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SOME VERBAL FACTORS INFLUENCING TACHISTOSCOPIC RECOGNITION OF WORDS

by

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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.

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Abstract

SOME VERBAL FACTORS INFLUENCING TACHISTOSCOPIC RECOGNITION OF WORDS

by

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Recently, tachistoscopic studies have investigated differences in hemispheric functioning in response to simultaneously exposed alphabetical materials. The results of these studies have been equivocal. This inconsistency can be explained by methodological shortcomings including failure to control for directional reading habits and allowing observers to develop field preferences. In addition, these studies can be criticized for reporting only group data; failure to consider the reliability of field asymmetries; and using a single exposure duration.

The present study sought to eliminate these deficiencies by employing the following paradigm. Four dextral observers were tested monocularly in five test sessions. Vertically mounted words and nonsense syllables were presented bilaterally at each of four exposure durations using a tachistoscope that illuminated the two

half-fields equally. There were four stimulus presentation conditions-words in both half-fields (WW); a word in the right half-field-a nonsense syllable in the left (WN); a nonsense syllable in the right half-field- a word in the left (NW); and nonsense syllables in both half-fields (NN). All stimuli were presented at a retinal eccentricity of 3° from fixation.

The task was to identify verbally any word and its location (RVF or LVF). Nonsense syllables did not have to be reported.

Each test session was divided into two parts (one for each eye) of 160 trials each. At each of four exposure durations, ten cards for each condition (WW, WN, NW, NN) were presented. Type of stimulus material, exposure duration, and field of presentation were randomly varied. The eye initially tested was counterbalanced across sessions.

The results do not seem to support the hemispheric specialization hypothesis. While all observers did correctly identify more words in the RVF than in the LVF, these differences were not significant at the group level. When stimulus conditions were compared, scores for the WN condition were significantly greater than those for the WW condition.

The results on an individual level reflected the group findings, i.e. most scores failed to achieve statistical significance when fields of presentation were compared, and most scores were significant when the two exposure conditions were compared.

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INTRODUCTION

In recent years, many studies have attempted to uncover the functional differences between the visual half-fields, most frequently by using short exposures of varied stimuli. Most of this tachistoscopic work has employed a successive design; i.e., on any given exposure, the stimulus material is presented in either the right (RVF) or left (LVF) visual half-field of the eye. When alphabetical material is exposed, the common finding is a right visual field superiority, that is, a greater per cent correct identification occurs in the right visual half-field (White, 1969). When a simultaneous design is employed, however, the findings are not so consistent. In this procedure, stimuli are presented in both half-fields of the eye at the same time, hence the designation simultaneous or bilateral. Under these conditions, some investigators (Heron, 1957; Bryden, 1960; Bryden and Rainey, 1963; Neill, Sampson, and Gribben, 1971) reported a LVF superiority; others found a RVF superiority (McKeever, 1971; McKeever and Gill, 1972; McKeever and Huling, 1971a and 1971b; McKeever, Suberi, and Van Deventer, 1972; Hines, 1972, 1975; Mackavey, Curcio, and Rosen, 1975). Most of these contradictory findings can be attributed to a myriad of factors, including differences in stimulus control, (orientation in space, placement in the field, nature of the stimulus material), and/or procedure (instructions, type of fixation spot, length of exposure) etc. It was the diverse findings obtained with the simultaneous exposure procedure that led to the present study.

Influence of Directional Reading Habits

The early work using simultaneous exposures usually employed a horizontal array of letters as the stimulus. Heron (1957) used eight letters, four to either side of the fixation point. He found that more letters were recognized in the left visual field than in the right visual field. When letters were displayed unilaterally (successive design), however, those to the right of fixation were recognized more frequently than those to the left. To explain these results, Heron postulated a neural process, based on the left to right reading habits acquired through experience. Since the exposure durations used were too short to allow actual eye movements, Heron postulated that neural traces of the stimulus material are reviewed ("scanned") post-exposure in a left to right order. Thus, in the English language, when using a horizontal display of letters presented bilaterally, the left-most item (analogous to the beginning of a line of print) would be scanned first, and according to Heron, the subject would be expected to demonstrate a LVF superiority. In the case of a unilateral stimulus presented in the right visual field, the tendency to scan from the beginning of the line and the tendency to move the eyes to the right are in agreement. Therefore, one might expect greater recognition scores in the right visual field than in the left visual field.

The foregoing concepts are not particularly precise and have been partially refuted by studies employing bilingual subjects whose first language was Hebrew (where reading is performed in the reverse direction from English; i.e. right to left). Barton, Goodglass, and Shai (1965), sought to eliminate the influence of reading habits by presenting vertically arranged words, using a successive exposure technique. On half the trials, Hebrew words were presented, on the other half, English words. Barton, Goodglass, and Shai found a RVF superiority obtained for either right or left eye, for both Israeli and American subjects, and for both Hebrew and English words. Unfortunately, a successive design was used and hence an accurate comparison between left visual field and right visual field scores could not be demonstrated on any one trial. Orbach (1953) too, used bilingual subjects to study the relationship between reading habits and the recognition of verbal material. He employed a successive exposure procedure for the binocular viewing of Hebrew and English words. For Hebrew words, Orbach found a LVF superiority for subjects whose first language was Hebrew, and a RVF superiority for subjects who had learned the English language first. For English words, a RVF superiority was reported, regardless of the subjects' native tongue.

Kershner and Jeng (1972) used some of the innovations suggested by Barton, Goodglass, and Shai, and in addition used Chinese subjects. (The Chinese language is read from right top to bottom left and is arranged in vertical columns.) A simultaneous design was used to present Chinese words and English words and geometric forms to subjects who viewed the stimuli binocularly. When vertically mounted Chinese words were presented in both right and left visual fields at the same time, more words were identified correctly in the right visual field than in the left visual field. When English words were presented simultaneously, in a horizontal orientation, again,a RVF superiority was found, not a LVF superiority as Heron's theory would predict. Simultaneous presentation of geometric forms yielded no difference in how the stimuli in the right- and left visual half-fields were perceived. On the other hand, when a successive presentation paradigm was employed, significantly more forms were perceived in the RVF than in the LVF. However, an important criticism of this study is that the exposure durations that were used were quite long (125 msec.) and overt eye movements may have occured.

Influence of the Nature of Stimulus Material

It should be clear from the foregoing that both the nature of the "verbal" material and its "spatial" orientation are important in demonstrating either a right visual field or left visual field superiority. Bryden (1960) used a continuous line of either letters or geometric forms covering both left and right visual half-fields (centered about a fixation point) which was viewed with both eyes (binocular viewing). He found that significantly more stimulus material of both types was recognized correctly in the LVF than in the RVF. He also noted that subjects tended to report both types of stimulus material in a left to right order, suggesting a response bias. In a later experiment, Bryden and Rainey (1963) used the same design as above, and in addition introduced a third type of stimulus, outline drawings of familiar objects. Still, the same findings were reported, a left visual field superiority regardless of the nature of the stimulus material presented upon binocular viewing.

Binocular observation, in fact, means stimulation of homonymous half-fields, hence nasal-temporal hemi-retinal differences may be involved. Neill, Sampson, and Gribben (1971) used three randomly chosen letters (per field) in a horizontal simultaneous display procedure, so that both half-fields of the same eye were stimulated on any one exposure. When nasal and temporal half-fields were compared in the monocular viewing condition, material in the temporal field was identified correctly significantly more often than that in the nasal field, irrespective of eye. Neill, Sampson, and Gribben examined left-right half-field differences as well. For monocular viewing of simultaneous stimulus displays, a left visual field superiority was found for both right and left eyes. When the simultaneous array was viewed binocularly, a left visual field superiority resulted, while a successive design yielded a right visual field superiority.

Influence of Central Fixation Devices

As noted by McKeever and Huling (1971b), the experimental designs used in all of the above cited studies can be criticized on several methodological bases. For example, the exposure durations employed were often longer than 100 msec., the minimum time needed for overt eye movements to occur. Secondly, long exposure durations can result in the formation of afterimages, particularly at high luminance levels. Further, the use of single letters or strings of letters (which do not connote meaning) might be inappropriate stimuli for determining whether the cerebral hemispheres differ in their ability to process verbal material. Moreover, in many cases, fixation could not be ensured; hence the subjects might not be equally attentive to both half-fields, and/or the stimuli might go to the unintended hemisphere. To overcome some of these objections, McKeever and Huling made the following improvements: short exposure durations; the use of horizontally oriented "meaningful" words (common nouns) to emphasize the verbal nature of the task; and a technique (borrowed from Sperry) to force fixation. Specifically, an Arabic numeral was used as a fixation point, and the subject was required to identify correctly this numeral along with the words presented simultaneously to the two half-fields of any one eye on every trial. If the numeral was not correctly identified, the trial was eliminated. Using these more stringent controls, McKeever and Huling found that significantly more words were correctly identified in the right visual half-field than in the left visual half-field. This study was unique in that it provided the reader with the raw data for each subject. These data show that differences between the two visual half-fields were: extremely small; did not occur reliably on an individual basis (although they were apparent in group data); changed during ensuing trials; and were generally more pronounced on early exposure trials than on later ones.

Mackavey, Curcio, and Rosen (1975) replicated McKeever and Huling's study, and they too reported a right visual field superiority when horizontally displayed words were viewed monocularly and a digit was used to force fixation. In the second part of this study, a right visual field superiority was reported again, even though a vertical stimulus array was used to test the subjects monocularly, and this finding held true whether or not a central digit was present.

For the most part in the aforementioned studies, the stimulus displays have been horizontally oriented, and hence the results may reflect the prior influences of directional reading habits. More importantly, the letters of each word do not fall on homogeneous retinal areas; i.e. are not on the same isopter. To avoid these problems, McKeever and Gill (1972) presented words in a vertical orientation and used centrally placed Arabic numerals to control fixation. Subjects binocularly viewed the simultaneously exposed stimuli. Under these conditions, a right visual field superiority was obtained, even though the recognition level was much lower than that found when words were presented horizontally. A problem with this study is that the stimulus words were presented at 1.6° of visual angle from fixation, and hence may have been on retinal loci thought to project to both cerebral hemispheres (bilateral representation of the macula). This criticism can also be leveled at the work done by Neill, Sampson, and Gribben (1971). The left visual field superiority that they reported was based on a six letter stimulus array that spanned only 2° 15' in total length.

In yet another study designed to investigate how forcing fixation affects the perception of verbal (meaningful words) and nonverbal (nonsense shapes) material, Hines (1972) confirmed the prevalent results; greater recognition of words in the left visual field with no center digit present, and a greater recognition of words in the right visual field when a central digit was present. Hines used a horizontal word display and tested his subjects binocularly using a simultaneous stimulus exposure procedure. For nonsense shapes, however, either with or without a central digit, more shapes were recognized in the right visual field. In brief, only on the verbal task did the presence of the central digit shift the asymmetry in recognition from the left visual field to the right visual field. That both words and nonsense shapes may be better identified in the right visual half-field was confirmed by Hines (1975) using a central digit to control fixation, and exposing horizontally arranged words or nonsense shapes or faces simultaneously to be viewed binocularly. In addition he found that regardless of what other stimuli the words were paired with on any one given exposure, a large right visual field superiority was always present. In short, pairing a word with either other words, or shapes, or even faces did not alter the right visual superiority for the recognition of horizontally oriented words.

In all five of the above mentioned studies, a right visual field superiority was reported for the first time using simultaneously exposed "verbal" material. All five used a digit to ensure fixation, but only two of the five (Mackavey, Curcio, and Rosen, 1975; McKeever and Gill, 1972) used vertically oriented words, and these studies used very long exposure durations, and presented the stimuli quite near to the fixation spot, respectively. Thus a central fixation digit may be a requirement for demonstrating a RVF superiority, but if so, this would obtain for both words and nonsense shapes. In any event, the possible role of "meaningful" words as opposed to "nonsense" syllables, has not been investigated with bilateral simultaneous stimulus exposures, either with or without a central fixation spot. Presumably a word becomes "meaningful" when it connotes action or describes an object (a verb or noun), while the same letters arranged in a different serial order would not, i.e. would be solely a nonsense syllable. Psycholinguistically speaking, the former would be a morpheme and would connote meaning, the latter a phoneme and would not.

Hemispheric Specialization

The possible physiological basis of a right visual field superiority for verbal material has been much stressed in recent years, with particular reference to the concept of hemispheric specialization (Milner, 1971; Kimura, 1966, 1973). According to this theory, each hemisphere is "specialized" to process different kinds of information or input. The underlying asymmetry or dominance of the left hemisphere is for the processing of "verbal" material. This concept basically reflects the known fact that left hemisphere lesions are much more prone to produce aphasia than are lesions in the right hemisphere. On the other hand, the right hemisphere is thought to be involved in visuo-spatial tasks. This concept finds support in the effects of right hemisphere lesions (parieto-temporal) which produce complex deficits in the visual recognition of common objects (visual agnosias). According to some (Kimura, 1966, 1973), when verbal material is presented in the right visual half-field, the retinal "input" traverses a more direct path to the contralateral (left) hemisphere than to the ipsilateral one. When the "input" arises from the left visual half-field, it must go first to the right hemisphere, then via the corpus callosum to the left, and hence it undergoes some "degradation". For bilateral presentation of stimulus material that is alphabetical in nature, Kimura acknowledges the role that reading habits might play, and hence that a left visual half-field superiority might be obtained due to the influence of prior reading habits.

Attentional Bias or Set

Other theories have emphasized the importance of set or attention in producing visual half-field differences. Kinsbourne (1970) attributed the RVF superiority for the recognition of verbal material to a left hemisphere dominance which results in a state of expectancy for verbal input. If the subject expects a word to be exposed, the left hemisphere becomes "primed" for activity, and attention is then biased to the right side of the field. Heron (1957) also offers an explanation focusing on attentional bias. He found that if subjects were informed as to where in the field the stimulus would appear, scores for correct identifications in the left visual half-field were significantly greater than if the subjects were uninformed. No such differences were reported for the right visual half-field. Heron suggests that the more efficient recognition of letters in the right visual half-field may be due to a tendency or set always to attend more to the right than to the left.

In general, some sort of interaction between set and cerebral dominance might account for the findings of a right visual field superiority when verbal material is presented in both half-fields. Of all the bilateral studies that report such a RVF superiority, none had conditions in which the subject was unsure as to the type of stimulus material to be presented. Moreover, in all of the above-cited studies, the subjects knew or soon learned that words would appear in both visual half-fields on every trial. Under such circumstances, it is possible that subjects would adopt a "set" or response bias strategy, presumably to the right side of the field. On the other hand, neurological studies have indicated that patients with damage of the cerebral visual system may exhibit an "extinction" of a perceived object in one half-field upon stimulation of the contralateral field, even when attention is not involved (Bender, 1952).

The present study attempted to minimize the role of attentional bias, while at the same time maximizing the "verbal" nature of the material to be presented. This was accomplished by exposing a three letter word in either the right or left visual field, while simultaneously exposing a three letter nonsense syllable or another three letter word in the contralateral half-field. The observer's task was to identify only the word(s) that was presented and its (their) field(s) of presentation. The fact that on any given trial words could be presented on the left, right, or both sides of fixation reduced the likelihood of attentional bias operating. This is because the best strategy for maximizing recognition in the present paradigm would be to maintain fixation and not to attend to a given field. The bias that might result from reporting stimuli in a fixed order (e.g. LVF stimuli, then RVF stimuli) was partially corrected for by using trials in which words were presented on either the LVF or RVF, while nonsense syllables were present in the contralateral half-field.

With two exceptions (McKeever and Huling, 1971b; and McKeever and Gill, 1972), all studies previously undertaken have presented only group data, usually in the form of per cent correct identifications. Hence little is known of individual performance, or, in fact, whether any given subject would reliably demonstrate a right visual field or left visual field superiority over several sessions. Moreover, none of the above-mentioned studies has measured psychometric functions at varying luminance or exposure durations, and as a result little is known about sensitivity differences between the visual half-fields. If a left cerebral dominance does indeed account for the presumed right visual field superiority for "verbal" material, then it should be consistent over time and reliably demonstrable at the individual level.

Summary and Objectives of the Present Study

In summary, many studies have been conducted to determine the field superiority that results when alphabetical material is simultaneously presented to both left and right visual half-fields. The findings of such studies have been inconsistent, owing in large part to methodological differences.

The primary objective of the present study is to determine what field differences can be demonstrated for simultaneously presented verbal material when an attempt is made to eliminate directional reading habits, and to minimize the biasing effects of attending to a given half-field and reporting stimuli in a fixed directional order (e.g., LVF then RVF or vice versa).

Directional reading habits were eliminated by using vertically mounted stimulus arrays. The problem of attentional bias was minimized by instructing observers to maintain fixation and to have them (as opposed to the experimenter) initiate stimulus presentations when fixation was maintained. Moreover, attentional bias was minimized by presenting, on a given trial, a word to the LVF, RVF, or both visual half-fields. Thus, because the task was to identify only words, and the observers could not be sure that a word would always appear in a given half-field, the best strategy for maximizing recognition would be to maintain fixation. The bias that might result from reporting stimuli in a fixed order was partially corrected for in one condition by using trials in which a word was presented in either the LVF or RVF, while a nonsense syllable was presented in the contralateral half-field (WN or NW condition). On such trials, observers had to report only one stimulus (the word) and thus, report order bias was eliminated. In addition to the above controls, the present study, unlike many previous studies, employed verbal material which has specific meaning (words). Moreover, in the present study, all three letters of the word have to be identified in order for a correct recognition to occur. This was accomplished by choosing words that were alike except for one letter, and by using nonsense syllables that had the same three letters as each stimulus word.

An additional shortcoming found in past studies is the reporting of group data (usually mean recognition scores), while totally ignoring and obscuring individual differences. This sort of data analysis presents a problem because half-field differences for individual observers may fail to achieve statistica significance, but when these scores are combined and treated as a group, previously insignificant results for individual observers may deliver a significant group score.

None of the previous studies measured performance over several sessions. This is the type of measurement necessary to determine if any reported field superiority is constant and reliable over time. The present study examined each observer's performance over five sessions, as well as how the observers did as a group.

Past studies uniformly used only a single exposure duration when presenting stimuli. One obvious problem with this methodology is that it does not allow for the generation of psychophysical functions, and thereby precludes the determination of threshold estimates (50% correct recognitions) for the two half-fields of presentation, thus eliminating a means of comparing the sensitivity of the two half-fields.

In brief, the present study sought to determine what field differences can be demonstrated when alphabetical stimulus material is bilaterally presented, when several methodological problems found in previous studies are controlled for or eliminated. The present study evaluated differences in recognition scores that occured in response to two types of stimulus materials, words presented to both half-fields, and the presentation of a word to one half-field and a nonsense syllable to the other. An additional objective of the present study was to determine how consistent and reliable recognition scores remained over several testing sessions.

