness and can be used. These processes are assumed to be part of the very early repertoire of the newborn as well as the elderly, and are held to be unaffected by differences in alertness, motivation, education, experience, culture and intelligence. Finally, these processes are said to be equally effective under conditions of incidental and intentional learning. According to Hasher and Zacks, being informed about the nature of the task will not improve performance.

The innate type of automatic processes obviously differ from the learned type in several ways. Unlike learned processes, they do not require practice, since they are available from birth. While learned automatic processes may show individual differences, the innate type do not. Learned processes do not, on their own, result in the storage of new information, however the information acquired through the mechanism of the innate automatic processes are always available and accessible.

Hasher and Zacks (1979) see automatic and effortful processes as two ends of a continuum. The learned type is on this continuum, near the automatic end.

Effortful processes are the mirror image of the automatic processes. According to Posner and Snyder (1975), these conscious mechanisms a) are slow acting, b) can not operate without intention and conscious awareness, and c) inhibit the retrieval of unrelated information.

Hasher and Zacks 1979) suggest that the automatic processes are involved in the input stage of the information encoding. In contrast, Shiffrin and Schneider's model (1977) proposes that automatic processes are involved in each step of information processing from the initial encoding of the input to the final response output stage. The work on semantic activation by Posner and Snyder (1975) and Neely (1977) suggests that at least some components of the retrieval stage are automatic. Thus, compromised automatic memory functions might produce either encoding or retrieval deficits.

Failure of "Effortful" Processing

Craik and Lockhart (1972) proposed the "levels of processing" theory, which claims that deeper, more meaningful analyses of perceived events are associated with more durable memory traces. Butters and Cermak (1975) extended this theory to explain amnesia as a failure to employ "deep" semantic processes, which normal people use spontaneously. In other words, amnesics do not spontaneously use, or are not able to use, elaborative, organizational, effortful processes. (For a discussion of this distinction see Burke & Light, 1981). Along the same lines, Jacoby (1982) proposed that the deficit in memory function seen in Korsakoff patients is due to a lack of distinctiveness in the encoded information. Korsakoff patients process information in a more routine and automatic fashion than do normals. This type of encoding does not include sufficient information to allow the event to be later retrieved. Kinsbourne and Wood (1982) make a very similar proposal. They view amnesics as processing information automatically and not in an actively attentive fashion. They point out that amnesics perform relatively better on recent information, and suggest that its recency make this information distinctive for the amnesic.

Failure of "Automatic" Processing

Huppert and Piercy (1976) attribute the memory deficits of amnesics to their failure to establish an adequate temporo-spatial context for the material, a process which is normally an automatic function. They showed that amnesics' judgments of recency are affected by the item's frequency of occurrence (Huppert & Piercy, 1978). Subjects' judgments were consistent with a simple trace-strength model. An item that appeared more frequently was judged as more recent, and vice versa. Normal subjects apparently have available to them, beyond trace strength, specific temporal and frequency information that allows them to differentiate effectively between recency and frequency.

Hirst (1982) in his review on amnesia reaches the conclusion that context theory best accounts for the features of the amnesic syndrome. He suggests that in the amnesic the breakdown in the automatic encoding of context will not abolish the process completely, but rather requires effortful allocation of attention to processes done automatically in normals.

In a more elaborate version of the theory, Hirst and Volpe (1984) point out that, under normal circumstances, a person would intentionally (effortfully) encode a certain event while the context of that event is encoded automatically. Later on, this contextual information serves as an important retrieval cue. Effortful and automatic encoding can occur simultaneously because, by definition, automatic processes do not interfere with effortful ones. However, in the case of amnesia, the automatic processes are posited to become effortful, and the amnesic is not able to encode simultaneously the event and its context. In the case when the event is at focus, the context would not be available to help retrieval; if the context is at focus, the event itself will not be encoded. The Hirst and Volpe model includes effort and context concepts, and accounts for many of the research findings on amnesics.

In summary, some theorists see amnesia as a loss of the ability to use effortful processes (Butters & Cermak, 1975). Others see amnesia as an inability to utilize automatic processes (Huppert & Piercy, 1978). More recently, Hirst (1982) explained amnesia as the consequence of effortful processing of information that normally is processed automatically.

In the next section the literature on normal memory is evaluated in terms of the support it provides for

Hasher and Zack's (1979) model which predicts that frequency of occurrence, temporal order, and spatial location are encoded automatically.

Automaticity and Young Normals

Frequency of occurrence. Many studies show that adults are sensitive to the frequency of occurrence of an event. Hasher and Zacks (1979), and Attig and Hasher (1980) show that not only adults, but also children and the elderly can accurately estimate the frequency with which words occur in a list. They interpet this lack of a developmental accurach trend as support for the view that frequency is encoded automatically. They also showed that informing the subjects about the type of memory test they would encounter did not improve the performance of either young or old subjects. Alba, Chromiak, Attig and Hasher (1980) show that not only are the frequency of individual events encoded automatically, but also the frequency of category exemplars are accurately judged, even under incidental learning conditions.

Zacks, Hasher and Sanft (1982) showed that other criteria of automaticity were confirmed in judging frequency of occurrence of an event. In their experiment, subjects showed neither improvement with practice nor impairment with competing demands, and individual differences were minimal. These results contrast with the findings of free recall studies, where effortful processing is presumably required.

<u>Temporal order</u>. The establishment of the temporal order in which events occur is an important component of normal memory functioning. This information reduces intrusion errors on succeeding lists, and allows the subject to differentiate between events on the basis of their recency. According to Hasher and Zacks (1979), the ability to encode temporal order is another type of contextual information which is processed automatically. Toglia and Kimble (1976) showed that instructing the subjects about the nature of the required temporal judgment failed to enhance their performance. However, other criteria of automaticity, when tested by Zacks, Hasher and Alba (1984), were not fulfilled. Their subjects' judgment of temporal order improved with practice. Moreover, reliable individual differences were observed. Subject's performance levels relative to others in their group remained stable across lists, and subjects with higher grade point averages performed better than those with lower levels of academic achievement. These results suggest that a modification of the Hasher and Zacks model is needed.

Spatial location. Spatial location information is also considered by Hasher and Zacks (1979) to be encoded automatically. The support for this view derives from findings that show that there is no difference between intentional and incidental recall of the position of items, nor any trade-off between item recall and location recall in the two conditions. Also, no difference was found between intentional or incidental recall of the location of pictures, at any age from five years to maturity (Von Wright, Gebhard and Karttuven, 1975). Mandler, Seegmiller and Day (1977) found that adults were more accurate in their spatial location judgments than were children. However, since no age-related interaction was significant, this indicated a similarity of functioning in the different age groups. Park and Mason (1982) reported a more complex set of findings. They did not find a trade-off between the recall of items and their spatial position in the intentional or incidental conditions. Unexpectedly, subjects performed better for the intentional condition than for the incidental.

These distinctions between automatic and effortful processes, which provide a framework for research in mainstream cognitive psychology, have also appeared in the amnesic literature. The following section discusses the ability of brain injured patients and normal elderly subjects to process information automatically and evaluates their ability to automatically encode information about the frequency of occurrence of events, their temporal order, and their spatial location.

The Automatic/Effortful Distinction and Memory: Function in the Head-Injured

Brain injury is not a single, unified condition. Symptoms following brain injury vary depending on the location and severity of the injury, the subject's premorbid personality, and many other factors. Because such a broad range of functions have been postulated to be automatic, a question arises as to whether they all of the same type.

Following left hemisphere damage, performance is usually deficient in the verbal domain. In spite of general loss of verbal abilities, one type of speech that is often preserved is automatic speech (Luria, Symernitskaya & Tubylevich, 1970). A patient who is not able to voluntarily express a word or a sentence may do so automatically if the right natural trigger is presented. Chusid and McDonald (1967) also found that many aphasic patients have preserved automatic speech (e.g., saying the alphabet, counting, and reciting well-rehearsed prayers). According to Lezak (1983), these verbal automatisms are impaired only with very severe and diffuse cerebral damage.

Symernitskaya (1974) compared the writing ability of patients with right and left hemisphere lesions. As expected, patients with left lesions did poorer. However, patients with right hemisphere damage did poorer than those with left hemisphere damage when asked to sign their names. On the basis of her findings, Symnernitskaya concluded that verbal function in general is controlled by the left hemisphere, while automatic graphical functions are controlled by the right hemisphere.

Another automatic skill often unimpaired following head injury is word association. Appelbaum (1960) showed that head injured patients perform as well as normal controls in word association tests. In this test the subject is instructed to utter the first word that comes to mind to each stimulus word. On the reproduction part of the test, the subject is required to name the same word that was reported to the stimulus words on its originally presentaion. Appelbaum concluded that this is accomplished through automatic or passive mechanisms which are not impaired after head injury, and that word association is therefore not useful as a diagnostic test.

Another use of the concept automatic processing appears in studies of "semantic activation," e.g., Posner and Snyder (1975). Semantic priming can automatically produce both facilitation and inhibition effects. The most common inhibitory example is the "Stroop effect," in which a color's name is written in ink of a different color, and the subject has to read lists of the words or name the colors as fast as possible. Typically, it takes longer to name colors when the ink color and the word do not match. One of the explanations of this inhibitory effect is that within this task two responses (the color and the name) automatically compete with each other for access to the output mechanism. Patients with frontal lesions find the Stroop task particularly difficult (Lezak, 1983). This suggests that while the semantic system is automatically activated, its control is mediated by the frontal lobes.

Automatic Encoding in Neurologically Impaired Populations

In this section the three types of information considered by Hasher and Zacks (1979) to be encoded automatically are discussed. Hasher and Zacks (1979) commented on their finding that one elderly patient they tested showed a loss of automatic functions. "Automatic processes should be functioning under all conditions of consciousness, except perhaps where brain damage has occurred" (p. 372). Thus, even Hasher and Zacks allow for the possibility that head injury might interfere with automatic processes.

Frequency of occurrence. Grober (1984) found that aphasic patients did not differ from control subjects in their ability to correctly judge the frequency of presentation of different items. Unmedicated Parkinson's disease patients are apparently as sensitive as normals to an item's frequency of occurrence (Weingartner, Burns, Diebel & LeWitt, 1984).

In contrast, Huppert and Piercy (1978) found that Korsakoff patients performed more poorly than controls on a task that combined frequency of occurrence judgments and recency judgments. Their patients could not discriminate between the effect of repeated presentation and recent presentation. It seems that the ability to automatically encode frequency of occurrence information is not invariably preserved in patients with brain damage.

Temporal order. Hammond (1982) concluded on the basis of his review of the literature that left-sided brain damage is typically followed by a deficit in the perception of temporal order. William and Zangwill (1950) proposed a modified version of the context theory which they called the "temporal order hypothesis." According to this model, events themselves may be available to the amnesic, but not the temporal relations among events. Huppert and Piercy (1978) found that Korsakoff patients were unable to discriminate between the effect of repeated presentation and recent presentation (see previous section).

Hirst and Volpe (1982) reported that amnesics (with various types of brain damage) showed a defective judgment of temporal order. In one experiment, the subjects had to judge the order of words presented in a list. In another, the subjects had to judge the recency of new events. In both experiments, recognition of the word or the events was above chance, but the temporal order judgment on the recognized items was not.

The case of temporal order seems clearer than the case of frequency. Many types of brain injury impair the ability of the patient to judge temporal order.

Spatial location. Visuo-spatial disorders take many forms: impairment of perception of depth, form, size, and positional orientation. The brain injury causing these deficits is usually in the right hemisphere, specifically in the parieto-occipital area

(Hecaen & Albert, 1978).

First and Volpe (1984) found that patients who suffered global amnesia (from hypoxia, ischemia, or aneurysm) were not able to improve their spatial encoding ability with instruction, whereas normal adults could. These results suggest that the encoding of spatial location is not an automatic process in normal subjects.