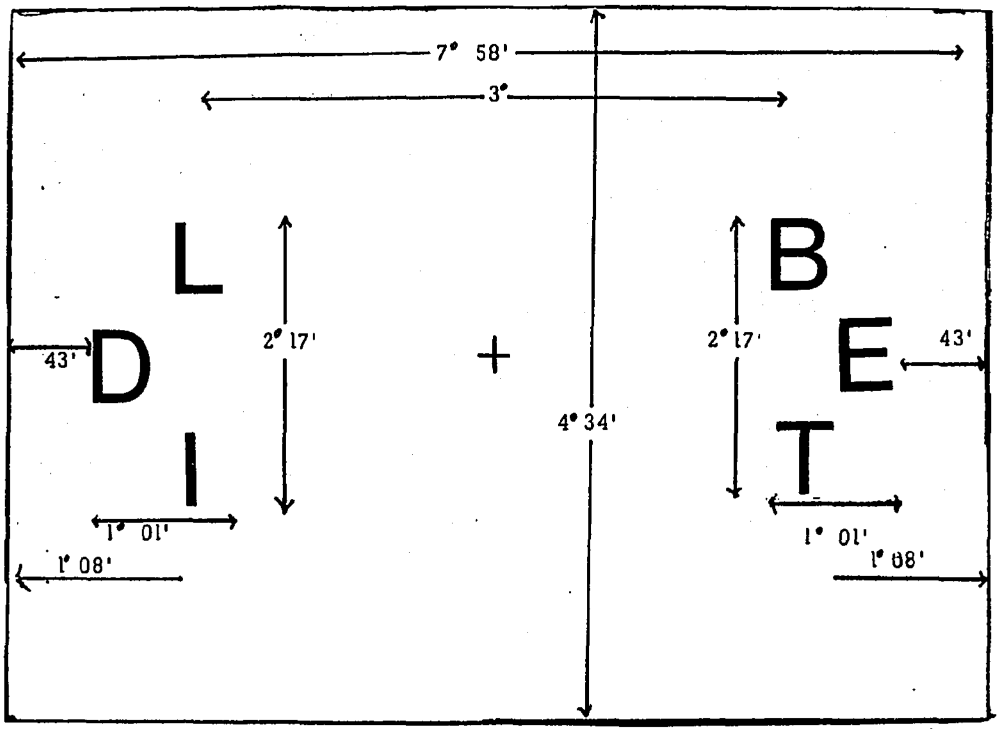
METHOD

Observers: Four graduate students served as observers (Os) in this study. All Os, three males (HC, JH, LG) and one female (MW) had normal or corrected to normal acuity and were right-handed and right eye dominant.[1] Each O was given as many practice sessions as were necessary in order to become facile at the task, and to generate estimates of the exposure durations to be used in the actual experiment. Os were paid $4 per hour and were tested individually in five test sessions, each lasting about 120 minutes.

Apparatus: A three-channel tachistoscope (Scientific Prototype model GA) was employed. The adapting field and fixation target were presented through the blank channel. Stimuli were delivered through channel 1. To make the visual half-fields of these channels approximately equal in luminance, aluminum foil and black cardboard were affixed to the white reflecting plates.[2] Both channels had luminances of .56 ft. L as measured by a Pritchard photometer (Photo Research Company, Inc.) at the eye. A standard viewing distance of 50 inches produced a visual field of 7°58' horizontally by 4°54' vertically.

The stimulus cards consisted of black upper case letters (Prestype #1248) affixed to blank 5x7 white cards (Figure 1). In

Figure 1. Diagram of representative stimulus used in the present study. Dimensions of field, stimulus material, and retinal eccentricity are indicated in degrees of visual angle.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D
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43'
2° 17'
2° 17'
4° 34'
1° 01'
1° 01'
1° 08'
1° 08'

an attempt to provide the Os with a stable view, a chin rest was used. Each O was instructed to adjust it until the right and left visual half-fields seemed to be of equal size. The idea was to have an eye-centered, rather than a head-centered observer.[3] The O initiated each trial by depressing a foot switch that triggered the stimulus 1.2 seconds later.

Procedure: The study was performed in a darkened room, with a red light bulb providing the ambient light needed for the experimenter, E, to change the stimulus cards and record O's responses, which were given verbally. A wooden screen was attached to the front of the tachistoscope, as was a viewing hood, to prevent the O from observing the stimuli to be presented.

Each O had both eyes tested, one at a time, during every session. The eye not being tested was occluded by a black patch. A simultaneous or bilateral paradigm was employed; i.e., on every trial, stimulus material was present in both the right and left visual half-fields. Stimulus material consisted of eight vertically mounted three letter words, (LIT, LET, LID, LED, BIT, BET, BID, BED) and eight vertically mounted three letter nonsense syllables, which were the same words as above, with the second and third letters interchanged, (LTI, LTE, LDI, LDE, BTI, BTE, BDI, BDE). The words subtended a visual angle of 1° 01' horizontally and $2^{\circ}17'$ vertically, and were presented at a retinal eccentricity of 3°. All letters were the same height, subtending 34' in the vertical extent and from 4' to 26' horizontally. The spaces between the letters subtended a visual angle of 17'.

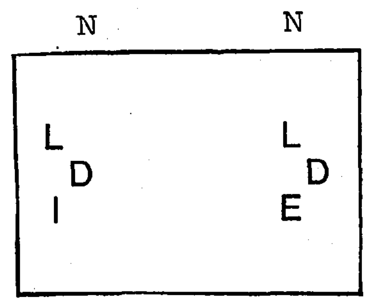
The similarity of the words chosen as stimuli reflected an effort to make the Os attend to all three letters before a correct identification could be made. An additional refinement toward the same end was to have the center letter of each vertically mounted stimulus transposed one letter width to either the right or the left of the other two letters. This was done so that once again, the O had to pay attention to all features of the lexical display in order to integrate the three letters into a whole word.

On any given trial, the O's task was to identify correctly any word(s) present and their field of presentation. Only words had to be identified, nonsense syllable did not. Four exposure durations were used. These were selected at the start of each test session in order to obtain psychometric functions ranging from about 20% to 80% correct recognitions for that particular day. An ascending method of limits was initially used to get an estimate of the range of durations needed for correct identifications. This was done at the beginning of the test session by selecting a subthreshold exposure duration which was increased in one msec. steps until O correctly identified six stimuli in succession. From the exposure duration that yielded the six correct identifications, two, four, and six msec. were subtracted, producing four exposure durations with a range of six msec.

There were four stimulus conditions: (Figure 2) -nonsense syllables appearing on both sides of the fixation spot (NN); words appearing in both the right and left visual half-fields, the word-word condition (WW); a word in the left visual half-field and a nonsense syllable in the right visual half-field, the word-nonsense syllable condition (WN); and a word to the right of fixation and a nonsense syllable to the left, the nonsense syllable-word condition (NW). From here on, WN will refer to both WN and NW.

In every testing session, each of the four conditions appeared ten times at each of the four exposure durations for a total of 160 cards being shown to each eye. Each of the eight words and eight nonsense syllables had an equal probability of appearing at a specific exposure duration in either the right or left visual half-field. Thus a total of 320 trials was presented at every sitting, half to the right eye, the other 160 to the left eye. The order of testing eyes was counterbalanced over sessions and across subjects. Within each session, field of presentation, type of stimulus (WW, WN, NW, NN), exposure duration, and transposition of the middle letter (either towards or away from the fixation spot), were all randomly varied. At the end of five sessions, there were

Figure 2. Diagram of the four types of stimulus materials used in the present study.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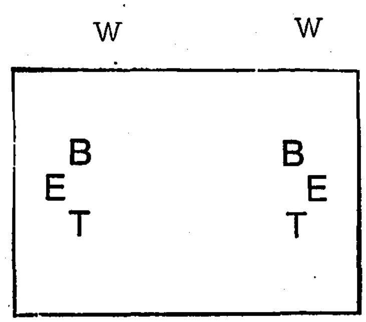
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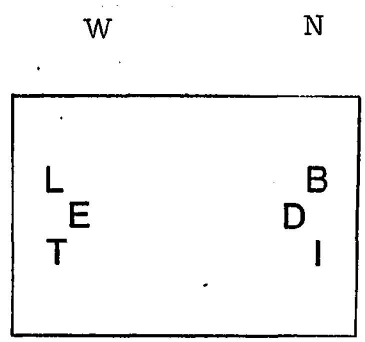
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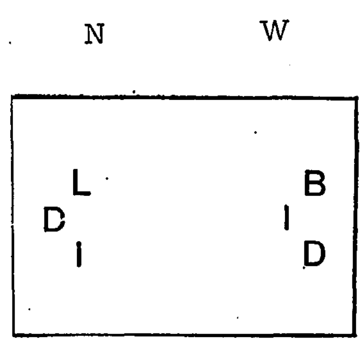
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50 trials contributing to each of the four data points (exposure durations) for the psychometric functions, for each eye. Thus a maximum recognition score of 50 per field, per exposure duration was possible, but never achieved.

A typical trial began with the stimulus cards being in position in card holders, and O telling the experimenter that fixation was being maintained. O then depressed the foot switch, and a stimulus was presented for a variable exposure duration. O then gave his (her) verbal response to the stimulus card, which E recorded. E changed the stimulus card, varied the exposure duration, and said "ready". When O believed that he was adequately fixating, he stepped on the switch and the sequence began again. Each half session was divided into ten blocks of 16 trials. Two to three minute rest periods were given between blocks of trials in order that E could position the next group of stimulus cards. When the 160 trials were completed, O was allowed a ten to fifteen minute rest period, and then the entire testing procedure was repeated for the eye that had been occluded during the first part of the testing session.

Prior to any testing, O was given a written list of the stimulus choices, and told the probability of the presentation of the four types of stimulus material. During testing, O was advised to initiate a trial only when he was maintaining fixation, and to respond only when he was reasonable sure of the word(s) being exposed on that trial. O was cautioned not to guess.

In order for a response to be scored as correct, accurate identification of the three letter word(s) and the exact field that the word(s) appeared in were required. Three types of correct responses were possible:

1. NO word present (NN condition). This received no score as only words were scored.
2. WORD in the left (or right) visual half-field, (WN or NW condition). A score of one correct response in that particular visual half-field was given for a correct identification and location.
3. WORD(S) in the right and/or left visual half-field(s), (WW condition). A score of two correct responses was possible in this situation, one for the right visual half-field, and one for the left visual half-field. If only one word and locus were identified correctly, then the O was credited with giving only one correct response.

Data Analysis: As noted above, for any given testing session, each O received ten exposures at each of four durations for each of the four stimulus conditions, or a total of 160 trials per eye. From this data, per cent correct identifications were calculated for each half-field, and for the WW and WN combinations. Over five testing sessions the cumulative per cent correct recognitions were calculated, (N=50). These were the mean or average per cent correct identifications for each O. Then values were calculated for the group as a whole. Mean per cent correct identifications over all four Os, over all five testing sessions at each of the four exposure durations were calculated for each half-field, for WW and WN pairings, and for each eye (N=200). From these values, a grand mean was calculated, i.e., the mean of the group means.

FOOTNOTES

[1] Hand and eye dominance were determined by procedures described by Crovitz and Zener.

[2] D'Amico found that for Channel 1, (the channel in which the stimuli were presented), "The luminance of the RVF was approximately 16% greater than that of the LVF. A discussion of this problem with a technical representative of Scientific Prototypes revealed that, for most planar tachistoscopes, the luminance of the RVF is considerably (approximately 15-20%) greater than that of the LVF in Channel 1, while the reverse is true for Channel 2 (the other stimulus channel, in which the stimuli are rotated 180 degrees)."

[3] D'Amico found that when observers had their heads centered in the chin rest and viewed the stimulus array monocularly with either eye, the two half-fields appeared unequal in size, with the stimuli in the temporal half-field appearing further away from the blackened border than did the stimuli in the nasal half-field. When the observers' eyes were centered, the two fields appeared to be of equal size and the stimuli in the temporal half-field and the stimuli in the nasal half-field appeared equally distant from their respective borders.

RESULTS

Raw Data

Tables la and lb contain the raw data for the left eye (OS) and right eye (OD) respectively. The data are in the form of per cent correct recognitions of the words that have been presented to either the left - or right visual half-fields. For each of the four Os the data is arranged vertically for each of the five test sessions. Successively longer durations of exposure, numbered one through four, are displayed across the top of the table. Near the bottom of the table are the group means which represent the average per cent correct recognition scores shown by the group of subjects for each of the four exposure durations and for each of the five test sessions and per subject. At the bottom of the table a grand mean has been calculated for each exposure duration over all subjects and testing sessions. This grand mean represents cumulative values averaged over all five testing sessions per condition and per eye.

Table 1a1

Individual Data:Left Eye (OS). Per cent correct recognition of words presented to the LVF under word-word (WW) and word-nonsense syllable (WN) stimulus presentations.

Observer		LVF							
		WW				WN			
	Exp.	1	2	3	4	1	2	3	4
HC	1	20	50	60	70	30	30	20	60
	2	0	50	70	100	0	70	70	100
	3	0	30	30	60	0	10	80	70
	4	0	50	90	80	10	50	90	80
	5	0	40	80	90	10	50	40	90
Mean=		4	44	66	80	10	42	60	80
MW	1	10	50	60	60	30	70	80	90
	2	20	50	30	50	30	50	60	80
	3	30	40	90	70	60	50	90	90
	4	30	50	80	50	30	30	100	70
	5	30	70	80	50	40	80	70	90
Mean=		24	52	68	56	38	56	80	84
JH	1	80	50	70	60	50	60	80	80
	2	60	40	20	50	50	70	70	90
	3	50	50	70	30	50	80	40	50
	4	20	40	20	40	60	70	70	50
	5	10	20	10	30	20	60	90	90
Mean=		44	40	38	42	46	68	70	72
LG	1	40	40	70	40	40	80	50	80
	2	60	10	40	20	20	60	60	90
	3	20	20	40	70	60	50	80	70
	4	30	50	70	50	30	60	70	50
	5	30	30	50	70	60	70	80	90
Mean=		36	30	54	50	42	64	68	76
GROUP Means	1	37.5	47.5	65	57.5	37.5	60	57.5	77.5
	2	35	37.5	40	55	25	62.5	65	90
	3	25	35	57.5	57.5	42.5	47.5	72.5	70
	4	20	47.5	65	55	32.5	52.5	82.5	62.5
	5	17 5	40	55	60	32.5	65	70	90
Means=		27	41.5	56.5	57	34	57.5	69.5	78

Table la2

Individual Data:Left Eye (OS). Per cent correct recognition of words presented to the RVF under word-word (WW) and word-nonsense syllable (WN) stimulus presentations.

Observer		RVF							
		WW				WN			
	Exp.	1	2	3	4	1	2	3	4
HLC	1	50	70	50	80	60	60	90	80
	2	0	70	80	90	50	70	80	100
	3	0	50	90	100	10	90	80	100
	4	10	70	90	100	10	80	80	100
	5	10	70	100	90	0	70	80	100
Mean=		14	66	82	92	26	74	82	96
MW	1	20	40	50	100	20	90	80	70
	2	10	40	50	70	20	70	60	70
	3	30	50	80	90	70	80	80	90
	4	30	50	100	100	40	50	80	80
	5	20	70	60	90	40	90	80	100
Mean =		22	50	68	90	38	76	76	82
JH	1	30	30	40	30	70	70	60	80
	2	0	50	70	60	30	70	60	80
	3	50	40	30	70	60	60	90	90
	4	40	60	80	60	60	50	60	70
	5	30	20	50	50	20	20	40	70
Mean =		30	40	54	54	48	54	62	78
LG	1	40	30	50	80	40	80	70	90
	2	40	70	90	90	40	60	100	70
	3	90	100	70	70	80	90	100	90
	4	50	60	80	80	80	80	100	100
	5	50	90	100	100	90	80	80	100
Mean =		54	70	78	84	66	78	90	90
GROUP	1	35	42.5	47.5	72.5	47.5	75	75	80
Means	2	12.5	57.5	72.5	77.5	35	67.5	75	80
	3	42,5	60	67.5	82.5	55	80	87.5	92.5
	4	32.5	60	87.5	85	47.5	65	80	87.5
	5	27.5	62.5	77.5	82.5	37.5	65	70	92.5
Means=		30	56.5	70.5	80	44.5	70.5	77.5	86.5

Table 1b1
Individual Data:Right Eye (OD). Per cent correct recognition of words presented to the LVF under word-word (WW) and word-nonsense syllable (WN) stimulus presentations.

Observer		LVF							
		WW				WN			
	Exp.	1	2	3	4	1	2	3	4
HC	1	10	60	40	80	20	70	80	90
	2	10	70	80	80	20	90	100	90
	3	0	40	90	80	0	60	60	100
	4	0	40	100	90	0	80	80	90
	5	0	40	100	100	0	30	80	90
Mean=		4	50	82	86	8	66	80	92
MW	1	0	20	50	30	10	30	60	70
	2	10	40	30	90	10	40	50	70
	3	0	50	50	40	30	50	60	90
	4	10	30	60	70	40	30	60	80
	5	10	40	60	70	20	60	80	90
Mean=		6	36	50	60	22	42	62	80
JH	1	50	50	30	40	60	80	60	70
	2	0	40	40	50	50	60	90	40
	3	30	50	20	70	50	80	50	70
	4	0	40	60	50	20	70	60	60
	5	10	40	50	80	30	20	50	50
Mean=		18	44	40	58	42	62	62	58
LG	1	50	70	40	40	60	70	60	80
	2	30	30	40	40	20	90	80	90
	3	40	20	60	70	60	60	90	70
	4	20	10	40	70	30	50	80	90
	5	10	70	80	50	50	70	60	90
Mean=		30	40	52	54	44	68	74	84
GROUP	1	27.5	50	40	47.5	37.5	62.5	65	77.5
MEANS	2	12.5	45	47.5	65	25	70	80	72.5
	3	17.5	40	55	65	35	62.5	65	82.5
	4	7.5	30	65	70	22.5	57.5	70	80
	5	7.5	47.5	72.5	75	25	45	67.5	80
Means		14.5	42.5	56	64.5	29	59.5	69.5	78.5

Table 1b2

Individual Data:Right Eye (OD). Per cent correct recognition of words presented to the RVF under word-word (WW) and word nonsense syllable (WN) stimulus presentations.

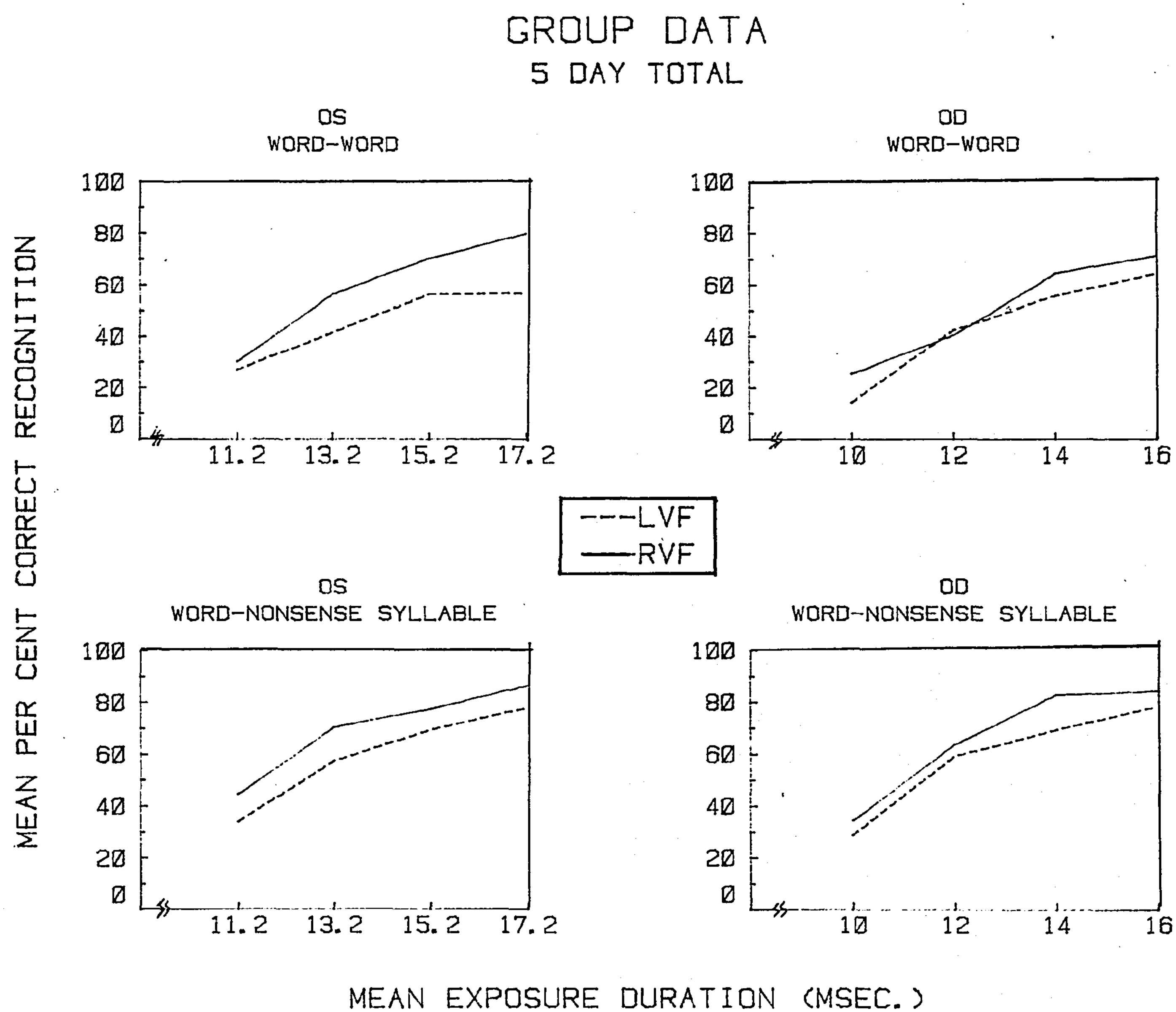
Observer		RVF							
		WW				WN			
	Exp.	1	2	3	4	1	2	3	4
HC	1	10	50	90	80	10	80	100	90
	2	10	50	70	100	10	80	90	100
	3	0	10	80	100	0	80	90	90
	4	0	10	80	80	0	60	100	90
	5	0	30	100	100	10	40	90	100
Mean =		4	30	84	92	6	68	94	94
MW	1	40	0	80	50	20	60	80	70
	2	20	40	80	40	40	30	30	70
	3	10	40	30	60	20	40	80	70
	4	10	30	50	80	10	60	70	90
	5	10	60	70	70	50	60	80	90
Mean=		18	34	62	60	28	50	68	78
JH	1	10	40	60	30	50	70	100	90
	2	30	30	50	80	30	80	70	80
	3	60	40	70	20	70	70	80	90
	4	10	20	30	40	20	20	70	50
	5	30	30	20	50	10	40	70	40
Mean=		28	32	46	54	36	56	78	70
LG	1	10	40	50	70	60	70	80	90
	2	60	60	50	80	60	70	100	100
	3	40	80	60	80	70	80	100	90
	4	70	90	90	90	60	100	90	100
	5	80	60	80	80	90	90	90	100
Mean=		52	66	66	80	68	82	92	96
GROUP	1	17.5	32.5	70	70	35	70	90	85
MEANS	2	30	45	62.5	75	35	65	72.5	87.5
	3	27.5	42.5	60	65	40	67.5	87.5	85
	4	22.5	37.5	62.5	72.5	22.5	60	82.5	82.5
	5	30	45	67.5	75	40	57.5	82.5	82.5
Means		25.5	40.5	64.5	71.5	34.5	64	83	84.5

Field Effect

The tabular data above are displayed graphically in Figure 3., for group data ,in terms of mean per cent correct recognitions on the ordinate versus mean exposure durations along the abscissa, with field of presentation (LVF vs. RVF) as parameter. Figure 3 represents data obtained from exposures both to the left eye (labelled OS on the left side of the figure) and to the right eye (labelled OD on the right side of the figure). At the top are shown the functions obtained for the viewing of the word-word pairs, and across the bottom for the viewing of word-nonsense syllable pairs. The data for right and left visual half-field presentations are represented by solid and dashed lines respectively. Visual inspection of this graphed data show a small but consistent difference in the recognition scores between the right and left visual half-fields (RVF - LVF) for both stimulus conditions for the left eye, and a similar but lesser difference for the right eye.

Group data was evaluated by an analysis of variance technique, and it found the field main effect to be not significant (Table 4).

Figure 3 . Mean per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for Group. The word-word (WW) condition is across the top; word-nonsense syllable (WN) is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.


GROUP DATA
5 DAY TOTAL
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)
LVF
RVF
0
20
40
60
80
100
11.2
13.2
15.2
17.2
10
12
14
16

The individual data were plotted in the same format as the group data. When so analyzed, the graphed results for only one O, LG, demonstrated a RVF superiority in both the WW and WN conditions for both the left and right eyes (Figure 4). One other O, HC, showed a RVF superiority for both the WW and WN conditions for only the left eye (Figure 5). On the other hand, Os JH and MW (Figures 6 and 7, respectively) showed no field preference for either eye in either stimulus condition. These descriptive observations were corroborated by the results of correlated t-tests (Table 2). For O:LG recognition was significantly greater in the RVF in both the WW and WN conditions for the left eye, and in the WN condition for the right eye. O:HC showed a significant RVF superiority in the WN condition for the left eye. The recognition differential favoring the RVF for O:HC in the WW condition, however, just missed being significant ($t_{05}=2.78$; $t_{calculated}=2.69$). O:HC's other field differences were not significant for the right eye. With the exception of O:MW, who showed a significant RVF superiority in the WW condition for the left eye, all other field differences were not significant.

The design of the present study permitted the investigator to compare within session variability of half-field differences. For each O, (LG,HC,JH,MW), the graphed data obtained from his or her five individual test sessions can be seen in the Appendix (pps. 92-131).

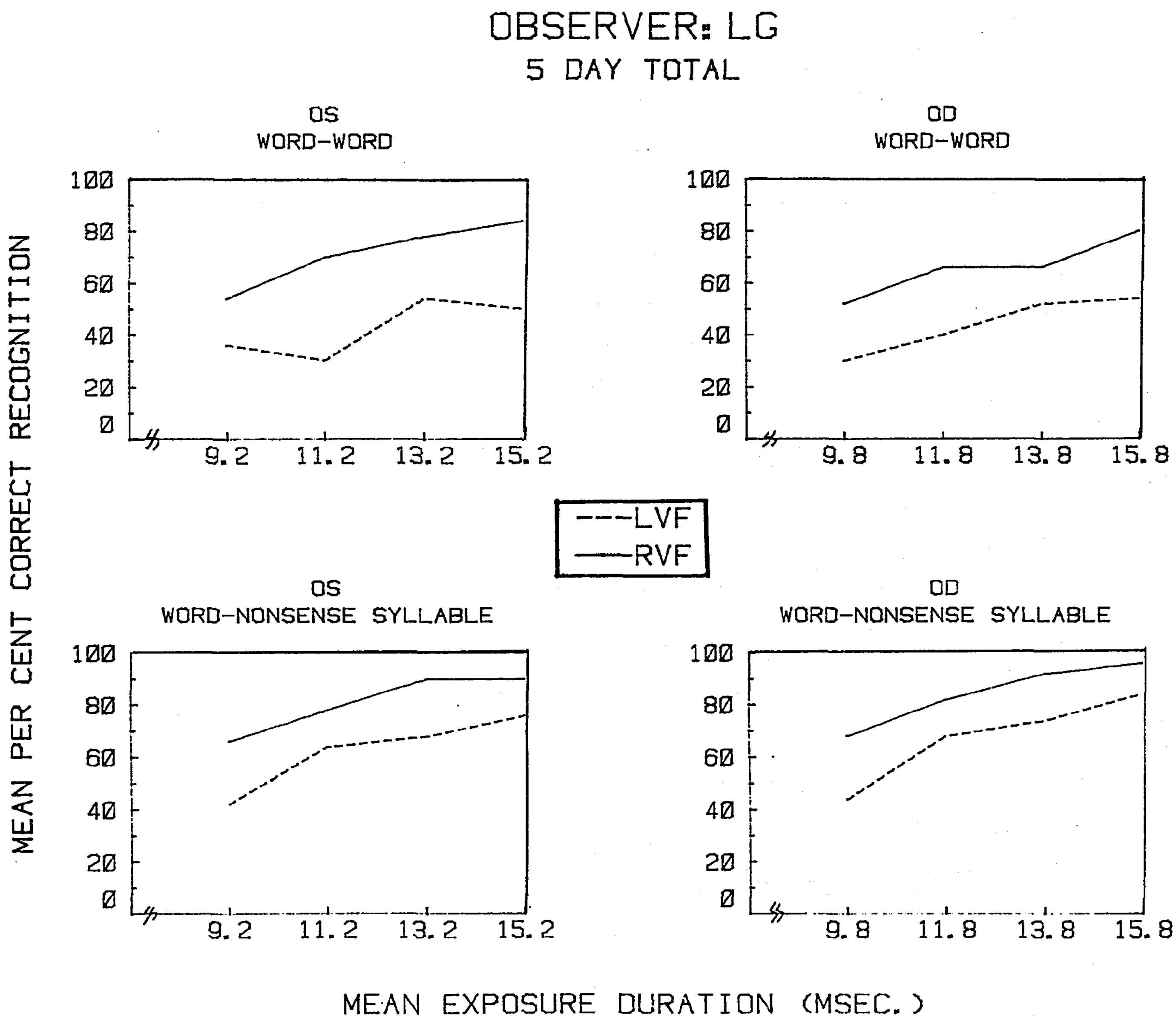
Table 2

Dependent t values for Field as Parameter: Same eye comparisons of half-field (RVF-LVF) differences in per cent correct recognitions for the viewing of word-word (WW) and word-nonsense syllable (WN) conditions.

	OS		OD	
Observer	WN RVF-LVF	WW RVF-LVF	WN RVF-LVF	WW RVF-LVF
HC	4.12*	2.69	1.37	-.75
MW	1.72	2.86*	1.12	2.12
JH	-.45	.33	-.76	1.11
LG	3.06*	4.03*	4.88**	2.38

*p .05
**p .01

Figure 4 . Mean per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: LG. The word-word (WW) condition is across the top; word-nonsense syllable (WN) is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: LG
5 DAY TOTAL
OS
WORD-WORD
OD
WORD-WORD
100
80
60
40
20
0
9.2
11.2
13.2
15.2
9.8
11.8
13.8
15.8
---LVF
——RVF
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)

Figure 5. Mean per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:HC. The word-word (WW) condition is across the top; word-nonsense syllable (WN) is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: HC
5 DAY TOTAL

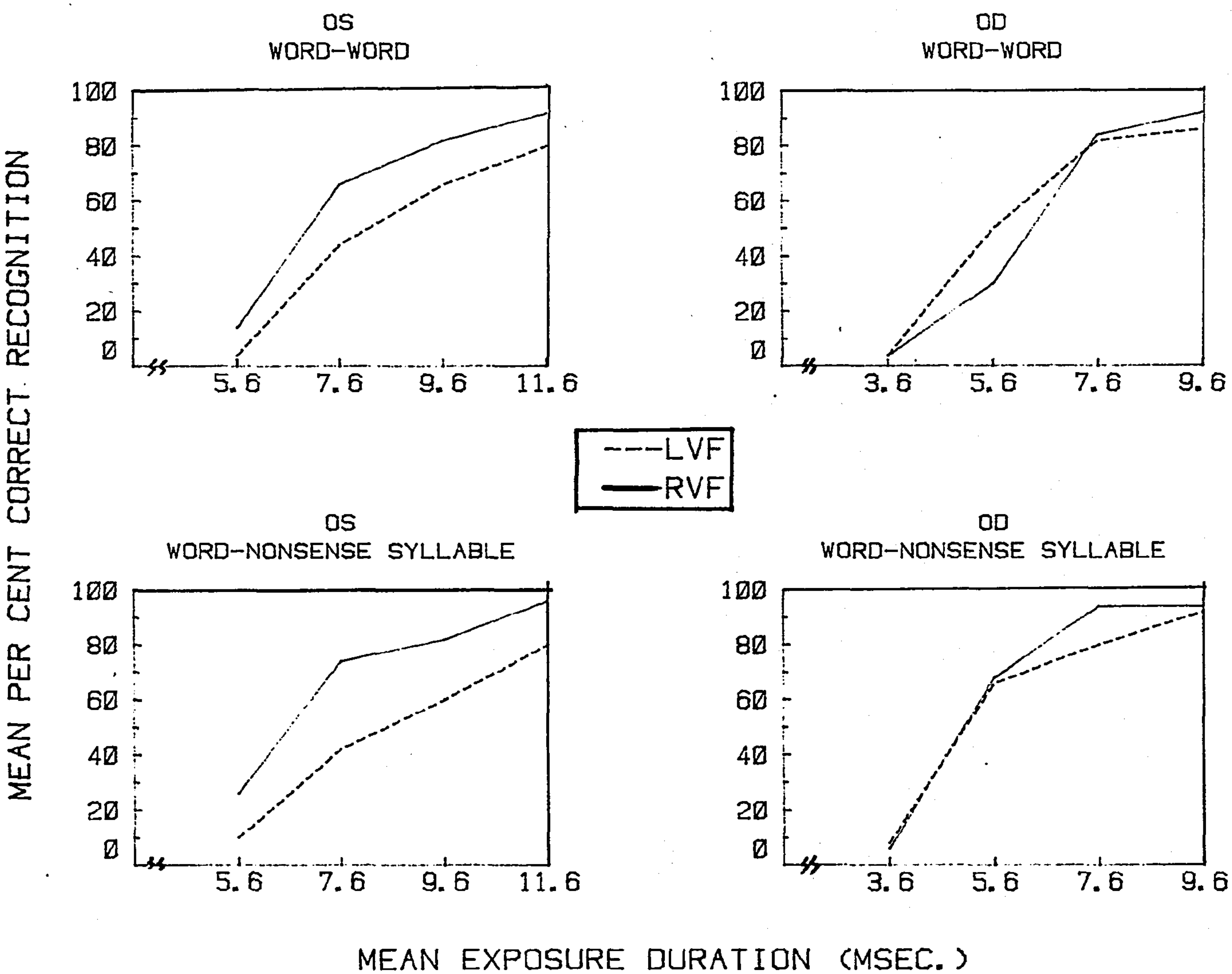
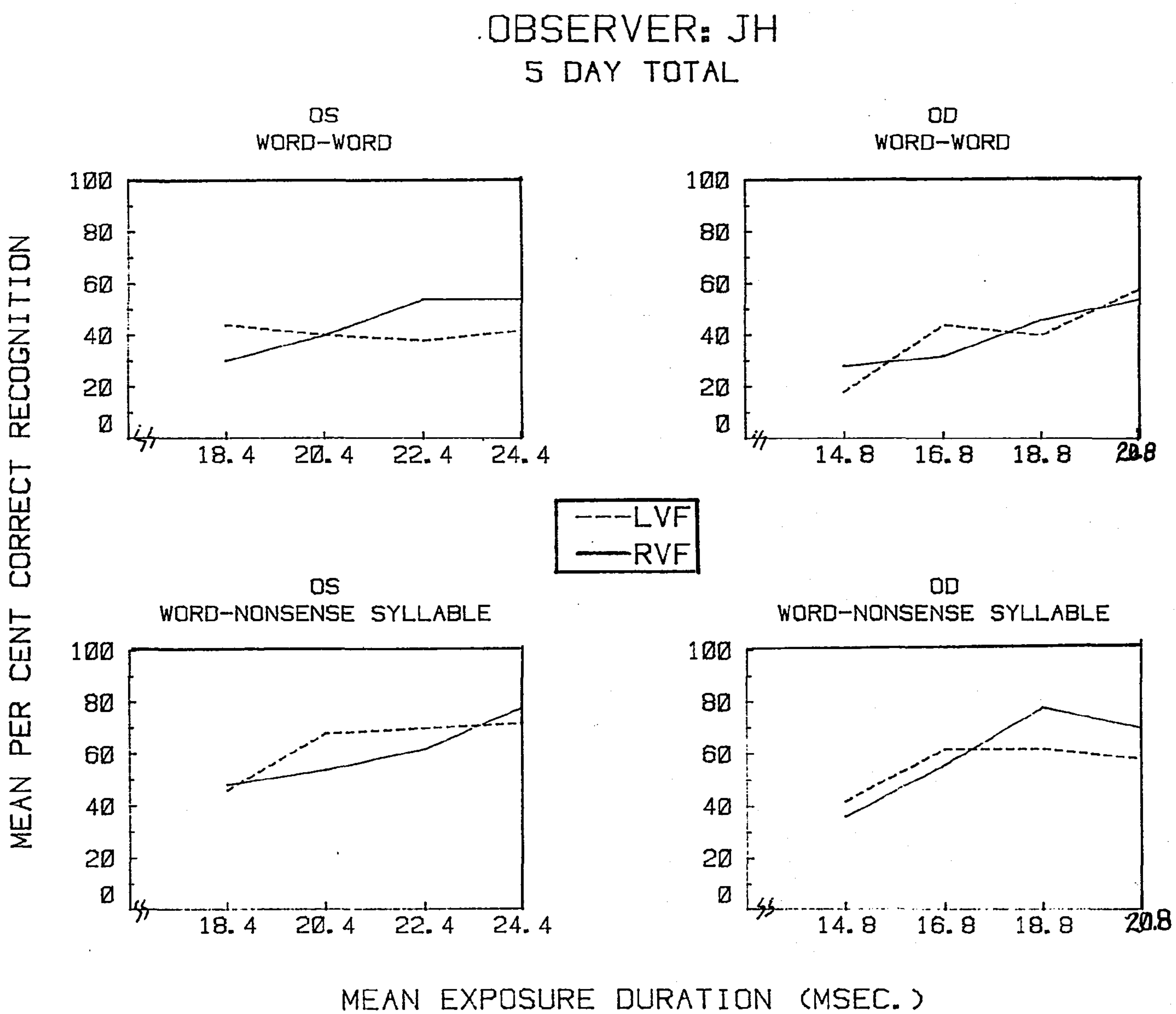
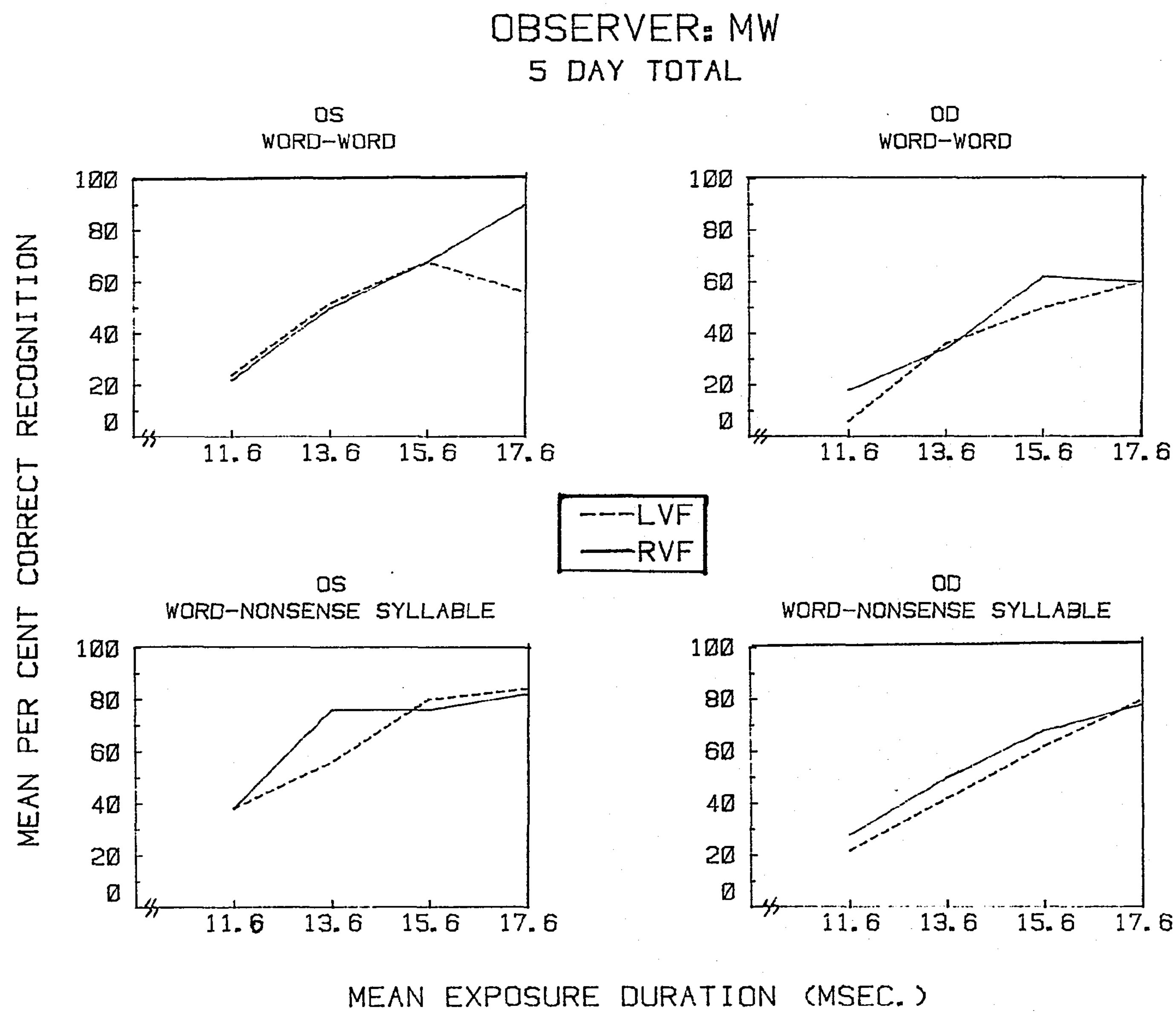