Smith and Milner (1981) tested patients with unilateral right and left temporal lobe lesions, and also the patient H.M., who has bi-temporal lobe lesions, and normal subjects. These subjects were asked to learn the prices of items arranged in an array. The test involved immediate and delayed recall of the prices (intentional learning), and also recall of the spatial arrangement of the items (incidental learning). Right-temporal lesioned patients did poorer than normals on the incidental recall of spatial arrangement, but the left-temporal patients performed as well as normals. On the delayed recall of the prices, right-temporal patients did better than left-temporal patients. H.M. was inferior to unilateral-lesioned patients. Smith and Milner (1981) interpret these results as suggesting that right-temporal lesions cause impairment in the automatic encoding of spatial information. Grober's (1984) findings support this interpretation. Her aphasic patients (usually with left hemisphere lesions) showed a normal performance on a spatial memory task.

Automaticity and the Elderly

One of Hasher and Zacks' (1979) criteria for automaticity is that automatic processes do not change with age. Burke and Light (1981) regard this proposal as unwarranted. Their review suggests that retrieval of information from semantic memory (e.g., on word fluency or word association tasks) slows down with age. They speculate that this may be due to the use of intentional processes instead of automatic ones. Studies using Stroop stimuli also found that elderly subjects were slower than young adults in naming the ink color of words which refer to a different color. This suggests that the automatic activation of colors by their names persists in the elderly, and that they have difficulty inhibiting inappropriate response tendencies that are activated.

Frequency of Occurrence. Hasher and Zacks (1979) reported that judged frequency increased with the true frequency increment for both young and elderly subjects. For the elderly it did so at a slower rate, particularly at the high frequencies. Identical results were obtained under intentional and incidental learning conditions. The less accurate judgment of the elderly subjects was attributed to their being more conservative or cautious in their judgment--a response bias interpretation. This assumption was confirmed by Attig and Hasher (1980). When the response bias was eliminated by using a two alternative forced-choice paradigm, neither age nor instructional condition had an effect. Kausler and Puckett (1980) replicated and extended these results and confirmed the predictions of Hasher and Zacks' model with regard to the automatic encoding of frequency of occurrence information. Similarly, when Attig (1981) mathematically corrected for response bias, no age or instruction effect was found. However, Zelinski and Light (quoted in Burke & Light, 1981) found a decline in the accuracy of frequency judgments with age, even after correcting for bias. Burke and Light (1981) are critical of the procedure of statistically correcting for response-bias. They claim that there is insufficient evidence to justify such corrections, and that the forced-choice procedures lead to ceiling effects, and therefore are insensitive to age differences.

Temporal order. On a task in which young and old adults were asked to judge which one out of two pictures appeared first, no significant differences were found between the two groups (Perlmutter, Metzger, Nezworski &

Miller, 1980). In contrast, McCormack (1982) found that young adults showed a better ability to judge the temporal position of the words than the elderly. The subjects were asked to judge the tenth of the list in which they had heard the word. The age effect obtained was attributed by McCormack to the response bias of the elderly, who tended to avoid assigning words to the beginning or to the end of the list. When an adjusted index was used, it disappeared. As expected of an automatic process, knowing in advance the nature of the task did not improve performance for either young or elderly subjects.

Spatial location. McCormack (1982) developed two variations of a spatial task, in which the subjects had to judge the quadrant in which each one of 64 nouns was originally presented. He found no age difference and no differences in performance under intentional and incidental learning conditions for either young or elderly subjects. Similar results were observed by Park, Puglisi and Lutz (1982). These findings support Hasher and Zacks' model. However, other findings do not. Perlmutter et al. (1980) asked their subjects to study the location of different buildings drawn on a map. Then the subjects were given the same map without the drawing of the building and their task was to indicate the original location of each building. The results showed that elderly subjects performed poorer than the young adults.

Moor, Richards and Hood (1984) analyzed the scores of 284 subjects (age range 19 to 76 years) on the Tactual Performance Test from the Halstead Neuropsychological Test Battery. In this test each participant, blindfolded, is asked to place blocks with different shapes into the appropriate space. After removing the blindfold the participants were asked to draw the shape of each block at the right spatial position. Age differences were observed for shape recall and location recall, contrary to predictions derived from Hasher and Zacks' model.

Proposal and Hypothesis

The performance of normal young adults, the elderly, and the closed head injured (CHI) patients is assessed on three tasks tapping putatively automatic memory function: judgments of frequency of occurrence, temporal order, and spatial location. This experimnt allows within-subjects comparisons on the three judgment tasks. Other measures of the intelligence and memory capacity of the CHI subjects are available from an evaluation done upon admission to the Head Trauma Program of the N.Y.U. Medical Center. These scores are correlated with data from the experiment.

Several hypotheses are advanced about performance on automatic memory tasks.

(1) Since it has been proposed that innate automatic processes are not influenced by subject variables such as age and intelligence, there should be no difference between the groups on any of the three judgment tasks.

(2) Since innate automatic processes are posited not to require the allocation of attention (Hasher & Zacks, 1979), performance on memory tests which are considered effortful (e.g., the Logical Memory and Associated Learning subtests from the Wechsler Memory Scale,

Wechsler, 1945; the Rey Auditory-Verbal Learning Test, Lezak, 1983) should be unrelated to performance on these judgment tasks.

(3) Since automatic processes are thought not to be effected by task variables such as instructions and practice, there should be no difference between performance in the informed and uninformed conditions on any of the judgment tasks for any subject group.

(4) Huppert and Piercy's (1978) findings that amnesics have difficulty differentiating between recency and frequency judgment is contrary to Hasher and Zacks' (1979) assumption of no individual differences on these tasks. Huppert and Piercy would predict that the CHI and the elderly groups would judge the recently-presented items as more frequent than items presented equally often but earlier in the list. Hasher and Zacks would predict no such effect of recency on frequency judgments.

Method

Two versions of the experiment (1A and 1B) are described in the following section.

Experiment 1A

Subjects. Twenty adults, fourteen males and six females, who had suffered blunt head trauma with loss of consciousness were tested. All attended the outpatient rehabilitation program at the Institute of Rehabilitation Medicine (IRM) of the New York University Medical Center, and were more than one year post-injury. The age range of these patients was 18 to 47 years. None had a language-based deficit sufficient to interfere with performance on the task. The control group consisted of twenty volunteers, eleven males and nine female undergraduate students at Queens College with an age range of 18 to 43 years.

Stimuli. Two sets of 52 high frequency words from Thorndike-Lorge (1944) normes were used to construct four versions of a 72-item presentation list. Each list was arranged as follows: The initial and final four items were fillers used to counteract primary and recency artifacts. The body of the list consisted of 64 items. Within each 16-item quarter of the list, six words to be given as temporal and spatial tests were presented once only. In the remaining ten positions four words were devoted to the frequency of occurrence task, either one, two, three, or four times. (See Figures 1 and 2 for the structure of the acquisition list and the testing sequence.)

Procedure. Subjects were tested individually. Each watched the sequence of words appear randomly in one of four quadrants of the display screen of a TRS-80 microcomputer at a rate of twenty items per minute (see Figure 3a). Following acquisition, half the subjects in each group first made twenty frequency of occurrence judgments. The sixteen words assigned to the frequency test and four novel foils were presented in random order, with the subject instructed to respond with a number between zero and four to indicate the number of times that word had been presented. Then the 24 words assigned to the temporal and spatial tests were presented. In the temporal order test, the words were presented two at a time, at the center of the screen, next to each other. The subject was asked, "Which word came first in the list?" Four types of pairs of words were presented: (1) two words from the same quarter; (2) two words from adjacent quarters; (3) two words originally presented two quarters apart; and (4) two words presented three quarters apart. There were three pairs of each type, for

Figure 1. Structure of the Acquisition List of Words.

Fillers	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Fillers
4	16	16	16	16	4

sum: 76 words

Each Quarter Contains:

1 Word 4 Times 1 Word 3 Times 1 Word 2 Times 1 Word 1 Time	10 Frequency Test
6 Words 1 Time	6 Temporal and Spatial Test

Figure 2. Structure of the Testing Sequence.

Task Order A.

Frequency	Temporal	Spatial
20	24	24

Task Order B.

Temporal	Spatial	Frequency
24	24	20

<u>Frequency Test</u>

4 Words Appeared 0 Times	20 Words
4 Words Appeared 1 Time	
4 Words Appeared 2 Times	
4 Words Appeared 3 Times	
4 Words Appeared 4 Times	

<u>Temporal and Spatial Tests</u>

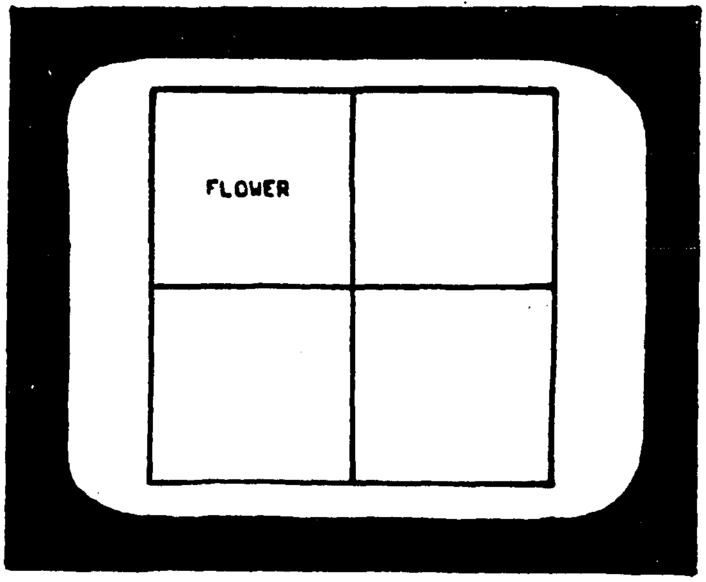
6 Words Each Quarter 24 Words

Figure 3a. Example of an Item Presented During the Acquisition Phase

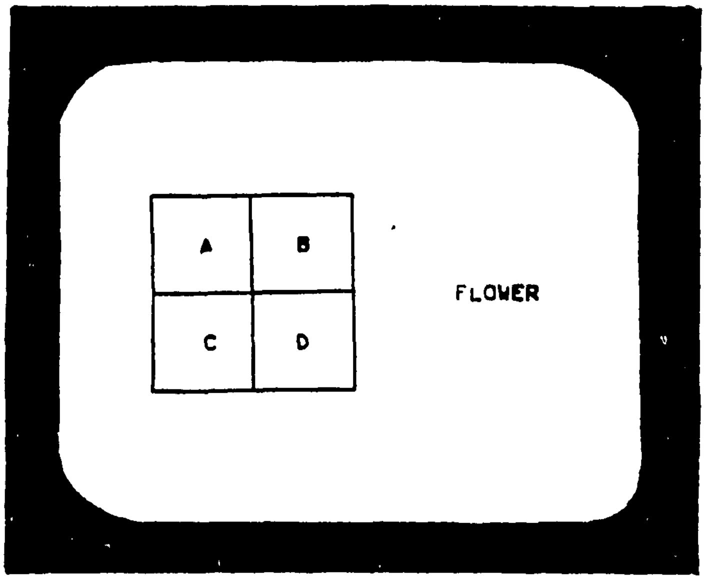
Figure 3b. Example of an Item Presented for the Spatial Location Task (Experiment 1A).

Figure 3c. Example of an Item Presented for the Spatial Location Task (Experiment 1B).

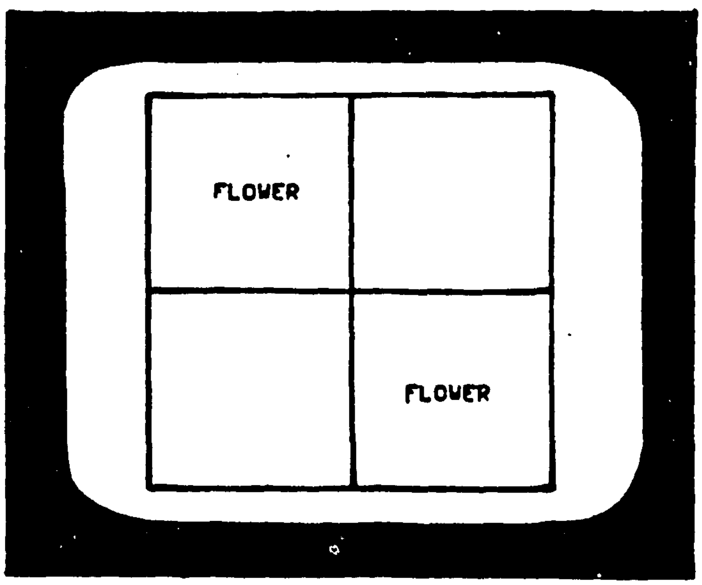
a)



b)



c)



a total of twelve pairs. To have the same number of pairs for each type, some words had to be used twice, and a few were not used.

In the spatial location test, 24 words were presented one at a time. At the same time, a small rectangle divided into four quadrants to represent the original four-quadrant display was presented on the screen. The quadrants were labelled "A," "B," "C," and D," to allow the subjects to indicate their judgment of where each word was originally presented (see Figure 3b). In half of the tests, the word appeared on the right side and the rectangle on the left side of the screen. In the other half, the words were displayed on the left, and the rectangle on the right.

The entire procedure was repeated. The first time the subjects were <u>uninformed</u> about the exact type of test to be used. They were told only to "pay close attention to what is presented on the screen because later your memory will be tested." In the <u>informed</u> condition which immediately followed the uninformed condition, subjects were told that a different list of words was going to be presented which would be followed with exactly the same types of tests used in the first part: when, where, and how often each word had occurred. All responses were typed into the microcomputer by the experimenter. Task order was completely counterbalanced over subjects within each group, except that spatial judgment always followed temporal order judgment. Since the same words were used in the temporal order test, recency judgments could have been influenced by order of presentation in the spatial task had this test preceded the temporal. The entire procedure took 25-30 minutes.

Inspection of the data collected during the first phase of the experiment revealed that performance on the temporal and spatial judgment tasks for all subject groups was either at chance, or very close to it. Therefore a second, hopefully easier, version of each of these tasks was developed. The frequency task did not require such a modification.

Experiment 1B

Subjects. The experimental group in this experiment consisted of 25 additional young adults who had suffered head injury, drawn from the population described in Experiment 1A. Six were female and nineteen were male. The age range was 19 to 49 years. Two control groups participated in this experiment: 25 young normal undergraduate students at Queens College who volunteered to participate in the experiment. The age range was 17 to 39 years. The second control group consisted of 25 normal elderly people, sixteem females and nine males. All were volunteer workers at the Institute of Rehabilitation Medicine at the New York University Medical Center. The age range was 55 to 85 years.

<u>Stimuli</u>. The stimuli used in this experiment were exactly the same as in Experiment 1A.

<u>Procedure</u>. The acquisition list and the frequency of occurrence judgment test were exactly the same as in Experiment 1A. Changes were made in the tests of temporal order and spatial location infomation.

Temporal order test: the 24 words devoted to the temporal test were presented one at a time at the center of the screen. The subject was requested to estimate in which of the four temporal quarters of the sequence the word had been presented.

Spatial location test: The screen was divided into four quadrants, and the same 24 words used for the temporal judgment were presented in a random order, one word at a time. The word appeared in two quadrants on the screen: the one in which it had been presented during acquisition, and also in the quadrant diagonal to that position (see Figure 3c). The subject was required to indicate the original spatial position of the word.

As in Experiment 1A, each subject was tested twice, first in an <u>uninformed</u> condition, then in an <u>informed</u> condition. As before, test order was counterbalanced, with the restriction that the temporal test always preceded the spatial test.

Results

First, the results on the various judgment tasks are considered separately and in succession: frequency, temporal, and spatial judgment data. Then the corelatin between the different judgment tasks is examined. Finally, correlation with performance on effortful memory tasks and a variety of subject variables are presented.

Frequency of Occurrence Task

With the two experiments combined, the results are based on 45 control, 45 CHI, and 25 elderly subjects. Data were assembled for analysis in two different ways.

For the averaged scores analysis, each subject's frequency of occurrence judgments for words presented at a particular frequency is computed. Each subject contributed five mean judgment scores, one for each presentation frequency. Each mean is based on four responses.

The second method of analysis, called absolute deviations, is based on the absolute size of the difference between the actual and judged frequency of occurrence for each of the twenty items in the list.

Figure 4 presents the performance of three hypothetical subjects A, B, and C, on the frequency task. Subject A performed perfectly and this is shown by each of the two methods of analyses: the means of the judged frequency are identical with the actual means, and the sum of absolute deviations is zero. Subject B is a case where the means again indicate perfect judgments, but the absolute deviations show impaired performance. Subject C represents the case where the means are not as accurate as in the previous case. However the absolute deviation analysis indicates a better performance (smaller deviation), than that obtained from Subject B.

Absolute deviation scores have two shortcomings. One is that they can be interpreted only relativistically. The other is that they allow more "deviation" at the extreme values of the independent variable than they do in the central values. In the case of frequency, for example, when the actual presentation frequency is 0 (or 4), a subject can have an absolute deviation score as great as 4, but when a word appears twice, the maximum deviation score that a subject can have is 2. A <u>corrected absolute deviation</u> score overcomes these problems.

Under the assumption of a model of chance

Figure 4. Data of Three Hypothetical Subjects A, B, and C, on Frequency Task.

<u>Subject A</u>

Actual Frequency	0	1	2	3	4
Judged Frequency	0	1	2	3	4
	0	1	2	3	4
	0	1	2	3	4
	0	1	2	3	4
Means	0.0	1.0	2.0	3.0	4.0
				$\sum \bar{x}_i - i$	$=0$
Absolute Deviations	0	0	0	0	0
				$\sum$	$=0$

<u>Subject B</u>

Actual Frequency	0	1	2	3	4
Judged Frequency	0	4	3	4	4
	0	0	3	4	4
	0	0	1	0	4
	0	0	1	4	4
Means	0.0	1.0	2.0	3.0	4.0
				$\sum \bar{x}_i - i$	$=0$
Absolute Deviations	0	6	4	6	0
				$\sum$	$=16$

<u>Subject C</u>

Actual Frequency	0	1	2	3	4
Judged Frequency	0	1	1	3	4
	0	0	2	2	4
	0	0	1	3	4
	0	1	2	2	4
Means	0.0	0.5	1.5	2.5	4.0
				$\sum \bar{x}_i - i$	$=1.5$
Absolute Deviations	0	2	2	2	0
				$\sum$	$=6$

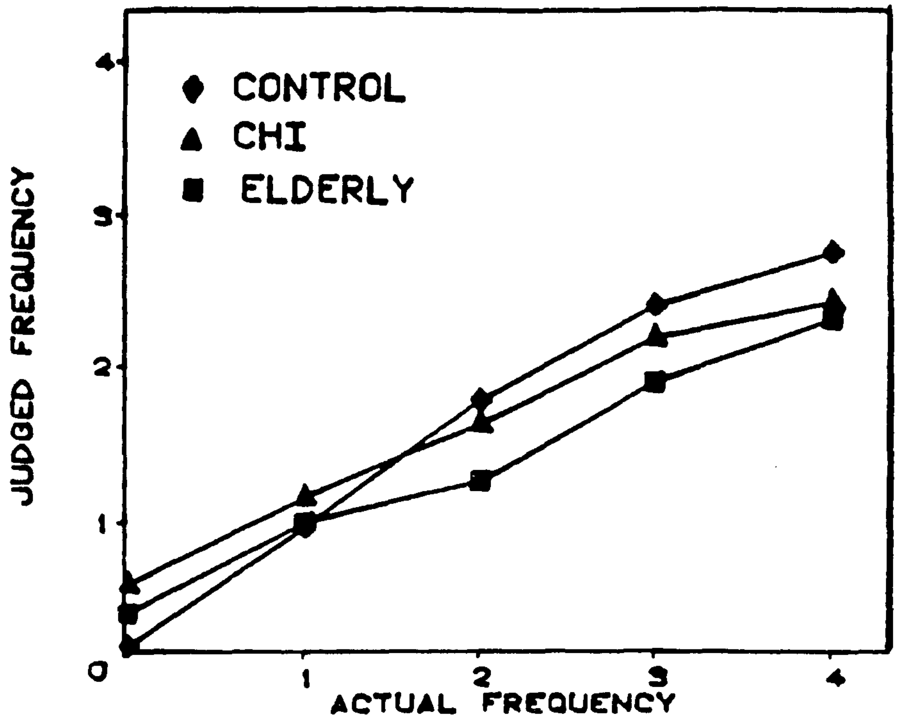
performance that assumes each possible response is equally likely, deviation scores were computed for each level of the independent variable. The absolute deviation for each subject at each level can be expressed as a ratio of actual performance and the performance score that would result from chance performance. A score of one reflects chance respondig, and zero a perfect performance.

Both the averaged scores and the absolute deviations data were submitted to three-way analyses of variance in which subject group (control vs CHI vs elderly) instructions (informed vs uninformed) and presentation frequency (0, 1, 2, 3, or 4) were the main effects. The ANOVA tables for the two analyses are presented in Appendices 1 and 2. Note: The probability values reported in the ANOVA tables reflect the Huynh-Feldt Epsilon adjustment (Myers, 1979). The averaged scores analysis is presented in Figure 5, the absolute deviations analysis in Figure 6.

Averaged scores analysis. The main effects for both group and instructions were not significant. The main effect for frequency was highly significant ($\underline{F}$ (4, 448) = 381.69, $\underline{p}$ < .001), indicating that averaged frequency of occurrence judgments increased with the

Figure 5. Performance on the Frequency Judgment Task for Three Groups of Subjects Using Averaged Scores Data in the Not Informed and Informed Conditions.