Figure 6 . Mean per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: JH. The word-word (WW) condition is across the top; word-nonsense syllable (WN) is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: JH
5 DAY TOTAL
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
—RVF
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)
0
20
40
60
80
100
18.4
20.4
22.4
24.4
14.8
16.8
18.8
20.8

Figure 7 . Mean per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: MW. The word-word (WW) condition is across the top; word-nonsense syllable (WN) is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.


OBSERVER: MW
5 DAY TOTAL
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
—RVF
100
80
60
40
20
0
11.6
13.6
15.6
17.6
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)

Visual inspection of these data show that half-field differences in recognition are not especially large nor consistent over test sessions in either the word-word or word-nonsense syllable conditions for either the left or the right eye.

Stimulus Material Effect

In the preceding graphs (Figures 3-7), data represent per cent correct recognition versus exposure duration with field (RVF versus LVF) as the parameter. A better comparison of the stimulus conditions (word-word versus word-nonsense syllable pairs) can be obtained by plotting per cent correct recognitions versus exposure duration with the stimulus condition as parameter. Right visual half-field presentations are across the top of the figure, and left visual half-field presentations are along the bottom, with the WW and WN pairings represented by broken and solid lines respectively. Figure 8 shows the group data for all four observers over the five test sessions represented in the same fashion. Recognition of words in the word-nonsense syllable condition is consistently higher than that for the word-word condition in all four comparisons. This feature of the graphic results is supported by the results of an analysis of variance for the group data. There was a significant difference between the scores for the two stimulus material conditions, with the word-nonsense syllable condition being greater than the word-word condition (Table 4). These data show that recognition of words is better in the word-nonsense syllable condition, in the right visual half-field and in the left visual half-field and in either eye. In short, recognition of stimulus words decreases when another word, rather than a nonsense syllable, is presented in the contralateral half-field.

When each individual's data, averaged over the five sessions were replotted in analogous fashion (Figures 9-12), there was agreement with the group findings. Os LG and JH (Figures 9 and 10 respectively) both showed greater recognition scores in the word-nonsense syllable condition than in the word-word condition for the right and left visual half-fields and for both eyes. MW (Figure 11) had greater recognition scores in the word-nonsense syllable condition for both right and left visual fields for the right and left eyes, with the exception of one instance (RVF in OS). The fourth O, HC, (Figure 12), showed higher recognition scores for the word-nonsense syllable condition than for the word-word condition only in the right visual field of the right eye. A smaller, but similar effect is seen in the left visual half-field in the right eye. In summary, when graphed results are examined, three out of four observers show greater recognition for words in the word-nonsense syllable condition than for words in the word-

Figure 8 . Mean per cent correct recognitions of words in the word-word (WW) [dashed line]; and word- nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for Group . The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

GROUP DATA
5 DAY TOTAL

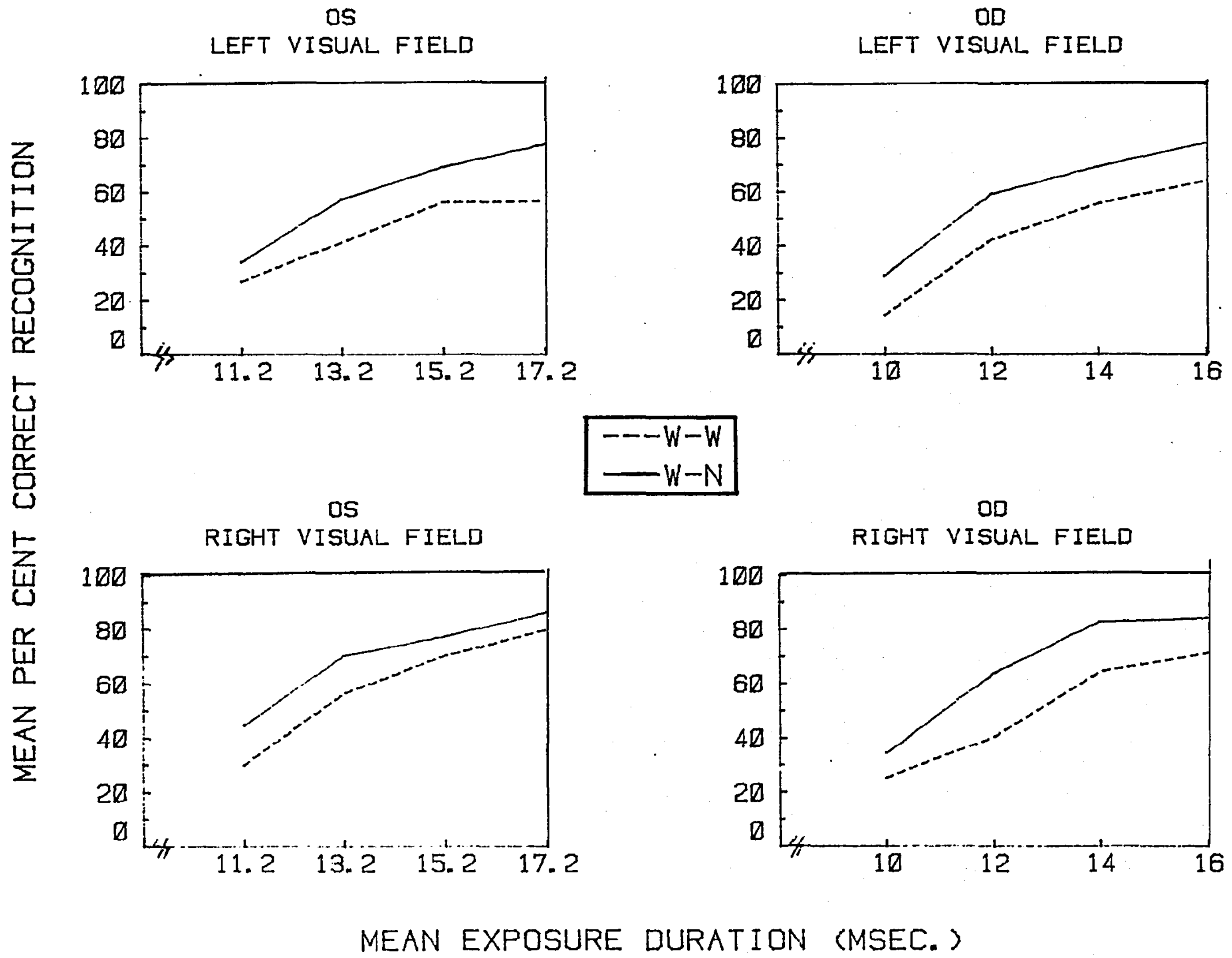


Figure 9 . Mean per cent correct recognitions of words in the word-word (WW) [dashed line]; and word- nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG . The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

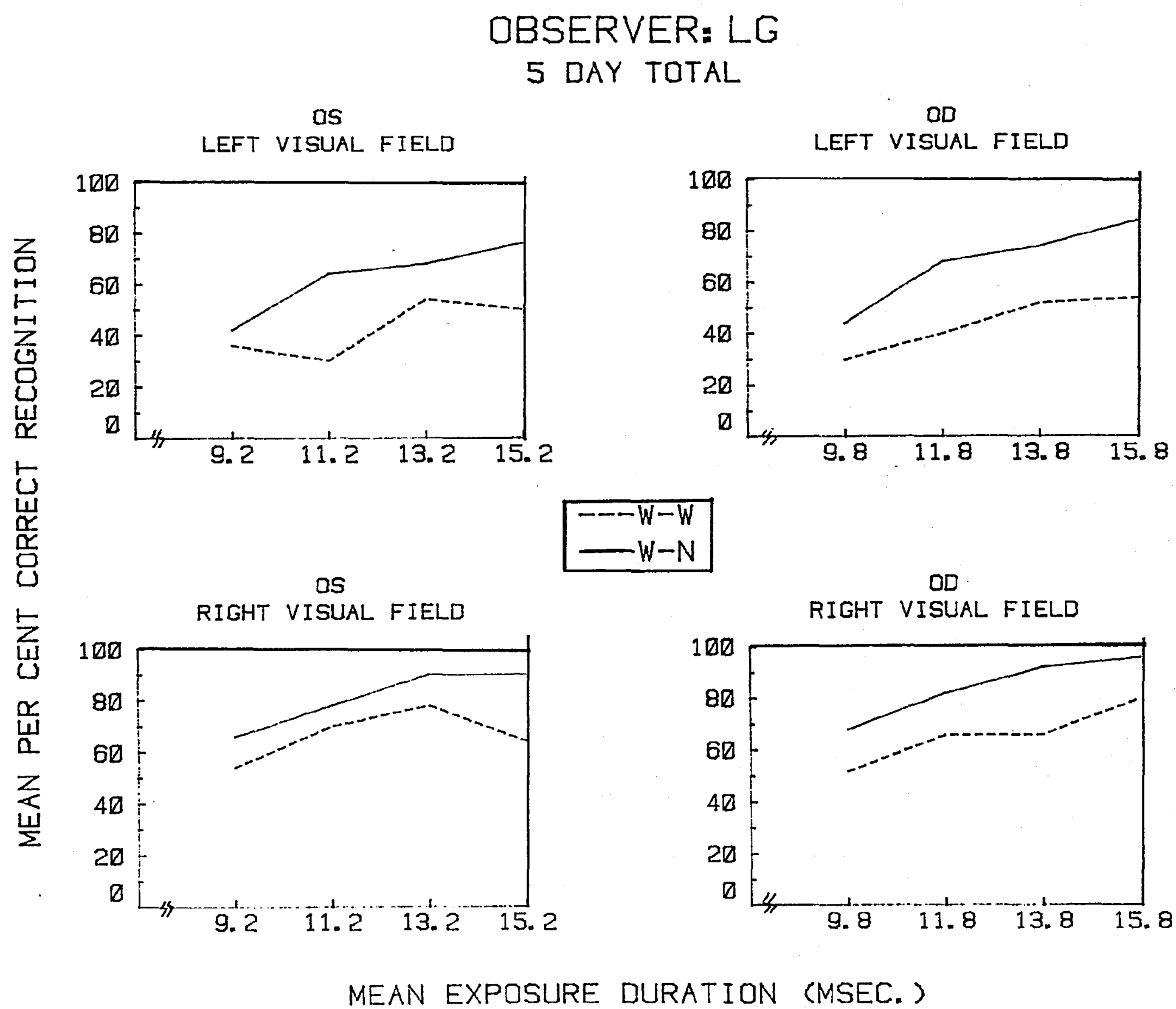

OBSERVER: LG
5 DAY TOTAL
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
W-W
W-N
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)
9.2
11.2
13.2
15.2
9.8
11.8
13.8
15.8
100
80
60
40
20
0

Figure 10 . Mean per cent correct recognitions of words in the word-word (WW) [dashed line]; and word- nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O: JH. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

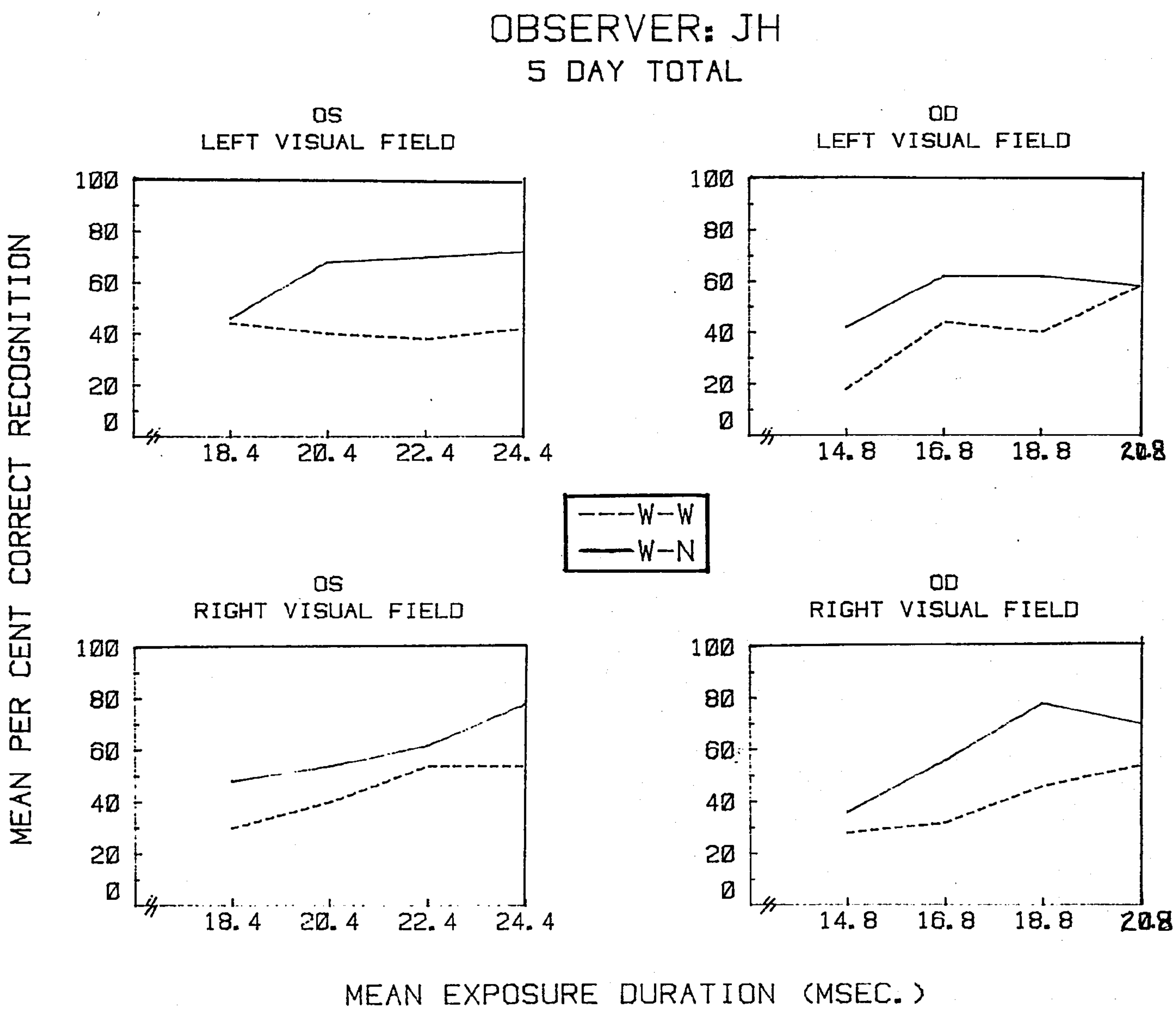

OBSERVER: JH
5 DAY TOTAL
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
18.4
20.4
22.4
24.4
14.8
16.8
18.8
20.8
---W-W
—W-N
MEAN PER CENT CORRECT RECOGNITION
MEAN EXPOSURE DURATION (MSEC.)

Figure 11. Mean per cent correct recognitions of words in the word-word (WW) [dashed line]; and word- nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O: MW. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: MW
5 DAY TOTAL

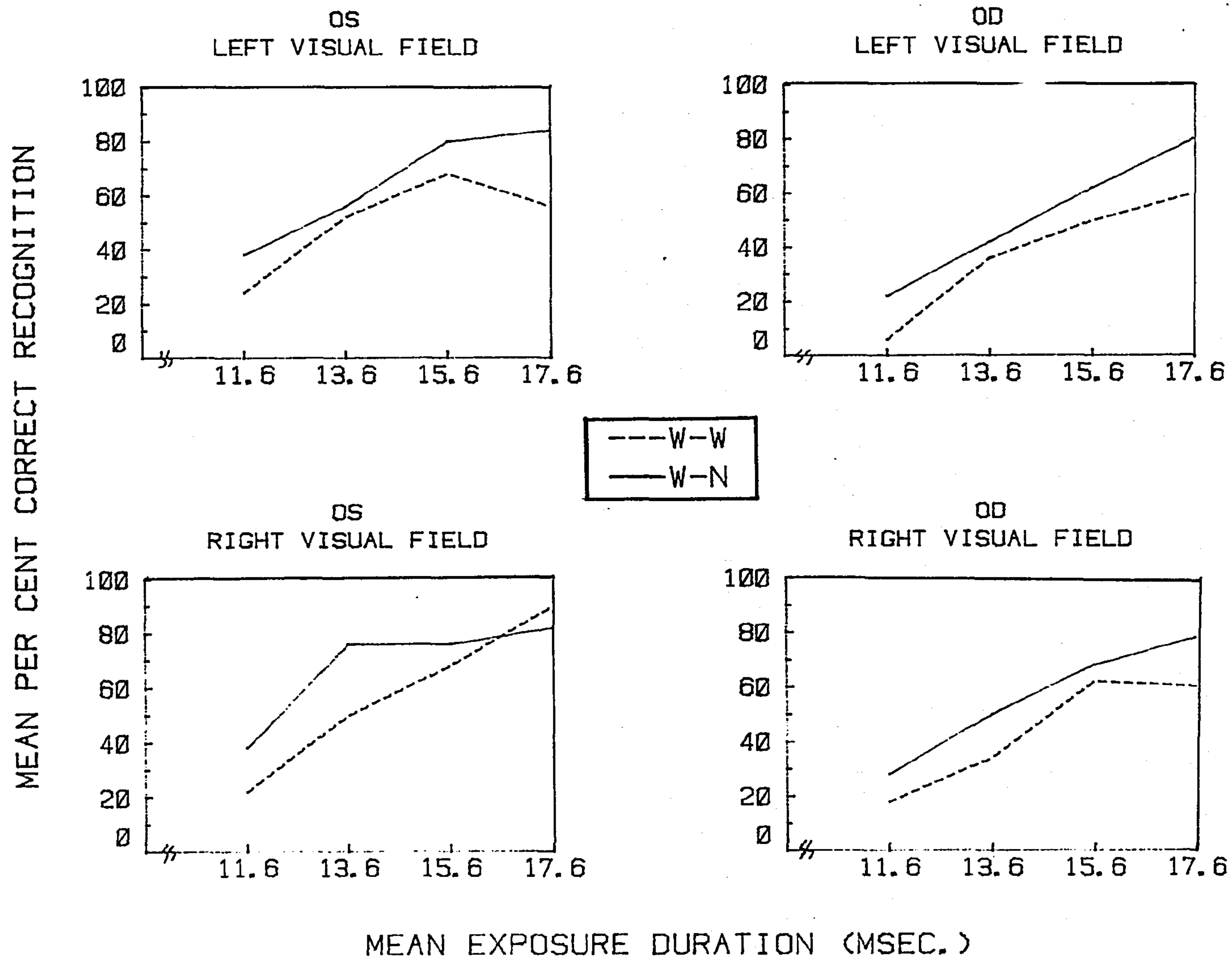
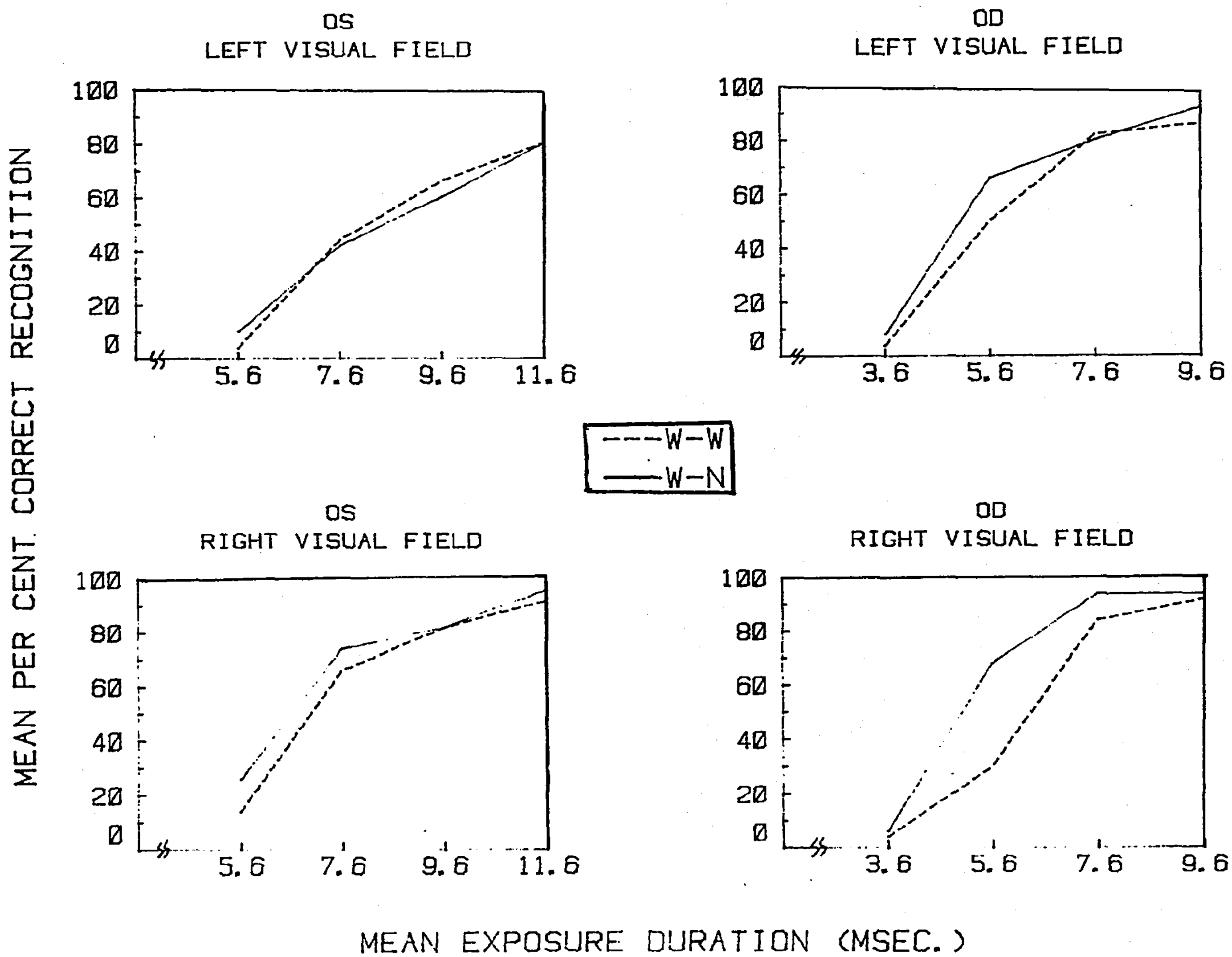


Figure 12. Mean per cent correct recognitions of words in the word-word (WW) [dashed line]; and word- nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: HC
5 DAY TOTAL



word condition for all viewings; the fourth observer shows it only for two viewing conditions. When these data were statistically analyzed using a correlated t-technique, observers LG, JH, and MW recognized significantly more words in the word-nonsense syllable condition than in the word-word condition for the right visual field ($p < .05$) and for the left visual field ($p < .01$) for the right eye (Table 3). For the left eye, observers LG and MW showed a significant word-nonsense syllable effect for the left visual half-field ($p < .05$), and O:JH just failed to achieve significance for the WN-WW difference for both the right and left visual fields ($p < .10$), as did MW, who also failed to show a significant WN effect for the right visual field ($p < .10$). O:LG showed no significant effect for the left eye. HC recognized significantly more words in the word-nonsense syllable condition than in the word-word condition in the right visual half-field for the right eye only. O:HC's other differences were not statistically significant.

The graphed data depicting session to session variability per observer over the five test sessions is presented in the Appendix (pps. 132-171).

Table 3

Dependent t values for Condition as Parameter: Same eye comparisons of stimulus differences (WN-WW) in per cent correct recognitions for the viewing in the RVF and the LVF.

	OS		OD	
Observer	RVF WN-WW	LVF WN-WW	RVF WN-WW	LVF WN-WW
HC	1.13	-.115	4.33*	1.22
MW	2.26	3.62*	3.30*	7.19**
JH	2.15	2.70	3.97*	8.04**
LG	1.67	3.81*	3.87*	6.55**

* p .05
** p .01

Analysis of Variance

In order to take into account all the independent variables, eye (OS or OD), field (LVF or RVF), stimulus condition (WW or WN), exposure duration (X_1, X_2, X_3, or X_4), and day (D_1, D_2, D_3, D_4, or D_5), as well as their interactions, a 2x2x2x4x5 analysis of variance was performed. All factors were repeated on subjects and the dependent variable was the per cent correct responses. The results of the analysis revealed a significant difference in the recognition of words in the word-nonsense syllable condition over the word-word condition. The only other significant main effect was duration. None of the interactions were statistically significant (Table 4).

Table 4- Analysis of Variance

Source	SS	df	ms	F	p
Eye (E)	2363.906	1	2363.906	1.1433	n.s.
Error (E)	6202.945	3	2067.648		
Field (F)	15112.66	1	15112.66	5.1090	n.s.
Error (F)	8874.207	3	2958.069		
Condition (C)	33495.16	1	33495.16	22.700	<.025
Error (C)	4426.668	3	1475.556		
Day (D)	885.937	4	221.4844	.1261	n.s.
Error (D)	21069.01	12	1755.750		
Exposure Duration (X)	187751.7	3	62583.89	11.8012	<.01
Error (X)	47728.75	9	5303.191		
E x F	743.898	1	743.8984	.8256	n.s.
Error (EF)	2702.973	3	900.9907		
E x C	701.398	1	701.3984	8.7505	n.s.
Error (EC)	240.464	3	80.15494		
F x C	237.648	1	237.6484	.5896	n.s.
Error (FC)	1209.141	3	403.0469		
E x D	766.551	4	191.6394	.9730	n.s.
Error (ED)	2363.462	12	196.9552		
F x D	877.171	4	219.2930	.4483	n.s.
Error (FD)	5870.309	12	489.1924		

Source	SS	df	ms	F	p
C x D	1216.500	4	304.1250	2.2343	n.s.
Error (CD)	1633.395	12	136.1162		
E x X	1295.375	3	431.7915	1.7122	n.s.
Error (EX)	2269.617	9	252.1797		
F x X	714.125	3	238.0417	1.1701	n.s.
Error (FX)	1830.980	9	203.4423		
C x D	1366.500	3	455.500	1.8948	n.s.
Error (CD)	2163.520	9	240.3911		
D x X	5705.063	12	475.4219	1.6067	n.s.
Error (DX)	10652.18	36	295.8938		
E x F x C	68.882	1	68.88281	1.6823	n.s.
Error (EFC)	122.835	3	40.94531		
E x F xD	1767.821	4	441.9553	1.8167	n.s.
Error (EFD)	2919.362	12	243.2802		
E x C x D	388.450	4	97.11255	.7685	n.s.
Error (ECD)	1516.369	12	126.3641		
F x C x D	2042.836	4	510.7090	2.1544	n.s.
Error (FCD)	2844.586	12	237.0488		
E x F x X	1307.914	3	435.9712	3.2232	n.s.
Error (EFX)	1217.348	9	135.2608		

Source	SS	df	ms	F	p
E x C x X	295.601	3	98.53384	.3643	n.s.
Error (ECX)	2434.098	9	270.4551		
F x C x X	1321.789	3	440.5962	1.4016	n.s.
Error (FCX)	2823.047	9	313.6719		
E x D x X	2289.441	12	190.7868	.8344	n.s.
Error (EDX)	2231.672	36	228.6575		
F x D x X	1698.703	12	141.5586	.6026	n.s.
Error (FDX)	8456.828	36	234.9119		
C x D x X	1536.750	12	128.0625	.4755	n.s.
Error (CDX)	9695.031	36	269.3064		
ExFxCxD	864.701	4	216.1753	.6733	n.s.
Error(EFCD)	3852.717	12	321.0596		
ExFxCxX	634.992	3	211.6641	2.2590	n.s.
Error(EFCX)	843.296	9	93.69965		
ExFxDxX	4156.801	12	346.3999	1.3226	n.s.
Error (EFDX)	9428.707	36	261.9084		
ExCxDxX	753.609	12	62.80078	.3821	n.s.
Error(ECDX)	5916.332	36	164.3425		
FxCxDxX	2574.289	12	214.5241	1.0241	n.s.
Error(FCDX)	7540.992	36	209.4720		
ExFxCxDxX	2513.484	12	209.4570	.7573	n.s.
Error(EFCDX)	9957.660	36	276.6016		

Intersession Reliability of Half-Field Differences

An analysis of variance was performed separately for each observer in order to ascertain the reliability of his or her performance over the five test sessions with respect to half-field differences in the word-word and word-nonsense syllable conditions. As seen in Table 5, the half-field differences did not vary significantly in either condition.

The half-field differences independent of condition were evaluated for each observer for each test session, using the same analysis of variance technique. Again, the dependent variable was the half-field differnces (RVF-LVF) in per cent correct recognitions for the viewing of words, and each of the five sessions was compared with the others (Table 5A). Only observer LG showed significant variablility. All other differences were not significant.

Table 5- Analysis of Variance for Individual Observers-(Variable: Day) RVF-LVF differences

Word-Word

Observer	SS	df	ms	F	p
HC	11·6	4	2·9	·74	ns
Error	138	35	3·9		
MW	5·35	4	1·3	·34	ns
Error	136·25	35	3·84		
JH	29·5	4	7·38	·81	ns
Error	320	35	9·11		
LG	78·9	4	19·72	2·37	ns
Error	291	35	8·31		

Word-Nonsense Syllable

Observer	SS	df	ms	F	p
HC	19·6	4	4·9	1·09	ns
Error	158·4	35	4·5		
MW	3·35	4	·84	·31	ns
Error	96·25	35			
JH	47·75	4	11·9	2·51	ns
Error	166·25	35	4·85		
LG	26·85	4	6·71	2·79	ns
Error	84·13	35	2·40		

Table 5A- Analysis of Variance for Individual Observers-All Conditions Combined- (Variable:Day) RVF-LVF differences

Observer	SS	df	ms	F	p
HC	30.37	4	7.59	1.86	ns
Error	306.32	75	4.08		
MW	5.2	4	1.3	.377	ns
Error	258.9	75	3.45		
JH	18.25	4	4.56	.603	ns
Error	567.50	75	7.57		
LG	81.95	4	20.49	3.74	.05
Error	410.94	75	5.48		

50% Threshold

In order to relate half-field differences in recognition to some physical measure, LVF and RVF exposure durations that correspond to 50% correct recognition were determined for each observer. Tables 6 and 6A show the threshold values (50% correct recognition) for left (OS) and right (OD) eyes respectively, for the two different stimulus conditions, WW (words presented in both right and left visual half-fields), and WN (word and nonsense syllable combinations). For every observer, the differences between the two fields (LVF-RVF) were calculated for each stimulus condition separately, and correlated t-tests were used to compare these differences. In general, there appeared to be no significant half-field differences in threshold exposure durations for either eye in either stimulus condition. When the individual data were collapsed and analyzed as a group, again, there were no significant findings for either eye in either viewing condition. This suggests that there were no differences between half-fields in the ease of recognizing words in each half-field under the different conditions of stimulus presentation.

Table 6

Left Eye:50% threshold data. Same eye comparisons of half-field (LVF-RVF) differences (D) in threshold exposure duration (in msec.) for the viewing of word-word (WW) and word-nonsense syllable (WN) pairs.

		OS						
		WN			WW			
Q		LVF	RVF	D_{wn}	LVF	RVF	D_{ww}	$D_{wn}-D_{ww}$
HC	1	18.7	10	8.7	15	11.4	3.6	5.1
	2	6.3	3.9	2.4	6.7	6.3	.4	2.0
	3	7.7	5.5	2.2	9.2	6.4	2.8	-.6
	4	6.4	5.7	.7	6.6	5.8	.8	-.1
	5	7.2	6.2	1.0	6.8	5.7	1.1	-.1
				t=1.19				
MW	1	11.2	10.9	.3	13.6	12.8	.8	-.5
	2	16.4	16.3	.1	20.6	17.8	2.8	-2.7
	3	12.5	6.0	6.5	15.1	14.8	.3	6.2
	4	13.2	12.3	.9	13.4	12.5	.9	0
	5	10.1	9.8	.3	10.9	12.0	-1.1	1.4
				t=.592				
JH	1	21.8	5.0	16.8	32.5	60.0	-27.5	44.3
	2	15.7	17.6	-1.9	16.0	19.5	-3.5	1.6
	3	29.5	22.8	6.7	27.0	28.0	-1.0	7.7
	4	29.3	16.0	13.3	31.0	18.5	12.5	.8
	5	13.8	16.5	-2.7	28.0	17.8	10.2	-12.9
				t=.864				
LG	1	11.2	11.1	.1	15.7	14.0	1.7	-1.6
	2	10.3	8.3	2.0	7.1	8.4	-1.3	3.3
	3	8.0	-7.0	15.0	14.5	20.2	-5.7	20.7
	4	11.3	2.0	9.3	12.0	8.8	3.2	6.1
	5	6.0	-14.0	20.0	11.7	6.6	5.1	14.9
				t=2.155				

Group value : t= -1.59

Table 6A

Right Eye:50% threshold data. Same eye comparisons of half-field (LVF-RVF) differences (D) in threshold exposure duration (in msec.) for the viewing of word-word (WW) and word-nonsense syllable (WN) pairs.