NOT INFORMED



INFORMED

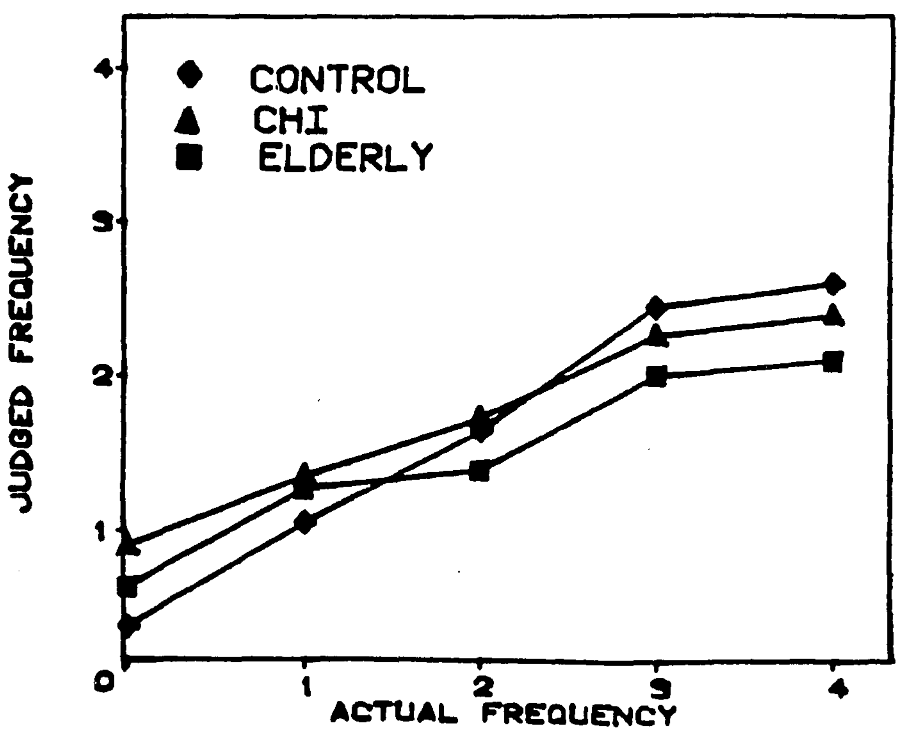
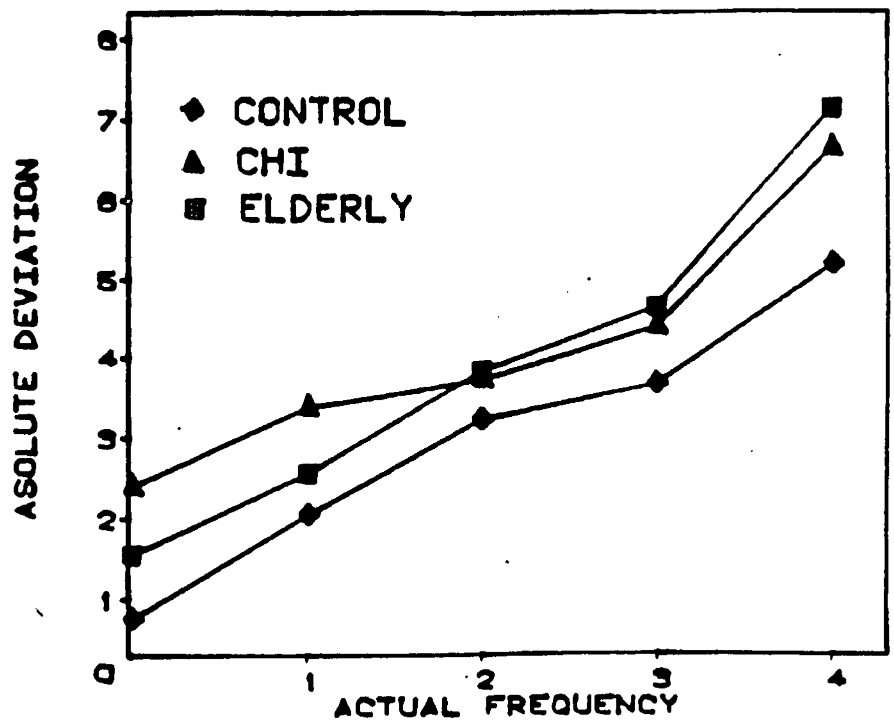
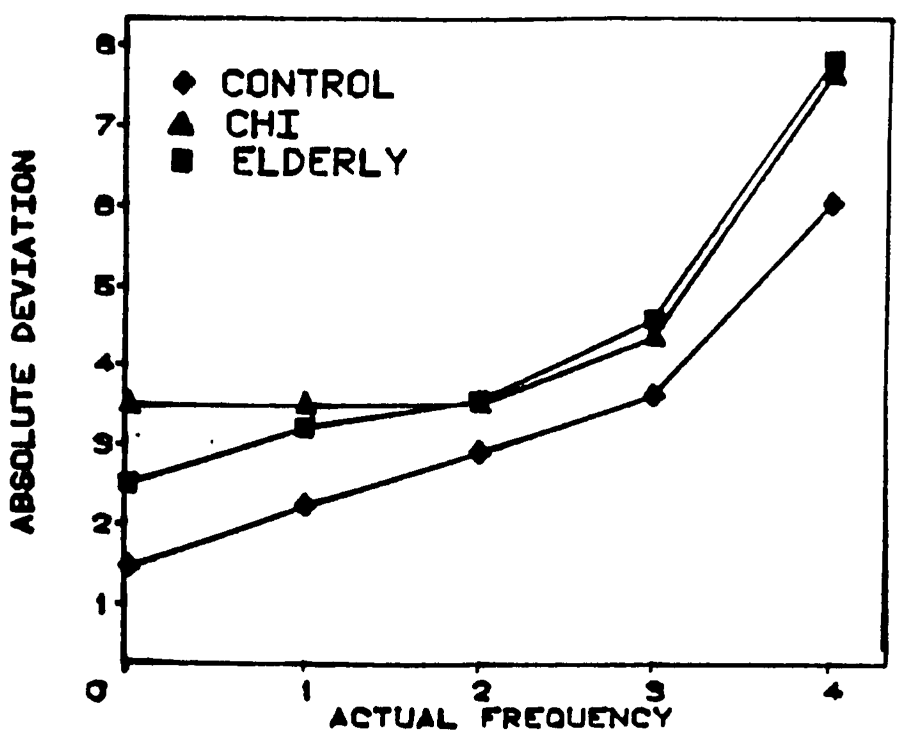


Figure 6. Performance on the Frequency Judgment Task for Three Groups of Subjects Using Absolute Deviations Scores Data in the Not Informed and Informed Conditions.

NOT INFORMED



INFORMED



actual frequency of presentation.

A trend analysis revealed that the linear trend accounted for most of the variability in the different groups and instruction conditions. These findings indicate that all groups showed sensitivity to changes in the actual frequency. A Shaffer-Welsch (Ramsey, 1981) post-hoc analysis revealed that at each actual frequency level, judged frequencies differed significantly from judgments made at adjacent levels.

The frequency variable interacted significantly with subject group variable ($F\ (8, 448) = 8.61$, $p < .001$). A post-hoc analysis using contrasts (Kirk, 1982) indicates that the interaction is mostly due to the control group surpassing the CHI and the elderly groups in the accuracy of their judgments. The averaged judgment scores of the control group for the novel foils and the words presented once are lower than the corresponding scores for the CHI and elderly groups, and at the higher presentation frequencies, (2 through 4), the controls' scores are above the CHI and elderly groups. In both cases the controls' judged frequency of occurrence comes closer to the actual presentation frequencies.

The interaction of frequency and instructions was also significant ($F\ (4, 448) = 5.23$, $p < .001$).

Post-hoc analysis using contrast revealed that, in the uninformed condition when the actual frequency was zero, three, or four, all the groups were more accurate in their judgments than for corresponding presentation frequencies in the informed condition.

Absolute deviation scores analysis. The three different groups, which could not be distinguished in the averaged scores analysis, were significantly different in the absolute deviations analysis (F (2, 112) = 15.19, $p < .001$). A post-hoc analysis using contrasts confirmed that the significant group effect is not due to the difference between the CHI group and the elderly group, but to the difference between these two groups and the control group.

The main effect for instructions (which was also not significant in the averaged scores analysis) was significant (F (1, 112) = 5.04, $p < .05$) in the absolute deviations analysis. Subjects were more accurate overall in their frequency judgment in the initial uninformed condition than in the subsequent informed condition.

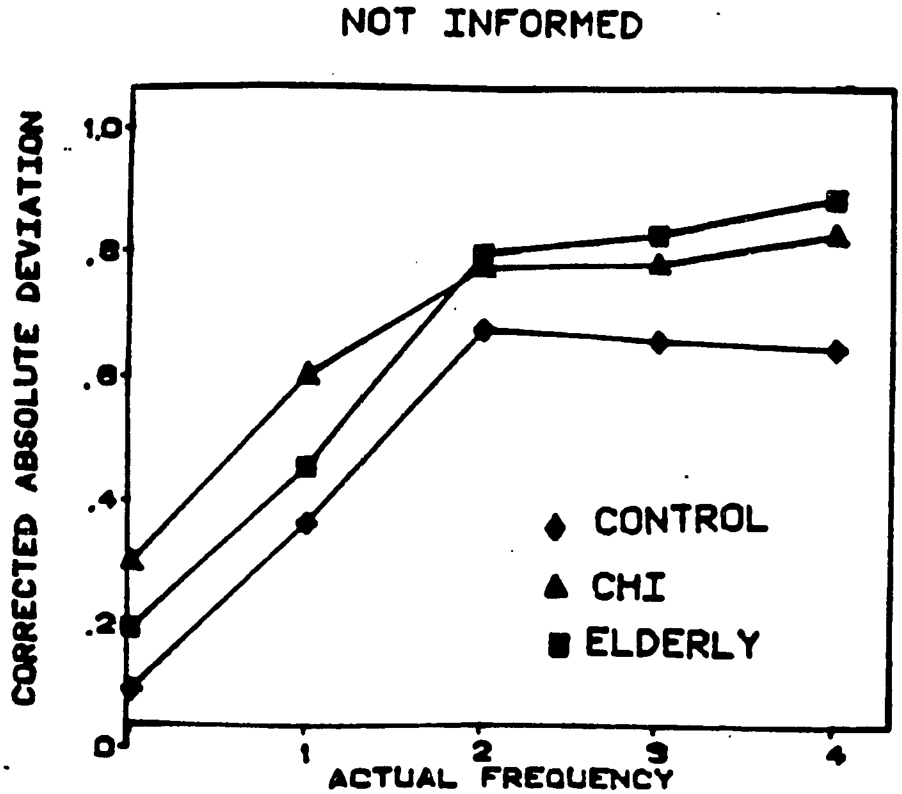
The significant effect of frequency in the absolute deviation analysis (F (4, 448) = 75.43, $p < .001$) indicates that the dispersion of a subject's frequency judgments around the true presentation frequency is greater when the number of actual presentation is high than when it is low.

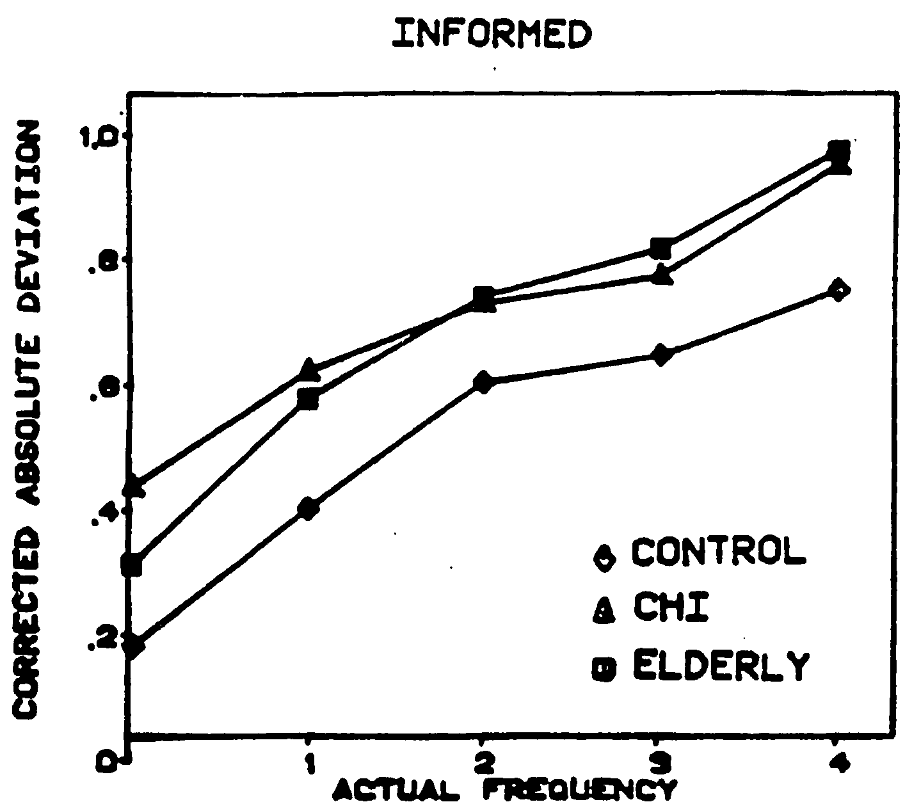
A Shaffer-Welsch post-hoc analysis revealed that the size of absolute deviation did not change significantly from one frequency to the adjacent one, except between frequencies three and four. By omitting an intermediate frequency, the change from one frequency to one once removed (e.g., from 0 to 2 or from 1 to 3) became significant. The interaction of instructions and presentation frequency was not significant.

<u>Corrected absolute deviation scores analysis</u>. Figure 7 presents the corrected absolute deviation scores as a function of the actual frequency in both the informed and uninformed conditions. An analysis of variance with the same factors used in the absolute deviation analysis was performed on the corrected absolute deviation scores (see Appendix 3). The results are very similar with one exception: the group and frequency main effects were significant at the .001 level, but the information factor in the new analysis was not significant, while in the analysis of uncorrected absolute deviations it was.

The averaged scores analysis is similar to those

Figure 7. Performance on the Frequency Judgment Task for the Three Groups of Subjects Using Corrected Absolute Deviation Scores Data in the Not Informed and Informed Conditions.


NOT INFORMED
CORRECTED ABSOLUTE DEVIATION
1.0
.8
.6
.4
.2
0
1
2
3
4
ACTUAL FREQUENCY
CONTROL
CHI
ELDERLY


INFORMED
CORRECTED ABSOLUTE DEVIATION
1.0
.8
.6
.4
.2
0
1
2
3
4
ACTUAL FREQUENCY
CONTROL
CHI
ELDERLY

done in several recent studies of this task (e.g., Hasher & Zacks, 1979) which also failed to find both instruction effects and subject group effects. This experiment used normal adults, elderly, and children as subjects, and replicates Hasher and Zack's (1979) findings. However, the alternative method of analysis using absolute deviation clearly demonstrates differences between the groups and between instruction conditions. The implication of these descrepancies in the analyses will be discussed in the following section.