		OD						
		WN			WW			
O		LVF	RVF	D_{wn}	LVF	RVF	D_{ww}	$D_{wn}-D_{ww}$
HC	1	5.6	5.5	.1	7.3	6.4	.9	-.8
	2	4.7	5.6	-.9	6.1	6.5	-.4	-.5
	3	6.7	5.9	.8	6.8	7.1	-.3	1.1
	4	5.1	5.2	-.1	5.5	6.5	-1.0	.9
	5	6.0	5.4	.6	5.4	5.6	-.2	.8
					t=.762			
MW	1	13.7	12.1	1.6	17.1	14.4	2.7	-1.1
	2	17.7	18.7	-1.0	22.0	18.0	4.0	-5.0
	3	15.2	15.7	-.5	18.5	18.1	.4	-.9
	4	12.7	12.4	.3	13.7	13.7	0	.3
	5	12.9	11.1	1.8	16.3	13.7	2.6	-.8
					t=-1.65			
JH	1	-14.0	17.3	-31.3	18.0	21.2	-3.2	-28.1
	2	17.0	14.9	2.1	19.3	17.3	2.0	.1
	3	14.7	15.1	-.4	24.7	22.4	2.3	-2.7
	4	12.5	14.4	-1.9	14.5	18.0	-3.5	1.6
	5	15.5	16.7	-1.2	-5.0	22.0	-27.0	25.8
					t= - .077			
LG	1	7.0	9.0	-2.0	14.0	14.8	-.8	-1.2
	2	11.0	8.7	2.3	20.5	8.0	12.5	-10.2
	3	6.3	4.3	2.0	13.4	10.0	3.4	-1.4
	4	9.8	4.2	5.6	12.7	-.7	13.4	-7.8
	5	9.8	-15.3	25.1	12.6	-12.0	24.6	.5
					t= -1.919			

Group value : t=2.23

DISCUSSION

In the present study an attempt was made to determine whether the widely reported right visual half-field superiority for verbal material occurs under conditions of simultaneous exposures of stimuli when several methodological controls were employed in order to eliminate, minimize, or take into account factors which were typically not considered in previous studies. In addition, if a half-field superiority could be demonstrated, did it occur with equal likelihood for both word-word and word-nonsense syllable conditions?

Some of the methodological problems found in past studies include the failure to control for directional reading habits, and the stimulation of nonhomogeneous retinal areas. The present study eliminated both of these factors by the use of vertically mounted three letter words. In previous studies, the stimulus material was often a single letter or meaningless string of letters. The present study sought to make the task more verbal in order to emphasize the hypothesized differential functioning of the two cerebral hemispheres (left thought to be more proficient at processing verbal material) and therefore employed words as stimuli. Furthermore, almost all past studies have reported only group data, and have had the observers view the stimulus material only once. This reliance on group data and lack of reliability measures were eliminated in the present study by collecting and reporting individual observer's data over several test sessions. Previous studies have typically used a binocular viewing paradigm, therefore, the separate contributions made by each eye cannot be determined. The present study used a monocular viewing paradigm to determine half-field preferences, which not only allowed for the determination of the separate input made by each eye, but also for the examination of the role that peripheral (as compared with central) factors play in half-field recognitions. The possibilities of eye movements and projections of retinal images to the ipsilateral cerebral hemisphere were minimized in the present study by using very short exposure durations (30 msec. or less) and by presenting stimuli at retinal eccentricities of 3° from fixation.

Many previous studies have employed fixation forcers in an attempt to eliminate attentional bias. This technique, however, has many attendant problems. In the present study, attentional bias was decreased by having each observer initiate his or her own trials when maintaining fixation, and by informing the observer that a word would not always appear in a given half-field on any given one trial, and thus the optimal strategy for increasing recognition would be to maintain fixation.

In all privious studies, the observer had his head centered, with his chin placed in a chin rest. The procedure used in the present study was to center the eye being tested (rather than the head). Head centered observers typically reported that stimuli in the temportal half-field seemed further away from the border of the tachistoscope's screen than did stimuli in the nasal half-field. With eye centering, observers reported that material in the nasal and temporal half-fields appeared to be equidistant from their respective borders.

An even more important methodological problem with the potential for obscuring true differences in hemispheric functioning is the unequal luminance levels found between half-fields in most planar tachistoscopes (the luminance of the RVF is about 20% greater than that of the LVF). Previous studies failed to note this difference. Reflecting foil and black cardboard were used in the present study to equalize the measured luminance of the right and left visual fields.

Visual Field Effect

The findings of the present study do not seem to support the hemispheric specialization hypothesis. Differences in the hemispheres' ability to process information do not seem important when verbal stimuli are simultaneously presented.

While it is true that all observers in the present study demonstrated greater total recognition scores for stimuli presented in the RVF than for those presented in the LVF (Tables 1a and 1b). the statistical significance of these differences is another matter. When group data was evaluated using an analysis of variance technique, the field main effect was not significant (Table 4).

This lack of a significant field effect is unlike results of most past studies which reported a statistically significant RVF superiority for simultaneously exposed alphabetical material (Hines, 1972, 1975; McKeever, 1971; McKeever and Gill, 1972; McKeever and Huling, 1971a, 1971b; McKeever, Suberi, and Van Deventer, 1972; Mackavey, Curcio, and Rosen, 1975) and is also unlike those studies which reported a significant LVF superiority (Bryden, 1960; Bryden and Rainey, 1963; Heron, 1957; Neill, Sampson, and Gribben, 1971).

On an individual level, the half-field recognition scores for word-word and word-nonsense syllable stimulus conditions for each eye were greater in the right visual half-field than in the left visual half-field in 13 out of 16 instances (Table 2). In spite of the large number of differences in which the recognition scores were greater in the RVF than in the LVF, only five achieved statistical significance when dependent t-tests were performed (Table 2). Three out of these five cases were scores for one observer, LG. If hemispheric specialization is an important determinant of half-field preference, why can a statistically significant RVF superiority be demonstrated in only one-quarter of the cases?

Thus on both a group and individual basis, the results of this study do not seem to support the hemispheric specialization hypothesis. This study's failure to demonstrate a significant field preference cannot be attributed to variable performance (whereby a preference shown in one test session might be cancelled by an opposite field preference demonstrated during another testing session) as this variable remained relatively constant over the five testing sessions (Tables 5, 5A).

The present study's failure to demonstrate a significant field preference was surprising since it was designed in such a way as to point out the specialized role of the left hemisphere. This was accomplished by using stimuli that were decidedly verbal in nature (they connoted a meaning) rather than using stimuli such as a single letter or meaningless groups of letters which could be analyzed either linguistically or spatially; and by the use of a verbal response indicator (again involving the left hemisphere) rather than a reaction time or pointing to a matching stimulus response indicator. Even with these two features of the present study, no significant RVF superiority could be demonstrated on a group level. True, more words were correctly identified in the RVF than in the LVF, but this half-field difference was not statistically significant. This may be due to the small number of observers (four) used in the present study. On the other hand, each observer was studied in depth, with 1,600 trials contributing to his final score. Hopefully, if structural differences between the hemispheres do exist and are responsible in part for laterality differences, one would expect to see a field superiority become apparent somewhere in those 1,600 trials, especially when one considers the lack of session to session variability.

Another possibility is that the presence of one of the factors that was controlled for or eliminated may be necessary in order to demonstrate a RVF superiority. Thus, field preference may be merely an artifact of poor methodology, equipment characteristics, statistical interpretation, etc.

Stimulus Material Effect

Two types of alphabetical stimulus material were presented in this study: three letter words exposed in the left and right visual half-fields at the same time (WW condition); and the combination of a three letter word and a three letter nonsense syllable appearing in opposite half-fields on any one exposure (WN or NW condition). Analysis of group data using analysis of variance technique showed that significantly more words were recognized in the word-nonsense syllable condition than in the word-word condtion (Table 4). On an individual level, the use of correlated t-tests demonstrated that in 15 out of 16 cases more words were correctly identified when they were paired with a nonsense syllable (WN condition) than when two words appeared on the same exposure (Table 3). Of these 15 cases, nine reached statistical significance. This finding demonstrates that the presence of words in both fields tends to lower the overall recognition level for either word. Hines (1975) observed that regardless of what type of stimulus the words were paired with (be it other words, faces, or geometric forms), one always finds a large right visual field superiority. The present study shows that the nature of the other stimulus in a simultaneous display does indeed affect recognition levels, unlike Hines' conclusion. In fact, this variable was more reliable and more significant than the half-field in which the word appeared.

In addition to the presence of a word in one half-field interfering with the recognition of a word in the contralateral half-field, there is an alternate possibility. The dampening of recognition in the word-word condition might be due to having two stimuli present that both require a verbal response. This might result in competition for the means of expressing the response. While one word was being verbalized, the signal representing the second word may have become attenuated or decayed and this might be reflected in the lower scores found in the word-word condition.

Intersession Reliability of Half-Field Differences

When each observer's half-field differences (RVF-LVF) in terms of per cent correct recognitions were evaluated for the viewing of word-word and word-nonsense syllable pairings by an analysis of variance, there were no significant findings (Table 5). Thus the half-field differences between sessions were relatively constant for the two viewing conditions (WW and WN) for all observers.

When the half-field recognition scores, independent of condition, were evaluated by an analysis of variance, only one observer LG, showed statistically significant variability in his session to session scores (Table 5A). Interestingly, LG was the only observer who demonstrated a significant RVF superiority in three out of four conditions (Table 2). It may be that this variability is an important determinant of field preference.

The observers in this study were well practiced in their viewing task. The fact that they were all experienced may account for the lack of variability seen on a day to day basis. White (1969, 1972) in reviewing the laterality literature, noted that field superiority can vary as a function of familiarity with the stimulus material.

Threshold Comparisons (50% Correct Recognitions)

When RVF and LVF threshold exposure durations were analyzed to determine sensitivity differences between the half-fields under the two stimulus presentation conditions (WW and WN), no significant half-field differences in threshold exposure durations were found for the viewing of words in either condition (Tables 6, 6A).

According to the laterality concept, one might anticipate significantly lower thresholds for words present in the RVF than for words found in the LVF. This contention was not supported by the results of the present study.

THEORETICAL CONSIDERATIONS

Post-exposural Directional Scanning

Heron's theory is predicated on the presentation of stimulus words in a way that resembles normal reading matter (in the English language, a horizontal arrangement). As one of its controls, the present study employed alphabetical stimuli that were vertically mounted. Therefore, no evaluation of the present study's findings in terms of post-exposure scanning is possible.

Attentional Bias

Attentional bias theories speculate that the left hemisphere is "primed" for the appearance of verbal material, so that the observer tends to pay attention to the right side of the visual field, and an attentional bias (and resulting RVF superiority) is the outcome.

The present study sought to eliminate attentional bias by the random presentation of words and nonsense syllables. Since only words had to be responded to, and the observer never knew in which field a word would appear, his most efficient strategy was to maintain fixation. In addition, the randomization of the four stimulus types (WW,WN,NW,NN) forced the observer to attend to the entire stimulus field, and made it virtually impossible for him to expect a certain type of stimulus to appear in any one half-field on any one exposure. Attention to one field (thereby neglecting the contralateral half-field) would have produced lower recognition scores.

In previous studies that employed a bilateral display, the observer knew or soon learned that words would appear in both half-fields on every trial, so that exclusive attention to one half-field would still result in an acceptable performance; hence the development of an attentional "set" was indeed possible. McKeever and Huling (1971b) noted that 16 out of 20 subjects recognized one or less LVF words.

Some recent investigations by McKeever and Huling (1971b) and Mackavey, Curcio, and Rosen (1975) report that the RVF superiority that results when a bilateral display is presented is much greater than the RVF superiority found when the observer views a unilateral display. A bilateral display guaranteed that words would appear in both fields on every exposure; unlike a unilateral display where a word would be in one field or the other on a random schedule. It seems possible that this enhanced RVF superiority for simultaneous exposures of words in the result of an attentional bias.

In the present study, the recognition levels for right and left visual fields were approximately the same, and this finding may be the result of removing the influence of attentional bias. Contrary to the results reported by McKeever and Huling, and Mackavey, Curcio, and Rosen, the presence of words in both visual fields was found to have a detrimental, not an enhancing effect on performance in the present study.

Hemispheric Specialization

The hemispheric specialization theory would predict a RVF superiority for simultaneously exposed alphabetical material, as it assumes that the left hemisphere is more efficient than the right hemisphere in processing verbal information (once the confounding effect of reading habits is removed). The results of the present study do not seem to support this position. No significant field effect was found. These results seem to show that both right and left hemispheres are capable of analyzing verbal stimuli.

Historically, the RVF superiority for verbal material was thought to be a function of the left hemisphere's greater proficiency at analyzing this type of stimulus matter. In addition, when verbal material was presented in the LVF, it went to the right hemisphere, and if a spoken response were required, the information had to be shunted from the right hemisphere to the left hemisphere (for most individuals). During this crossover, from right to left hemispheres, the signal would be attenuated, and a RVF superiority would result.

In contrast to this theory, the findings of the present study seem to show that the right hemisphere is as efficient as the left hemisphere in analyzing or processing information under the conditions and methodology used. Unlike the results of previous bilateral studies which reported a significant RVF superiority, the recognition scores for the RVF in the present study were only somewhat larger than those for the LVF, and this slight favoring of the RVF may have been due to the use of a verbal response indicator.

Previous bilateral studies have had many methodological flaws. Some of these problems which the present study controlled for or eliminated include directional reading habits, attentional bias, unequal luminance levels of the tachistoscope, reliance on group data to the extent that individual performance is ignored, and lack of reliability measures. When these and other variables were controlled for, no field effect was found. In summary, the left hemisphere may not necessarily be more efficient than the right hemisphere in processing verbal information. A RVF superiority may merely be an artifact of methodology.

Double Simultaneous Stimulation

The present study sought to investigate the effects of double simultaneous stimulus presentation (DSS) and laterality; i.e. what is the role of a second word in relation to field differences? Specifically, if the word-nonsense syllable pair is regarded as the baseline or control condition, what happens to the recognition level for that word (the test stimulus) when the nonsense syllable is replaced by a second word. Even more specifically, does a word replacing a nonsense syllable in the LVF result in a greater number of correct recognitions for the other word (in the RVF) as compared to when a word replaces a nonsense syllable in the RVF? The cerebral dominance theory would predict higher RVF scores for both situations. Yet the results of the present study demonstrate that the presence of a second word (WW condition) decreases performance regardless of which field the test stimulus appears in. For example, exposing a word in the LVF decreases the per cent correct recognitions in the RVF. How is this possible if the projection of verbal material from the RVF depends primarily on its termination in the left hemisphere? The conclusion seems obvious that neither projection is stochastically independent. What is initiated in the RVF can be altered differentially by the presence of verbal material in the LVF and vice versa.

Since interactions between left and right hemiretinal inputs cannot occur along the classic retinogeniculostriate pathway (not at the lateral geniculate nucleus, not striate cortex levels), one is left with the possibility of intercerebral interactions at the prestriate and inferotemporal cortical areas (Mishkin, 1972). The primary visual area, striate cortex (Brodmann's area 17) has for all intents and purposes, no known connections with the opposite hemisphere (Mountcastle, 1974). The ipsilateral prestriate region (both areas 18 and 19) receives efferents from striate cortex, and in turn projects to inferotemporal cortex (areas 20 and 21) of the same hemisphere (Hubel and Weisel, 1965). Homologous prestriate areas in the two cerebral hemispheres are connected by the corpus callosum, while homologous inferotemporal areas are linked via the anterior commissure (Mishkin, 1972; Mountcastle, 1974). Thus, the prestriate relays visual information from the striate to other cortical areas of the same and opposite hemispheres. Indirectly, the striate cortices of the two hemispheres are interconnected through the prestriate and inferotemporal areas. It has been postulated that the prestriate interhemispheric connection may be responsible for the confluence of the right and left halves of the visual field (Hubel and Weisel 1965).

Subcortical connections exist as well. The prestriate area is reciprocally connected with the pulvinar, which in turn sends efferents to the superior colliculus, pretectum, and other midbrain structures (Mishkin, 1972). The inferotemporal cortex is connected with the amygdala, pulvinar, superior colliculus,and pretectum (Mountcastle, 1974).

In summary, a great number of intra- and interhemispheric connections are present in the human brain. Bilateral simultaneous stimulation of the two hemiretinae elicit responses in both the left and right sides of the brain, which in turn can interact post-synaptically in a very complicated fashion. Hence there are numerous possibilities for interhemispheric "crosstalk" and interchange. It seems most unlikely that visual information would travel an isolated route with no possibility of interhemispheric interactions when the stimulus display is bilateral.

In addition to the possibility of hemispheric interaction, the present study points up the finding that the results of bilateral stimulation of two hemiretinae appears to depend on the type of stimulus material presented to the observer. The presence of two words (WW), rather than a word and a nonsense syllable (WN), could result in more hemispheric interaciton and interference, and hence lower recognition scores. Further processing may be necessary when two words have to be identified (WW), as compared to the presence of a word and a nonsense syllable (WN). Subtle patterns of excitation in the prestriate and inferotemporal areas may be involved, bilaterally (Mishkin, 1972).

In summary, the visual system has a complex, interactive arrangement, and any theory that expounds the notion that the two hemispheres function in a stochastically independent manner is neglecting known anatomical and physiological findings.