Temporal Order Tasks

The hypothesis that CHI and the elderly groups confound judgments of frequency of occurrence and temporal order was confirmed. The temporal order judgments of each group was submitted to a three-way analysis of variance. The main effects were: subject group (control vs CHI vs elderly) instructions (informed vs uninformed) and the quarter of the list (1, 2, 3, or 4) in which each item appeared (see Appendix 4).

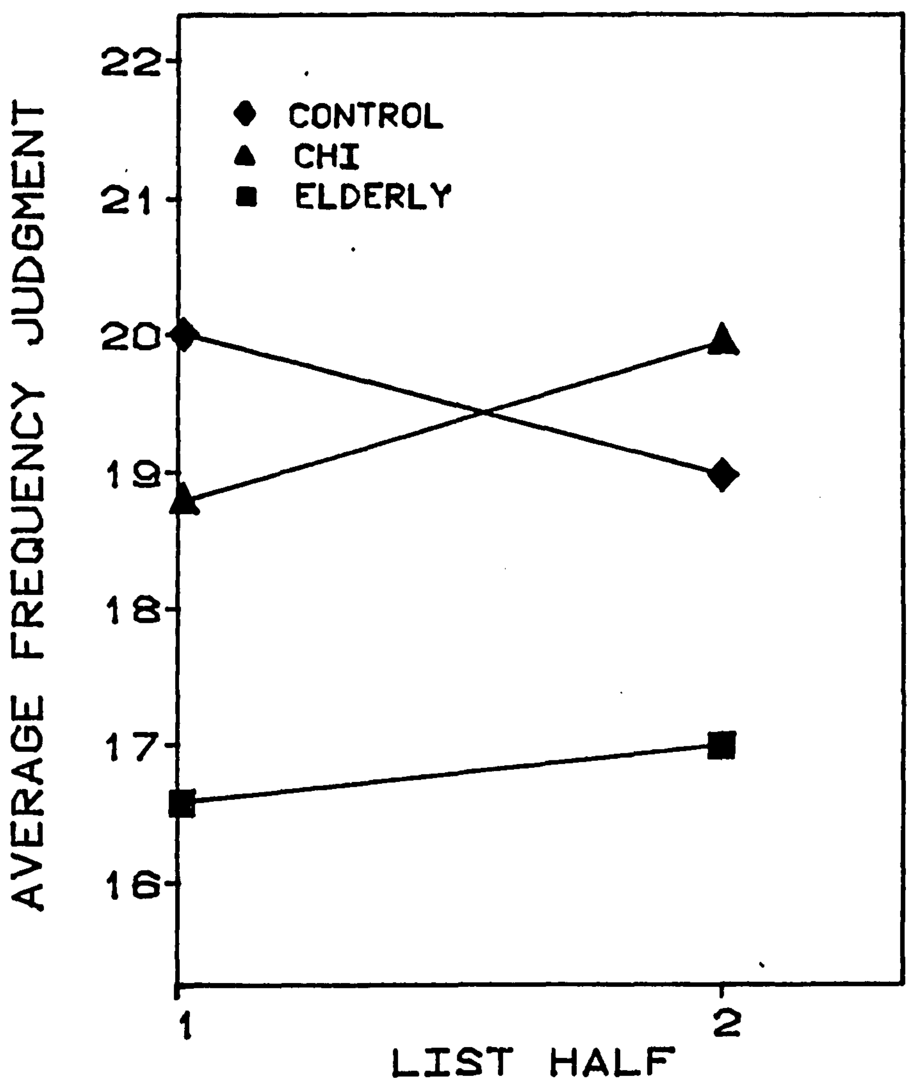
The main effects for group and instruction were not significant. The quarter effect was significant (F (3,36)=3.05, $p < .03$), as were the interactions of quarter by group and quarter by instruction. The triple interaction was not significant. The most interesting result in terms of the hypothesis above was the significant interaction of group by quarter (F (3,336)= 2.62, $p < .02$). A post-hoc analysis using contrasts confirmed the hypothesis that the CHI and elderly groups tended to judge words that appeared at the second half of the list as more frequent than words from the first half. The control group showed the opposite tendency (see Figure 8). This difference between the CHI and the elderly groups on one hand, and the control group on the other, was the source of the significant group by quarter interaction.

Since two different procedures for this task were used in the two versions of the experiment, the results are presented separately.

Experiment 1A. The subjects (20 control and 20 CHI patients) in this experiment were asked to make a relative primacy judgment. Two words appeared in the center of the screen and the subject was asked to judge which word was presented first on the list. The percent of correct answers for each subject group is presented in Table 1.

A two-way analysis of variance, subject group (control vs CHI) by instructions (informed vs

Figure 8. Averaged Judged Frequency as a Function of List Half for the Three Groups of Subjects with the Informed and Not Informed Conditions Combined.



CONTROL
CHI
ELDERLY
AVERAGE FREQUENCY JUDGMENT
22
21
20
19
18
17
16
1
2
LIST HALF

Table 1

CHI and Control Groups' Percent Correct Means and Standard Deviations Scores on the Relative Primacy Judgment Task at Informed and Not Informed Conditions

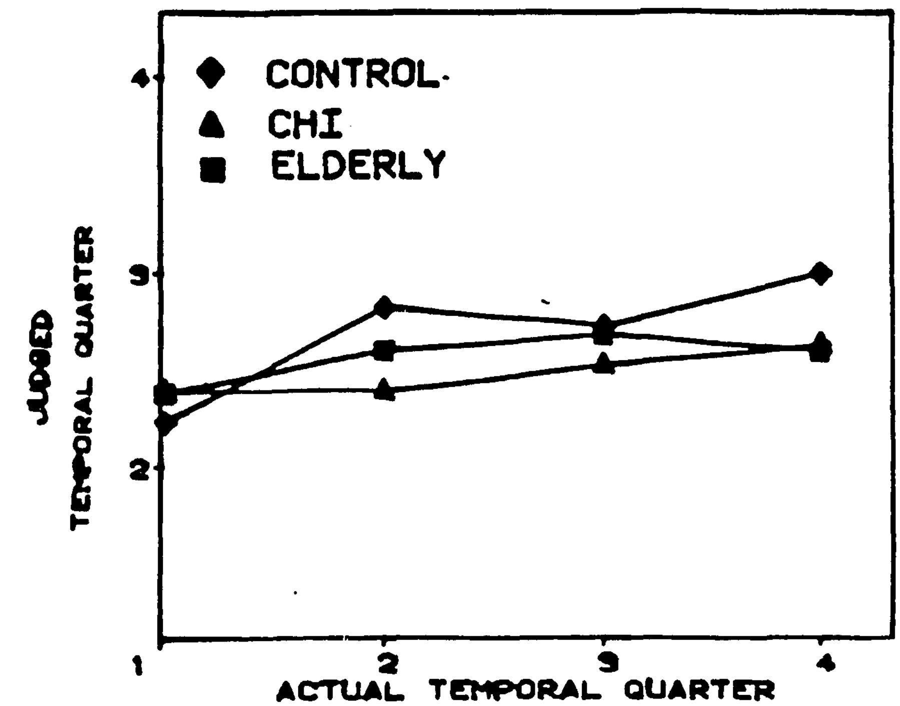
Instructions	Groups Control (n=20)	CHI (n=20)
Not Informed		
M	56	55
SD	14	15
Informed		
M	55	53
SD	16	21

uninformed), using the number of correct responses as the dependent measure showed that none of the effects reached significance (see Appendix 5). These results may be attributed to the difficulty of the task, which caused a "floor effect" in performance. The CHI subjects and the controls in the uninformed condition did not perform significantly better than chance (50%). Only the control subjects at the informed condition exceeded chance significantly (t (19) = 1.97, $p < .05$).

Experiment 1B. The task was modified to make it easier for the subject, thus avoiding the floor effect. A single word was presented, and subjects had to judge in which quarter of the list it was presented. Twenty-five control, twenty-five CHI patients, and twenty-five elderly participated in this experiment. As in the frequency task, this procedure permits analysis of the data in two ways, using averaged scores and absolute deviations measures of the accuracy of temporal judgments. The group means of the averaged scores in the informed and uninformed conditions are presented in figure 9. Mean absolute deviations in the informed and uninformed conditions are presented in Figure 10. Both the averaged scores and the absolute deviations were submitted to a three-way analyses of variance in which

Figure 9. Performance on the Temporal Judgment Task for Three Groups of Subjects Using Averaged Scores Data in the Not Informed and Informed Conditions.

NOT INFORMED



INFORMED

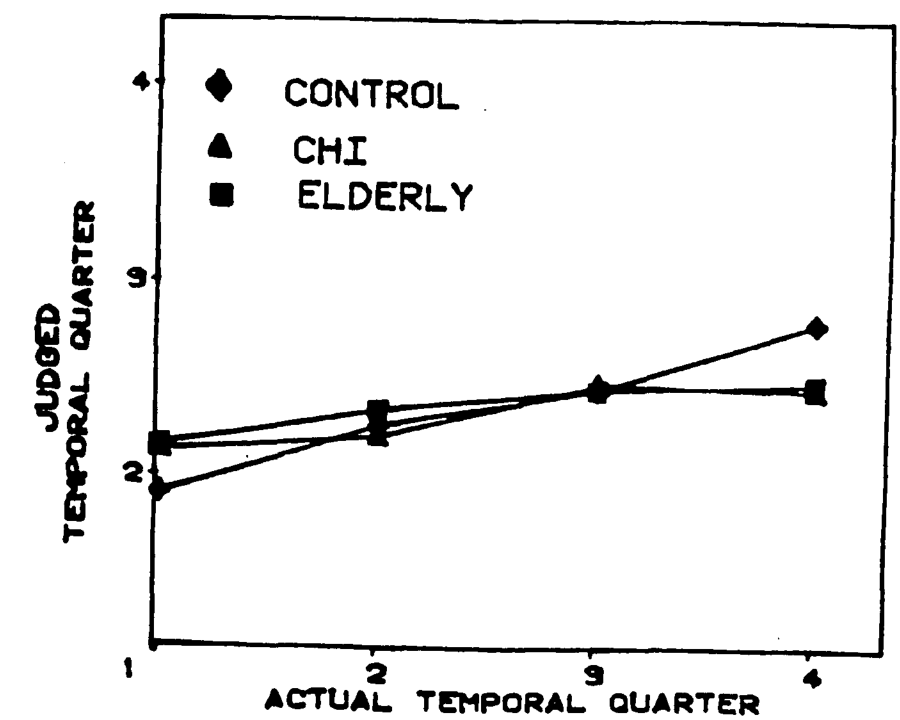
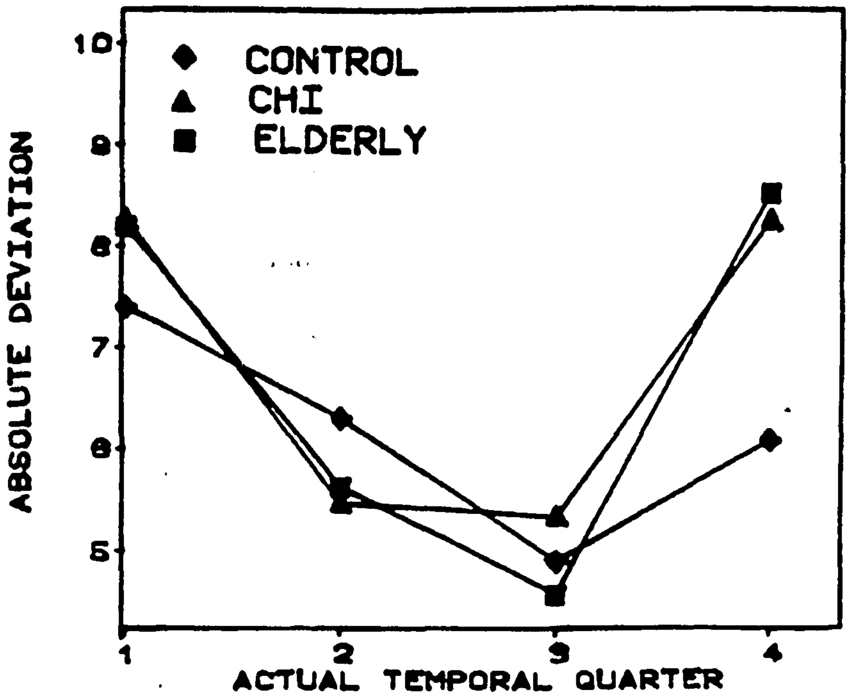
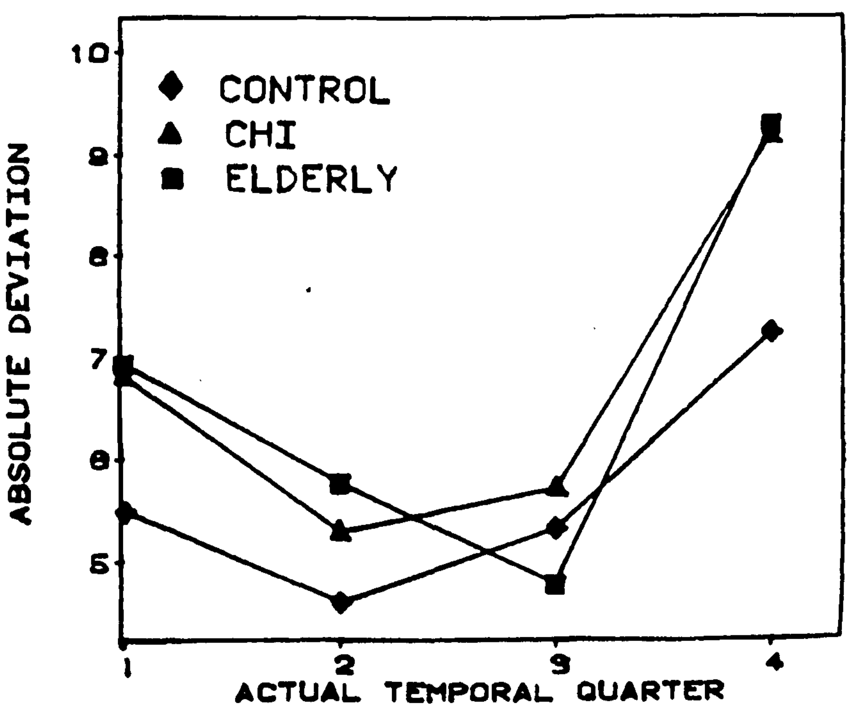


Figure 10. Performance on the Temporal Judgment Task for Three Groups of Subjects Using Absolute Deviations Scores Data in the Not Informed and Informed Conditions.

NOT INFORMED



INFORMED



subject group (controls vs CHI patients vs elderly) instructions (Informed vs Uninformed) and quarter of the list (1, 2, 3, or 4) were the main effects (see Appendices 6 and 7).

Averaged scores analysis. The main effect for subject group was not significant in this analysis. In contrast, the instruction effect was significant (F (1, 72) = 42.23, p < .001). Judgement in the initial uninformed condition was more accurate than in the subsequent informed condition.

A main effect for quarter emerged (F (3,216) = 29.07, p < .001), indicating that averaged quarter-presented judgments increased with the actual recency of quarter presentation.

A post-hoc analysis using contrasts indicates that the effect emerges mostly from differences in judged recency of items presented in the first two quarters of the list compaired with items from the last two (F (1,216) = 62.91, p < .001). However, the increase from first to second quarter and the third to fourth also appeared as a significant contributor (F (1, 216) = 21.68, p < .001).

A quarter by group interaction also emerged in analysis of the averaged scores (F (6, 216) = 2.76, p

< .02). A post-hoc analysis using contrasts suggest that the control group differs from the CHI and elderly groups in their change in judgment from first two quarters to the last two quarters. The controls show more increase from the first half to the second half than the other two groups.

Absolute deviation scores analysis. In contrast to the averaged scores analysis, this analysis clearly distinguished the groups (F (2, 72) = 6.86, p < .002). A post-hoc analysis using contrasts indicates that the significant group effect is not due to the difference between the CHI and elderly groups, but to the difference between these two groups and the control group. The instruction effect was not significant in the absolute deviations analysis which means that the instructions did not influence the dispersion of temporal judgments for words presented in a particular quarter. The significant effect of quarters in the absolute deviation analysis (F (3, 216) = 39.99, p < .001) indicates that the disperion of a subject's quarter judgments around the true quarter presented is not equal in all quarters. The interaction of quarter by group was also significant (F (6, 216) = 2.76, p < .02). A post-hoc analysis using contrasts revealed that controls differ from the other two groups mostly by making more accurate judgments in the first and last quarters.

A post-hoc analysis using contrasts revealed that significant effect emerged mostly because of the difference between the middle (quarters 2 and 3) and the ends (quarters 1 and 4) of the list. The subjects made many more errors judging words that appeared at the beginning or end, and significantly less on words from the center of the list. The drop in the magnitude of the absolute deviation from quarter one to two, and the increase from quarter three to four, also contributed significantly to the overall effect. The comparison of the first two quarters and the second two quarters was not significant.

<u>Corrected absolute deviation scores analysis</u>. Corrected absolute deviation scores were computed for the temporal task in the same manner as the frequency task. When the actual quarter was either 1 or 4, the absolute deviation for a chance performance was 1.5. When the actual quarter was either 2 or 3, the absolute deviation expected in a chance performance was 1.0. Since six words were used in the temporal task, the expected absolute deviations sum for all words presented in quarters 1 or 4 in a chance performance was 4, and for

all words presented in quarters 2 or 3, it was 6. The corrected absolute deviation scores were computed accordingly. Figure 11 represents these scores as a function of actual quarter.

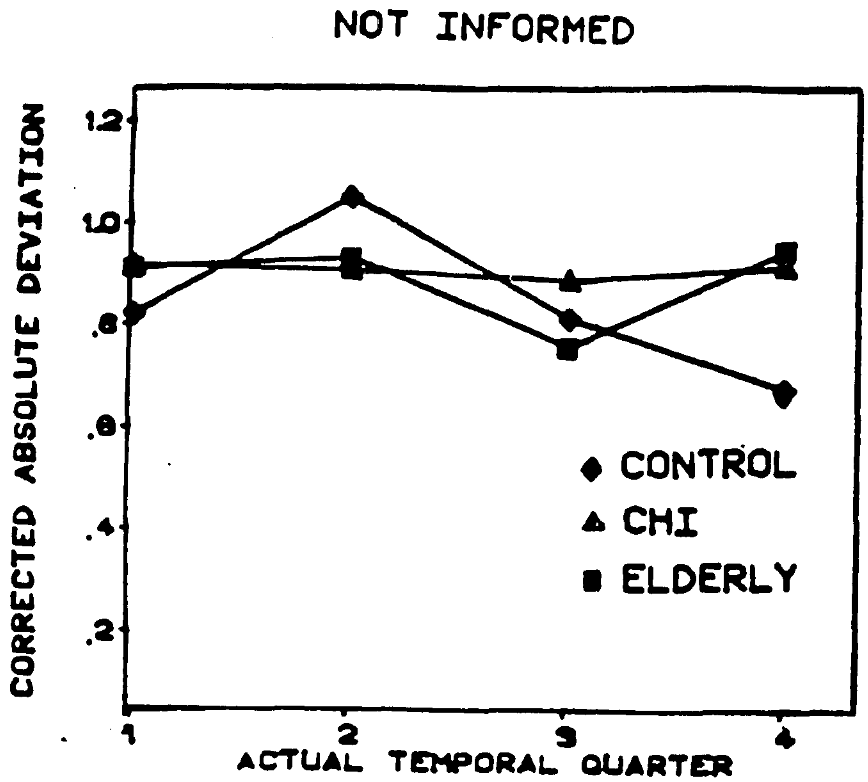
An analysis of variance with the same factors used in the uncorrected absolute deviation analysis, was performed on the corrected absolute deviation scores. The results of this analysis are almost identical to the original absolute deviation analysis (e.g., group and quarter main effects and the interactions of quarter by group and information by quarter all remain significant). The only differences are the magnitude of the quarter main effect. After the correction, the quarter effect dropped from $F(3, 216) = 39.99$, $p < .0001$ to $F(3, 216) = 3.54$, $p < .02$ (see appendix 8). This change suggests that part of the quarter effect in the original absolute deviation was an artifact. However even after correction, this factor remains significant.

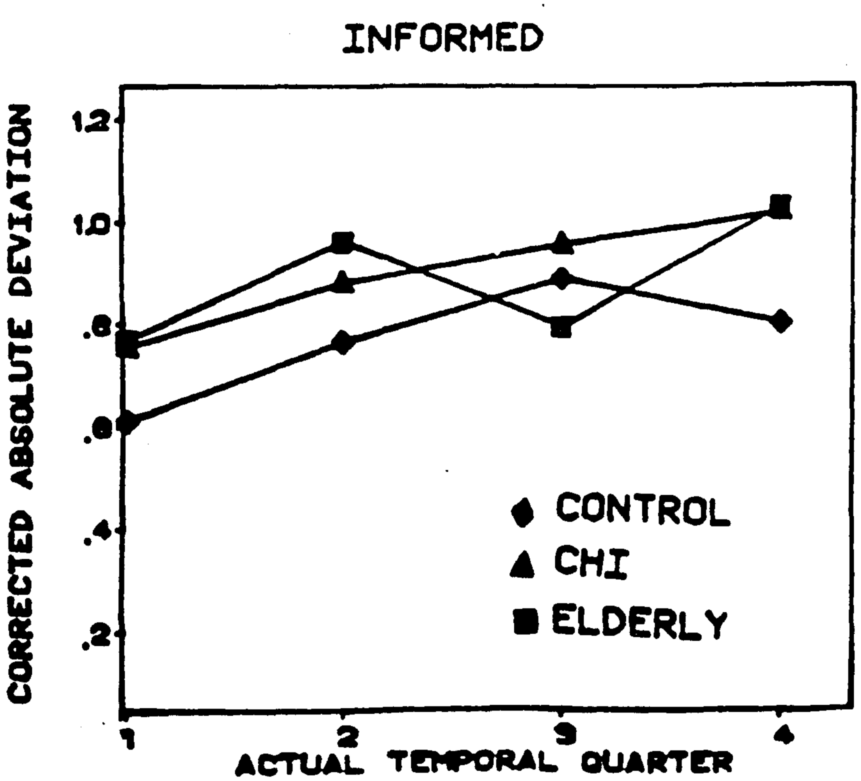
Spatial Location Tasks

Since the procedure for this task was different in the two experiments, the results are presented separately.

Experiment 1A. The subjects (20 control and 20

Figure 11 Performance on Temporal Judgment Task for the Three Groups of Subjects Using Corrected Absolute Deviation Scores Data in the Not Informed and Informed Conditions.


NOT INFORMED
CORRECTED ABSOLUTE DEVIATION
1.2
1.0
.8
.6
.4
.2
1
2
3
4
ACTUAL TEMPORAL QUARTER
CONTROL
CHI
ELDERLY


INFORMED
CORRECTED ABSOLUTE DEVIATION
1.2
1.0
.8
.6
.4
.2
1
2
3
4
ACTUAL TEMPORAL QUARTER
CONTROL
CHI
ELDERLY

CHI patients) were presented with 24 words, six from each quarter of the list. They had to indicate in which spatial quadrant each word was originally presented. The results are presented in Table 2.

The number of correct responses was analyzed using a two-way analyses of variance in which subject group (control vs CHI patients), and instructions (informed vs uninformed) were the main effects (see Appendix). The group effect was the only significant result obtained in this analysis (F (1, 38) = 3.93, p < .05). Controls judged the spatial position more accurately than CHI patients. Floor effects did not apear in this experiment. The performance of the CHI patients was significatly better than chance (25%) in both the uninformed (t (1, 19) = 2.59, p < .01), and the informed condition (t (1, 19) = 2.40, p < .05).

Experiment 1B. In this spatial task subjects (25 control, 25 CHI patients and 25 elderly) were presented at the testing phase with a word in the quadrant in which it was originally presented and in the quadrant diagonal to it, so chance performance in this experiment is 50%. The results are presented in Table 3.