APPENDIX

Figure A1. Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: LG for testing session 1. The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: LG

DAY=1

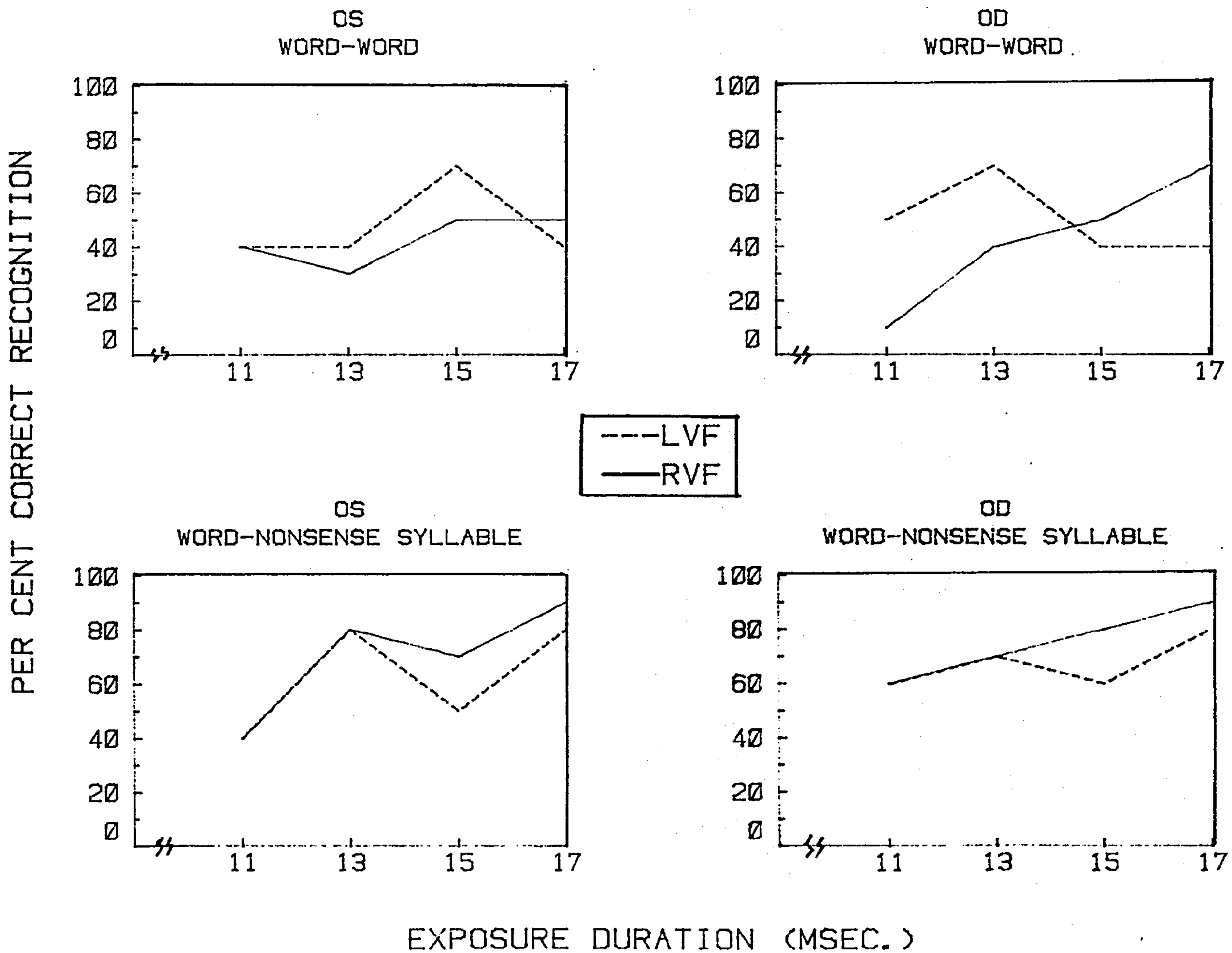


Figure A2 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: LG for testing session 2 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

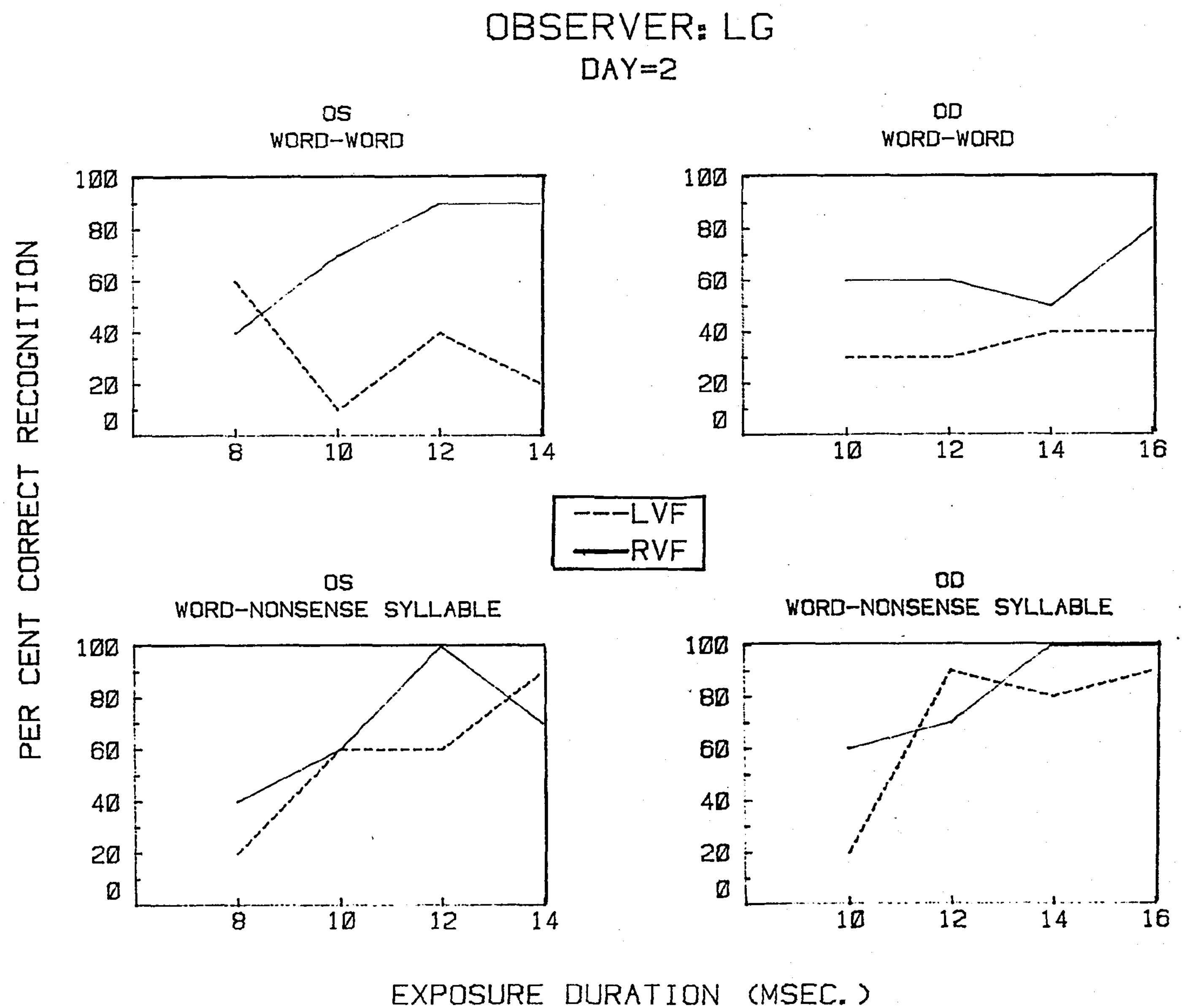
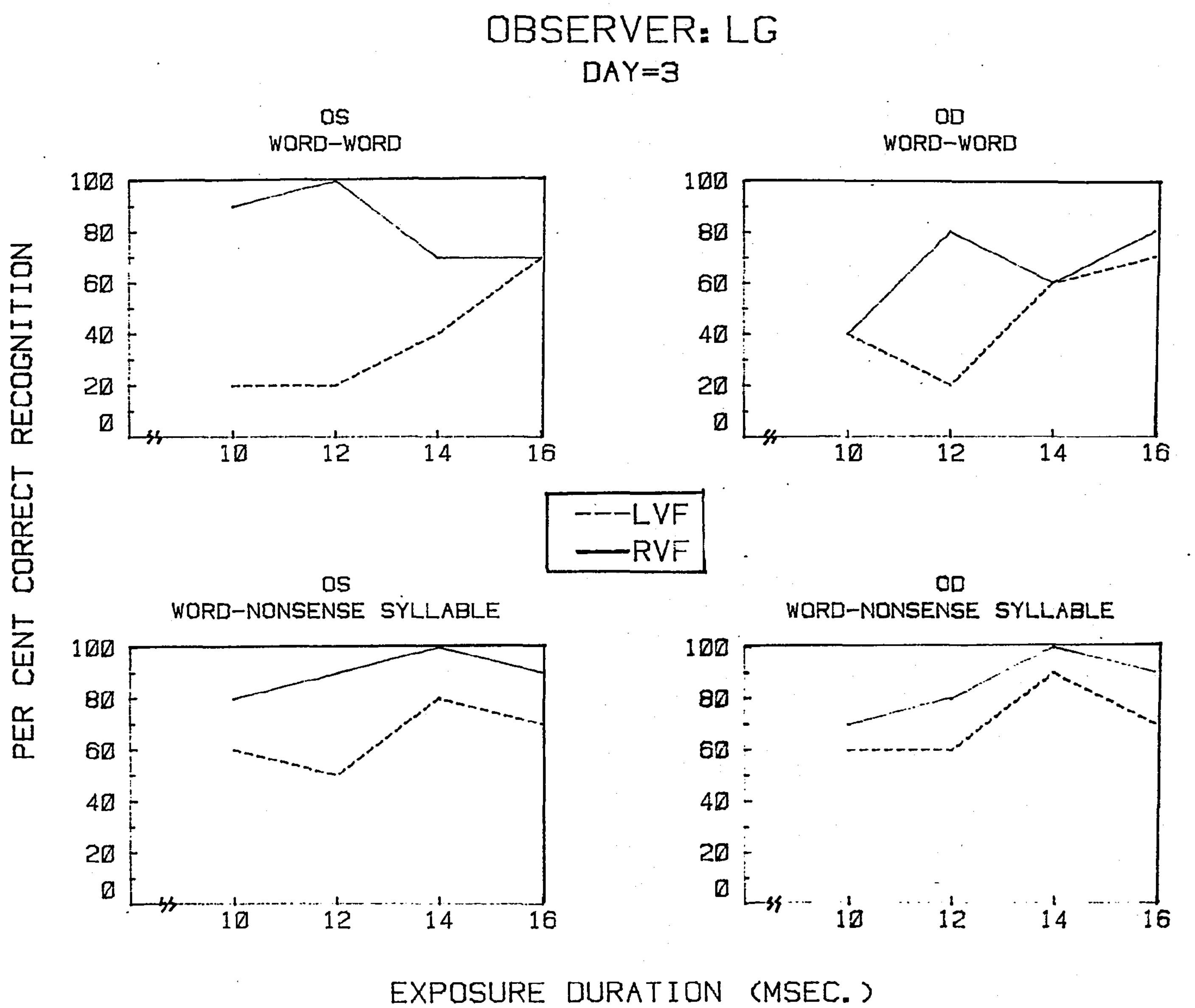

OBSERVER: LG
DAY=2
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
LVF
RVF
100
80
60
40
20
0
8
10
12
14
16
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A3 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: LG for testing session 3 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: LG
DAY=3
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
—RVF
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)
100
80
60
40
20
0
10
12
14
16

Figure A4 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: LG for testing session 4 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

HEWLETT PACKARD

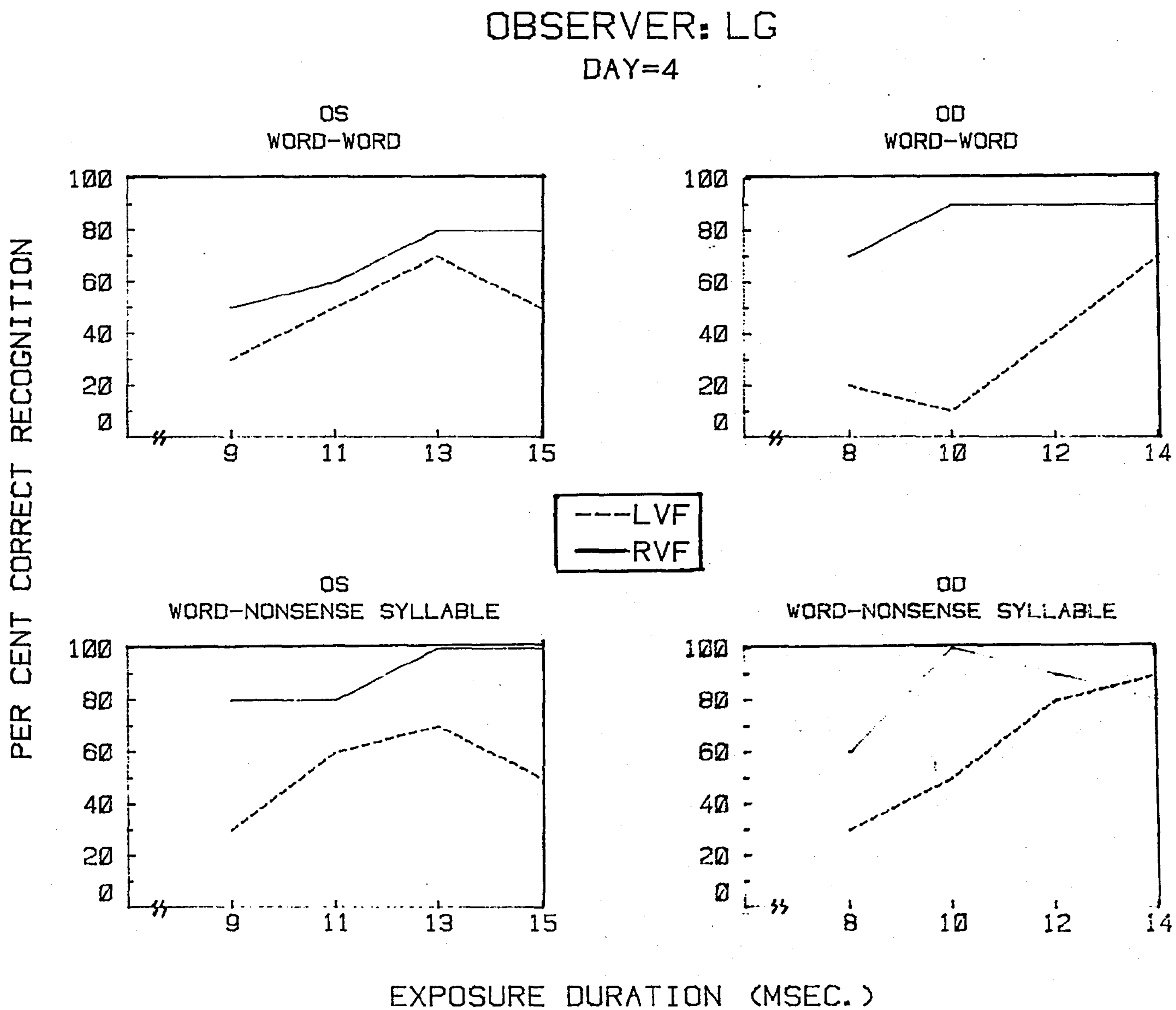


Figure A5 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:LG for testing session 5 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

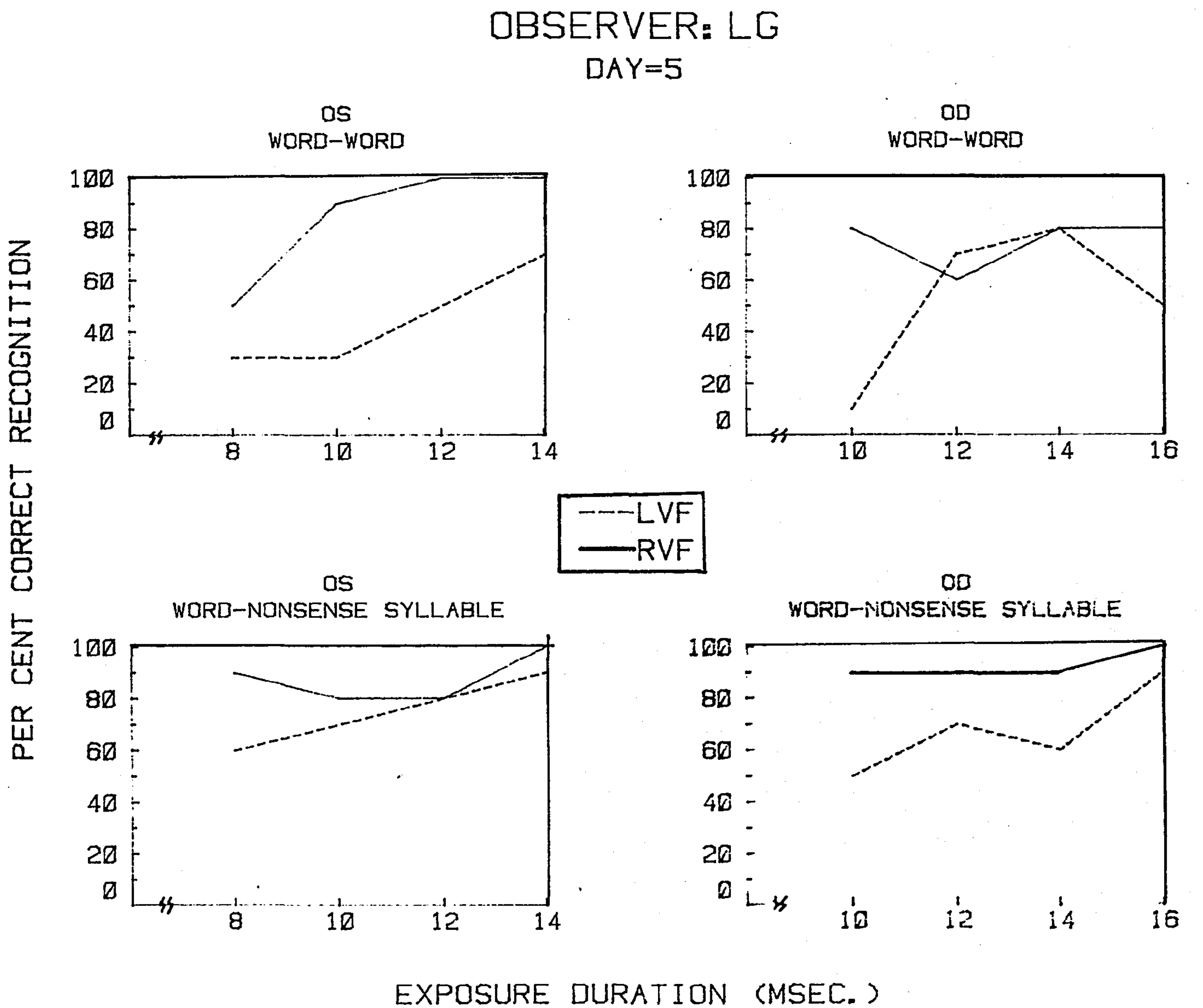

OBSERVER: LG
DAY=5
OS
WORD-WORD
OD
WORD-WORD
100
80
60
40
20
0
8
10
12
14
16
LVF
RVF
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A6 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:HC for testing session 1 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