An analysis of variance similar to the one used for the previous spatial task was performed, except that

Table 2

CHI and Control Groups' Mean and Standard Deviation of Percent Correct Performance on the Four Alternative Spatial Location Judgment Task in the Informed and Not Informed Conditions

	Groups	
Instructions	Control (n=20)	CHI (n=20)
Not Informed		
M	33	31
SD	11	10
Informed		
M	38	30
SD	15	09

Table 3

CHI, Elderly, and Control Groups' Mean and Standared Deviation of Percent Correct Performance on the Two Alternative Spatial Location Judgment Task in the Informed and Not Informed Conditions.

Instructions	Control (n=25)	CHI (n=25)	Elderly (n=25)
		Groups	
Not Informed			
M	60	57	52
SD	12	14	13
Informed			
M	59	57	56
SD	12	13	13

three groups were compaired: controls, CHI patients, and elderly (see Appendix 10). Neither the two main effects (group and instructions) nor their interaction were significant. Except for the group of elderly subjects in the uninformed condition, all groups in both instruction conditions significantly exceeded chance level of performance.

In summary:

Frequency task. In using an averaged scores analysis, no group effect emerged. However in the absolute deviations analysis, scores of the young control group were clearly distinguishable from both the CHI group and the elderly group. All groups showed sensitivity to the actual frequency, and tended to make more errors with the increase of the actual frequency. Paradoxically, subjects did better in the uninformed condition than in the informed condition. This effect was detected by the absolute deviation analysis, but not by the averaged score analysis.

Temporal task. The CHI group did not differ from the control group in the first version of the task, which required a relative primacy judgment (two alternatives). The task was difficult for both groups. With the exception of the control group in the uninformed condition, performance did not exceed chance statistically.

In the second version of the task when the correct quarter had to be judged (four alternatives), the results of the averaged scores analysis did not differentiate among the groups. However, absolute deviation scores showed clearly that the young control group were more accurate in their judgment than the CHI and the elderly groups, which did not differ from each other. In this regard the temporal judgments were similar to the frequency of occurrence judgments. The information effect was significant with the averaged scores analysis but not with the absolute deviations analysis. More errors in judgment were made by all groups for words presented at the beginning and the end of the list, and this was the place where the groups differed the most.

Spatial task. The control group did better than the CHI group when the original quadrant had to be indicated (four alternatives). Information about the nature of the task did not have an effect. In the second version of the spatial task, when the subject was required to select the original quadrant out of two alternatives, no group or information effect was detected, even though all groups except the elderly in the uninformed condition performed better than chance.

Both the temporal and spatial tasks had two versions: one in which the subjects had two alternatives and another in which the subjects had four alternatives to choose from. Whenever the subjects were presented with two alternatives, group differences were not present. When they had four alternatives to choose among, group differences emerged in both temporal and spatial judgment tasks. The implications of this observation will be discussed in the next section.

Correlation Among the Judgment Tasks

This experimental design, in which each subject was tested under informed and uninformed conditions on the three different tasks allows within-subject comparisons between tasks which are not possible in most prior studies of this type, because they typically presented each subject with only a single judgment task.

Table 4 presents the correlation of the subjects' performance under the two instructional conditions: informed and uninformed. Each group showed a different pattern of relationship between the informed and uninformed conditions. None of the correlations reached significance in the control group. The correlation in spatial judgment is significant in the CHI group, and the temporal judgment correlation is significant in the elderly group.

Table 4 Intercorrelations Between Informed and Not Informed Conditions of Each Judgment Task for the CHI, Elderly, and Control Groups

Judgment Tasks	Groups		
	Control	CHI	Elderly
Frequency	.283	.249	.502**
Temporal	.291	.087	.203
Spatial	.315	.355*	.203

*$p < .05$.

**$p < .01$.

Table 5 presents the correlations between pairs of the judgment tasks across the four possible pairings of the two information conditions. In general these relationships were positive, though not particularly strong. Judgments of frequency of occurrence and judgments of spatial location appear to be the most consistently related. Frequency of occurrence and temporal location judgments were also consistently related in the young controls and CHI subjects, but not in the elderly. Spatial and temporal performance was generally less strongly related, despite the fact that in the NI/NI and I/I instructional combinations, the same words were used for temporal and spatial tests.

Correlations Between the Automatic and Effortful Tasks in the CHI Group

The Hasher and Zacks model predicts a minimal relationship between measures of effortful and automatic measures. They suggest that effortful tasks are dependent upon and influenced by subject variables like age, mental status, intelligence, etc., while automatic tasks are unaffected by these factors.

Various neuropsychological tests scores were available from the intake evaluation of the CHI subjects. These tests include different memory tests and some general intelligence scores. Table 6 lists these tests and shows how they

Table 5

Intercorrelations Between the Frequency (F), Temporal (T) and Spatial (S) Judgment Tasks in the Informed (I) and Not Informed (NI) Conditions for CHI, Elderly and Control Groups

Judgment Tasks	Instructions NI/NI	I/I	NI/I	I/NI
		Control		
F/S	.419*	.304	.033	.380*
T/S	.314	.277	.001	.076
T/F	.556**	.308	.238	.236
		CHI		
F/S	.166	.312	.397*	.333*
T/S	.390*	.045	.233	.197
T/F	.410*	.114	.237	.282
		Elderly		
F/S	.659**	.511**	.281	.349**
T/S	.016	.218	.218	.162
T/F	-.016	-.256	.140	.002

*$p<.05$. **$p<.01$.

Table 6

Intercorrelations Between the Judgment Tasks, in the Informed (I) and Not Informed (NI) Conditions, and Effortful Tests for the CHI Group

Effortful Tests	Judgment Tasks					
	Frequency		Temporal		Spatial	
	NI	I	NI	I	NI	I
Benton (VRT)	.405**	.115	.366*	.097	.286	.176
WMS-LM	.347**	.238	.353*	.151	.094	.117
WMS-AL	.218	.086	-.004	.093	-.149	-.031
LAVA (match)	.784**	-.093	.272	-.121	.328	.432**
LAVA (memory)	.429*	.093	.041	.344	.092	.460*
WAIS-R PIQ	.251*	.035	.277	-.047	.366*	.347*
WAIS-R VIQ	.127	.120	.023	-.178	.145	-.068
Rey (recog.)	.425	.836**	.195	.159	-.276	.508*
Rey (1 to 5)	.595**	.301	.373	.121	.505**	.314
Rey (2-1)	-.360*	-.032	.330	.053	-.392	-.334
Rey (5-1)	.564**	.210	.057	.178	.472*	.290

*p<.05. **p<.01.

correlate with the three experimental tasks.

The Performance IQ (PIQ) from the WAIS-R (Wechsler, 1981) was not related to the temporal task, but significantly related to the frequency task in the not informed condition and to the spatial task in both conditions. The Verbal IQ (VIQ) from the WAIS-R and paired associate learning (AL) subtest from the Wechsler Memory Scale (Wechsler, 1945) seem not to be related to any task. The Logical Memory (LM) subtest of the Wechsler Memory Scale (WMS) is significantly related to the frequency and temporal task in the not informed condition.

The LAVA (Lateral Asymmetries Visual Attention) perceptual recognition task involves encoding unfamiliar figures and then selecting the target from six alternatives. There are two administration procedures. In the match procedure, the target figure is present when the six alternatives are given. In the memory administration, the target figure is not present when the six alternatives are presented (Piasetsky, 1981). Performance on this task was related to the frequency not informed and spatial informed tasks.

Four different scores were computed from the Rey AVALT (Auditory Verbal Learning Test) (Lezak, 1983) data to reflect the learning abilities of the subjects. Rey 1 to 5 is the sum of all words recalled in the acquisition stage (trials one to five). Rey (2-1) reflects the gain between the first to the second trial, and Rey (5-1) reflects the gain between the first and fifth trial. Rey (recognition) reflects performance on the final recognition phase of the procedure. Rey (1 to 5), Rey (2-1), and Rey (5-1) all correlated significantly with the frequency and spatial task in the uninformed condition. The Rey recognition scores correlated significantly with the scores on the frequency and spatial scores in the informed condition.

The Benton Visual Retention Test (BVRT), (Benton, 1974) test is significantly related to the frequency and temporal tasks in the not informed condition.

Overall, the frequency task seems to be most closely related to the effortful tasks (nine significant correlations out of 22, eight of them with the not informed condition and one with the informed condition. The spatial task had seven correlations which reached significance, four in the informed and three in the not informed condition.The temporal task seems to be the least related to the effortful tasks. Only two correlations reached significance, both in the not informed condition.

Discussion

The primary objective of this research was to investigate the performance of CHI patients on three judgmental tasks: frequency of occurrence, temporal order, and spatial location. According to Hasher and Zacks (1979), these tasks tap the "innate" type of automatic memory function, and are not influenced by subject variables such as mental status, age, and intelligence.

The CHI patients were a particularly interesting group to test since they commonly exhibit memory impairment (Brooks, 1978). Since innate automatic processes can also be described as "prewired," Hasher and Zacks' model may not be appropriate for this population whose "wiring" has been damaged. Hasher and Zacks (1979) raise the possibility that head injured patients might exhibit impairments in these automatic processes.

A group of elderly subjects was included for two reasons. Since some of the studies of automatic tasks have used elderly subjects, this allowed a comparison of the results obtained in this experiment to similar ones in the literature. Second, the elderly are also known to have memory deficits (Burke & Light, 1981). Comparison of the elderly and the CHI subjects enabled determination of whether the pattern of performance impairments is the same for these two groups.

This experiment was designed to allow the comparison of results on the three automatic tasks, under uninformed and informed conditions, within the same subjects. Thus, the second objective of this experiment was to study the relationships between the three automatic tasks under different instruction conditions.

The averaged scores analysis used by Hasher and Zacks does not take into account the variability of a subject's responses. An alternative method of analysis developed here is based on absolute deviation scores, which measure the deviation of each answer from the correct judgment. The third objective was to compare the results of these two different analysis procedures.

The hypothesis that there would be no group differences in the performance on the three jüdgment tasks, was rejected in most cases. In the judgment of frequency of occurrence, the averaged scores analysis supported the hypothesis of no group differences, but the absolute deviation analysis revealed clear differences between groups. These differences remained even after correcting absolute deviation scores for guessing. The control group made fewer errors than the CHI and elderly groups, which did not differ from each other.

In the temporal order task, which required relative primacy judgments, no group difference emerged between the control and CHI groups. This finding also cannot be interpreted as supporting the hypothesis of no group difference, since both CHI and young control groups did not perform significantly above chance. In the second temporal task, when the subjects had to judge in which quarter each word was presented, the pattern of results was the same as in the frequency task. Averaged scores analysis did not differentiate between the groups, but the absolute deviation scores analysis revealed a clear group effect. This group difference also emerged when corrected absolute deviation scores were analyzed. Again, the control group performed more accurately than the CHI and the elderly groups, which did not differ significantly from each other.

In examining subjects' absolute deviation scores for temporal order, we found that all groups were less accurate in judgments for words occurring in the first and fourth quadrants. Further analysis revealed that correcting these data for "chance" performance reduced the interquarter differences substantially. Yet, these findings remain puzzling in that subjects would be expected to be more accurate in correctly judging words which occurred in the fourth quadrant owing to a recency effect. A plausible explanation for this is that since one-half of the subjects were tested for temporal order after being tested for frequency, recency effect for temporal order in these subjects would be abolished. Such an effect, however, would be expected for the remaining subjects who were tested for temporal order immediately following acquisition. The group as a whole, therefore, would not evidence a distinct recency effect. Further analysis will be needed to verify that this is in fact the case.

In the first spatial location task, in which the subjects were asked to judge in which quadrant each word was originally presented, group differences also emerged, again contrary to the hypothesis drawn from the Hasher and Zacks model. In the second version of the spatial experiment, when only two alternatives were presented, all groups exceeded chance level, but the groups did not differ significantly from each other. This finding supports the hypothesis that no group differences exist.

Thus, group differences emerged for each of the three tasks tested, if the correct analysis was performed (absolute deviation scores analysis in the case of frequency and temporal tasks), or when four alternatives instead of two were presented in the temporal and spatial tasks.

In regards to the relationship between judgment tasks, the intracorrelations and intercorrelations suggest that some consistent individual differences do exist, contrary to the prediction from the Hasher and Zacks model. In terms of performance, the CHI and elderly groups were not distinguishable, but when inter-task correlations were examined, clear differences between the CHI and the elderly groups emerged.

The second hypothesis, that informing the subjects about the nature of the task should not have an effect, received qualified support. One way of looking at the effect of instruction is by comparing the level of performance in the two conditions, informed and uninformed. In the case of frequency judgment the averaged scores analysis revealed no information effect. In contrast, the absolute deviation scores analysis showed unexpectedly that under the uninformed condition subjects were more accurate in their judgment than under the informed condition.

In the first temporal task (primacy judgment), instructions had no significant effect, but this may result from the generally low performance levels in this task. In the second version of this task, when the correct quarter had to be identified, the instruction effect was significant, this time in the averaged scores analysis. Again, subjects judged the correct quarter more accurately in the uninformed condition. The absolute deviations analysis revealed no significant instruction effect, which means that being informed about the task did not have an effect on the dispersion of judgments of each subject.

The performance of the subjects on the two spatial tasks supported the hypothesis that practice and prior information does not improve the efficiency of these memory functions. In the first experiment (with four alternative answers) even with a significant group effect, no instruction effect was found. In the second experiment (with two alternatives) neither group, nor instruction effect were obtained.

In some cases the instruction effect emerged, in others it did not. Whenever it did, it surprisingly demonstrated a disadvantage of the informed version over the uninformed condition. A possible explanation is that in the informed version of the experiment, the subject tried to prepare simultaneously for three different recognition tasks. This may have induced the adoption of inappropriate memorizing strategies. If the information tapped by the three tasks is encoded automatically, as the Hasher and Zacks model proposed, then even a simultaneous effortful task should not interfere. However, more direct tests of the instruction effect in studies requiring only a single kind of judgment almost invariably fail to demonstrate instruction effects (Hasher & Zacks, 1979).

Another explanation is that the paradoxically negative effects of being informed about the specific memory tests experiment presented the subjects with two alternatives, they disappeared. In the case of temporal judgment, this may have been due to a floor effect.

Future experiments might reduce the frequency of occurrence judgments to two choices and to determine if that will eliminate the group effect in this task as well. More research is also needed to determine whether testing with three different tasks may have masked the benefit that the subjects obtain from information about the nature of the task.

What do these results suggest about the value of the automatic/effortful dichotomy? The distinction may be a useful one, but the extreme version presented by Hasher and Zacks was mostly not supported in this research. On the other hand, the results of this research do not contradict in any way Shiffrin and Schneider's (1977) definition of automaticity, which makes no claims about the presence or absence of individual differences.

It is, of course, impossible to create a task which involved <u>only</u> automatic or effortful processes. It is possible then that Hasher and Zacks are correct in their assumption that automatic processes remain intact after head injury. The deficiencies observed on these tasks may reflect the effortful components involved in each of the judgment tasks. This interpretation is also compatible with that there are very consistent individual differences within the groups, which again is not predicted by the Hasher and Zacks model. It is important to note that Hasher and Zacks (1979) tested the hypothesis of lack of individual differences by making between-group comparisons (e.g., young versus elderly subjects).

On the other hand, some of the findings are in agreement with the model. The finding that instruction failed to improve performance seems to support the model. Despite group differences, even the CHI and elderly groups apparently encoded information under the uninformed condition, one of the criteria of automaticity. All groups showed sensitivity to the actual frequency presented, and when the controls performed better than chance in the temporal and spatial tasks, the CHI and elderly usually performed better as well.

Previous studies which detected group differences between young and old normals attributed the effect to a response bias. Once the response bias was eliminated, either by procedural change or by score correction, the group difference disappeared (Attig, 1983; McCormack, 1981). One of the ways that Attig (1983) suggested for eliminating response bias is to reduce the number of alternative choices. In this experiment, when four alternatives were presented, group differences were evident; but when the experiment presented the subjects with two alternatives, they disappeared. In the case of temporal judgment, this may have been due to a floor effect.

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It is, of course, impossible to create a task which involved only automatic or effortful processes. It is possible then that Hasher and Zacks are correct in their assumption that automatic processes remain intact after head injury. The deficiencies observed on these tasks may reflect the effortful components involved in each of the judgment tasks. This interpretation is also compatible with the significant correlations between the judgment tasks in this experiment, as well as the correlations between these tasks and the conventional memory measures which were observed in the CHI group.

Finally, the results of this experiment raise questions concerning whether it is justified to consider Hasher and Zacks' theory a coherent model or simply a collection of independently verifiable hypotheses. Depending on the judgment task and analytical procedure used, some of these criteria were supported, and others were not. More research is needed to determine precisely the empirical relationship among these criteria. The use of other types of stimuli, such as pictures, may reveal a different pattern of results. For example, Grober (1970) has shown that aphasics have excellent memory for the spatial location of pictorial stimuli.

The design used in this experiment is potentially a powerful diagnostic tool. Since three memory functions are measured simultaneously, the level of performance on each can be compared with a single individual.

Recent studies with humans and animals suggest that specific memory impairments result from particular lesions in the brain. Smith and Milner (1981) showed that lesions to the right hippocampus causes selective impairment in the encoding of spatial location information. Mishkin (1982) showed that lesions to the amygdala of monkeys causes impairment to the encoding of temporal order, whereas hippocampal lesions cause defects in cross-model matching. Subjects with localized brain lesions may be impaired on one automatic function, but not the others. With this task, it may be possible to specify the brain areas controlling each of these functions.

Appendix 1

Experiment 1A and 1B combined: Analysis of variance summary table for the averaged scores on the frequency judgment task (3 x 2 x 5 mixed-design)

Source	SS	df	MS	F	P
Group (G)	9.19	2	4.59	2.94	0.06
Error	174.97	112	1.56	--	--
Instructions (I)	1.65	1	1.65	2.96	0.09
I X G	0.85	2	0.43	0.76	0.47
Error	62.69	112	0.56	--	--
Frequency (F)	520.24	4	130.06	381.69	0.00
F X G	23.48	8	2.93	8.61	0.00
Error	152.66	448	0.34	--	--
I X F	4.54	4	1.14	5.23	0.00
I X F X G	0.69	8	0.09	0.40	0.92
Error	97.17	448	0.22	--	--

Appendix 2

Experiments 1A and 1B combined: Analysis of variance summary table for the absolute deviation scores on the frequency judgment task (3 x 2 x 5 mixed-design)

Source	SS	df	MS	F	P
Group (G)	352.89	2	176.44	15.19	0.00
Error	1301.21	112	11.62	--	--
Instruction(I)	33.97	1	33.97	5.04	0.27
I X G	0.79	2	0.40	0.06	0.94
Error	755.38	112	6.74	--	--
Frequency(F)	2752.57	4	688.14	75.43	0.00
F X G	83.56	8	10.45	1.15	0.34
Error	4087.27	448	9.12	--	--
I X F	58.86	4	14.72	2.39	0.10
I X F X G	4.48	8	0.56	0.09	1.00
Error	2761.76	448	6.16	--	--

Appendix 3

Experiments 1A and 1B combined: Analysis of variance summary tabe for the corrected absolute deviation scores for the frequency judgment task (3 x 2 x 5 mixed-design)

Source	SS	df	MS	F	P
Group (G)	8.08	2	4.04	16.60	0.00
Error	27.26	112	0.24	--	--
Instruction(I)	0.50	1	0.50	3.58	0.06
I X G	0.02	2	0.01	0.07	0.93
Error	15.58	112	0.14	--	--
Frequency(F)	47.74	4	11.93	66.52	0.00
F X G	1.07	8	0.13	0.75	0.65
Error	80.38	448	0.18	--	--
I X F	1.16	4	0.29	2.38	0.08
I X F X G	0.11	8	0.14	0.11	1.00
Error	54.78	448	0.12	--	--

Appendix 4

Experiment 1A and 1B combined: Analysis of variance summary table for the frequency judgment in each quarter of the list (3 x 2 x 4 mixed-design)

Source	SS	df	MS	F	P
Group (G)	9.09	2	4.54	2.72	0.07
Error	187.27	112	1.67	--	--
Instructions(I)	1.62	1	1.62	2.75	0.10
I X G	1.78	2	0.89	1.51	0.23
Error	65.99	112	0.59	--	--
Quarter (Q)	3.14	3	1.05	3.05	0.03
Q X G	5.41	6	0.90	2.62	0.02
Error	115.41	336	0.34	--	--
I X Q	11.97	3	3.99	11.32	0.00
I X Q X G	3.71	6	0.62	1.75	0.11
Error	118.42	336	0.35	--	--

Appendix 5

Experiment 1A: Analysis of variance summary table for the temporal judgment task with two alternatives (2 x 2 mixed-design)

Source	SS	*df*	*MS*	*F*	*P*
Group (G)	0.00	1	0.00	0.13	0.72
Error	1.00	38	0.03	--	--
Instruction(I)	0.00	1	0.00	0.10	0.76
I X G	0.00	1	0.00	0.01	0.91
Error	1.07	38	1.07	--	--

Appendix 6

Experiment 1B: Analysis of variance summary table for the averaged scores on the temporal judgment task with four alternatives (3 x 2 x 4 mixed-design)

Source	SS	df	MS	F	P
Group (G)	1.60	2	0.80	1.79	0.17
Error	32.08	72	0.45	--	--
Instruction(I)	8.40	1	8.40	42.23	0.00
I X G	0.80	2	0.40	2.00	0.14
Error	14.32	72	0.20	--	--
Quarter (Q)	17.06	3	5.69	29.07	0.00
Q X G	5.66	6	0.94	4.82	0.00
Error	42.24	216	0.20	--	--
I X Q	0.67	3	0.22	1.34	0.26
I X Q X G	0.67	6	0.11	0.67	0.68
Error	36.07	216	0.17	--	--

Appendix 7

Experiment 1B: Analysis of variance summary table for the averaged scores on the temporal judgment task with four alternatives (3 x 2 x 4 mixed-design)

Source	SS	df	MS	F	P
Group (G)	91.86	2	45.93	6.86	0.00
Error	482.13	72	6.70	--	--
Instruction (I)	6.20	1	6.20	1.41	0.24
I X G	6.62	2	3.31	0.75	0.47
Error	316.05	72	4.39	--	--
Quarter (Q)	893.57	3	297.86	39.99	0.00
Q X G	123.43	6	20.57	2.76	0.01
Error	1608.63	216	7.45	--	--
I X Q	133.38	3	44.46	10.18	0.00
I X Q X G	21.74	6	3.62	0.83	0.55
Error	943.51	46	4.37	--	--

Appendix 8

Experiment 1B: Analysis of variance summary table for the corrected absolute deviation scores on the temporal judgment task with four alternatives (3 x 2 x 4 mixed-design)

Source	SS	df	MS	F	P
Group (G)	1.18	2	0.59	5.16	0.01
Error	8.20	72	0.11	--	--
Instruction(I)	0.01	1	0.01	1.37	0.25
I X G	0.17	2	0.08	1.17	0.32
Error	5.16	72	0.07	--	--
Quarter (Q)	1.28	3	0.43	3.54	0.02
Q X G	1.81	6	0.30	2.50	0.03
Error	26.08	216	0.12	--	--
I X Q	1.88	3	0.63	8.06	0.00
I X Q X G	0.56	6	0.09	1.21	0.30
Error	16.77	216	0.08	--	--

Appendix 9

Experiment 1A: Analysis of variance summary table for the spatial judgment task with four alternatives (2 x 2 mixed-design)

Source	SS	df	MS	F	P
Group (G)	0.05	1	0.05	3.93	0.05
Error	0.52	38	0.01	--	--
Instruction(I)	0.01	1	0.01	0.43	0.52
I X G	0.01	1	0.01	1.04	0.31
Error	0.47	38	0.01	--	--

Appendix 10

Experiment 1B: Analysis of variance summary table for the spatial judgment task with two alternatives (3 x 2 mixed-design)

Source	SS	df	MS	F	P
Group	0.07	2	0.04	1.74	0.18
Error	1.54	72	0.02	--	--
Instructions	0.00	1	0.00	0.23	0.63
I X G	0.02	2	0.01	0.70	0.50
Error	0.84	72	0.01	--	--

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