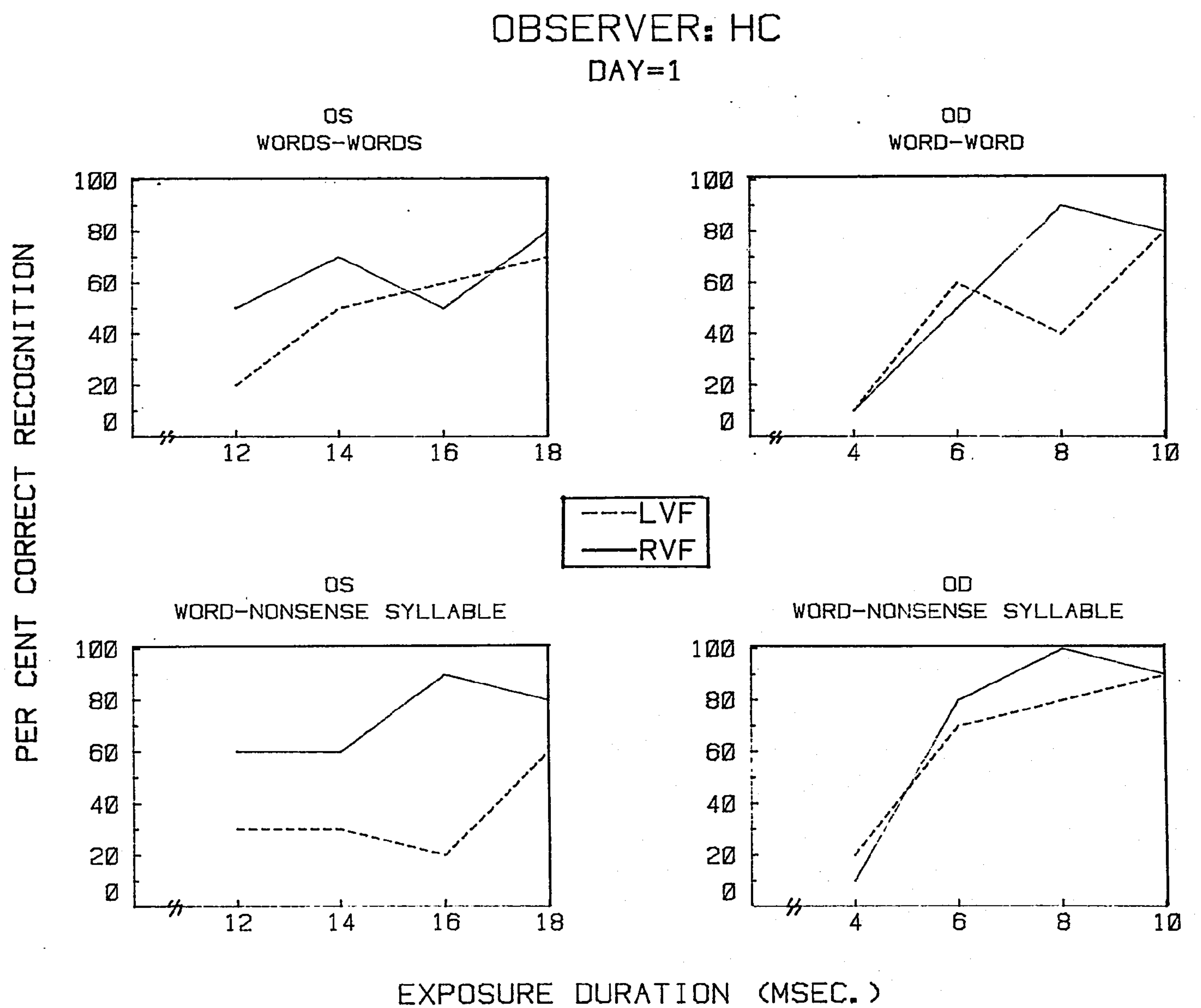

HEWLETT PACKARD
OBSERVER: HC
DAY=1
OS
WORDS-WORDS
OD
WORD-WORD
LVF
RVF
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
PER CENT CORRECT RECOGNITION
0
20
40
60
80
100
12
14
16
18
4
6
8
10
EXPOSURE DURATION (MSEC.)

Figure A7 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: HC for testing session 2 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: HC

DAY=2

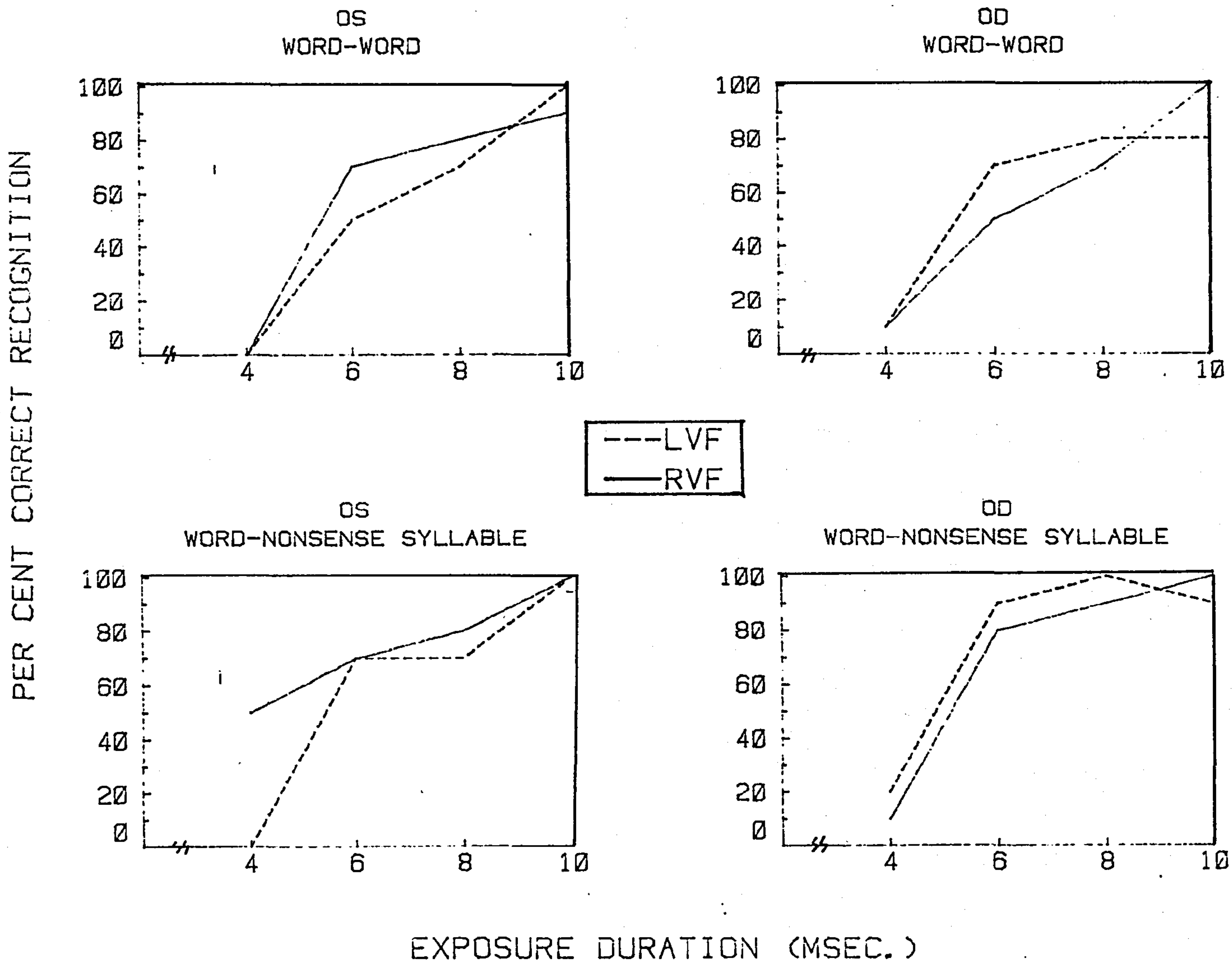


Figure A8 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: HC for testing session 3 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

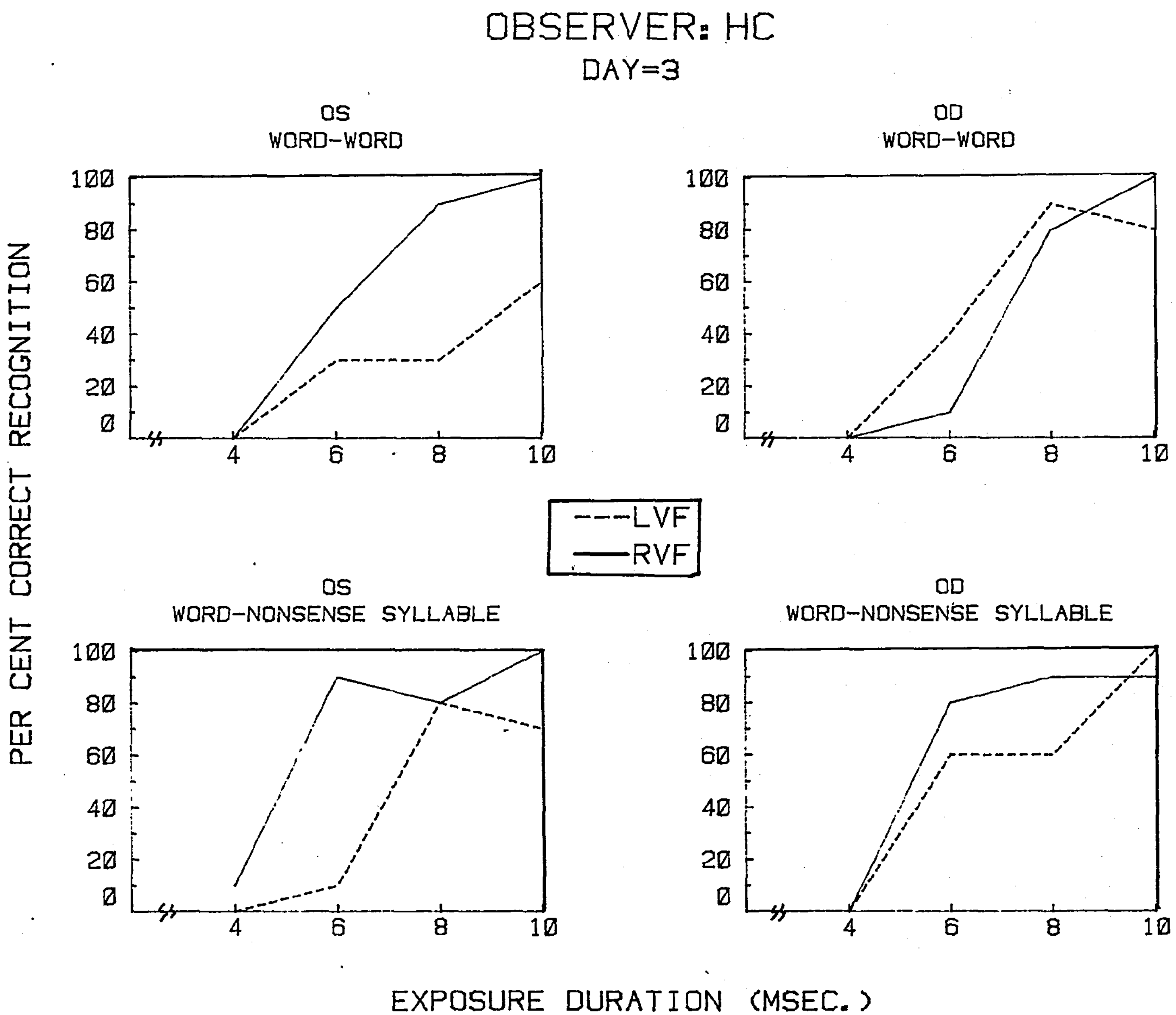

OBSERVER: HC
DAY=3
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
PER CENT CORRECT RECOGNITION
100
80
60
40
20
0
4
6
8
10
---LVF
—RVF
EXPOSURE DURATION (MSEC.)

Figure A9 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: HC for testing session 4 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: HC

DAY=4

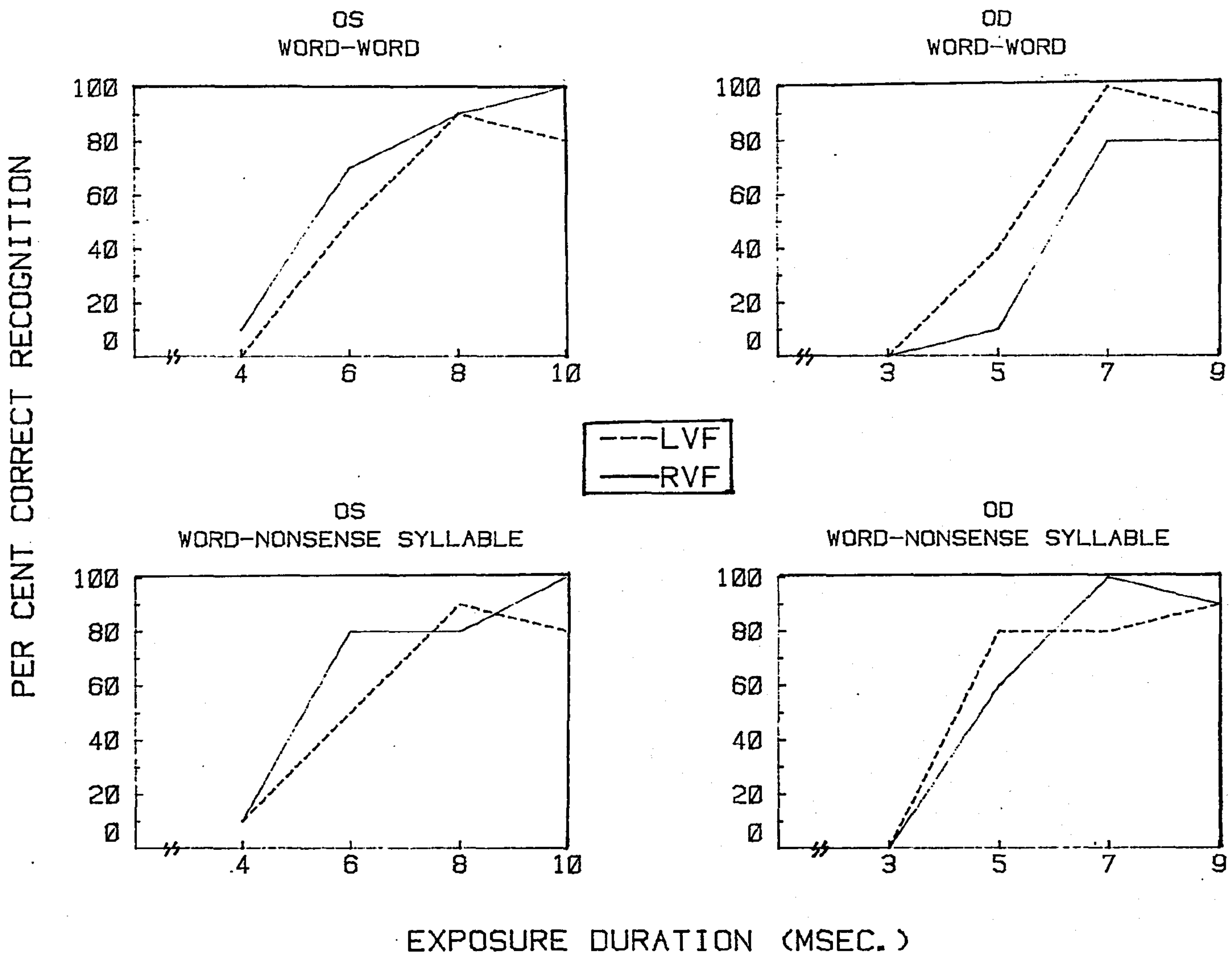


Figure A10 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:HC for testing session 5 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: HC

DAY=5

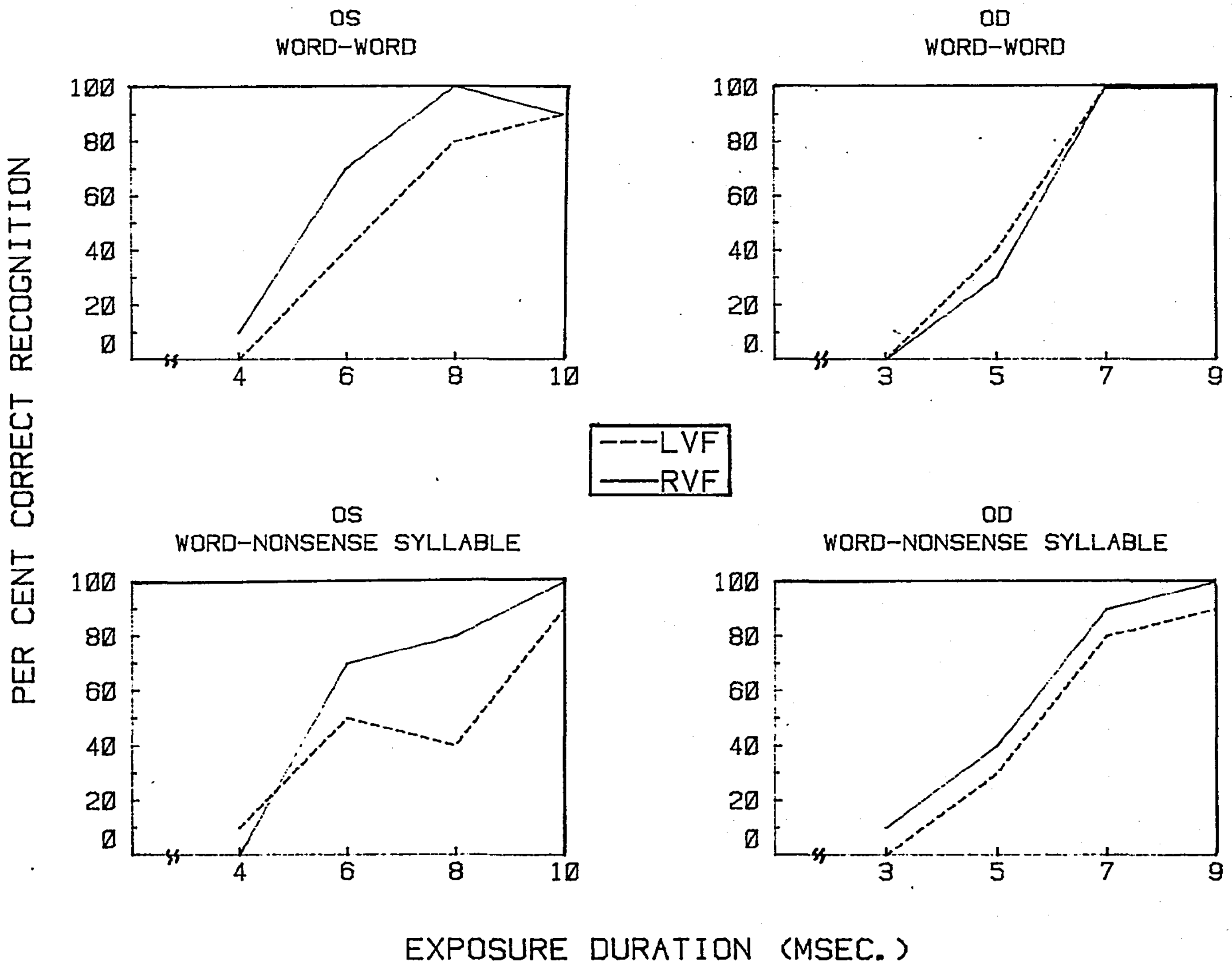


Figure A11 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: JH for testing session 1 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

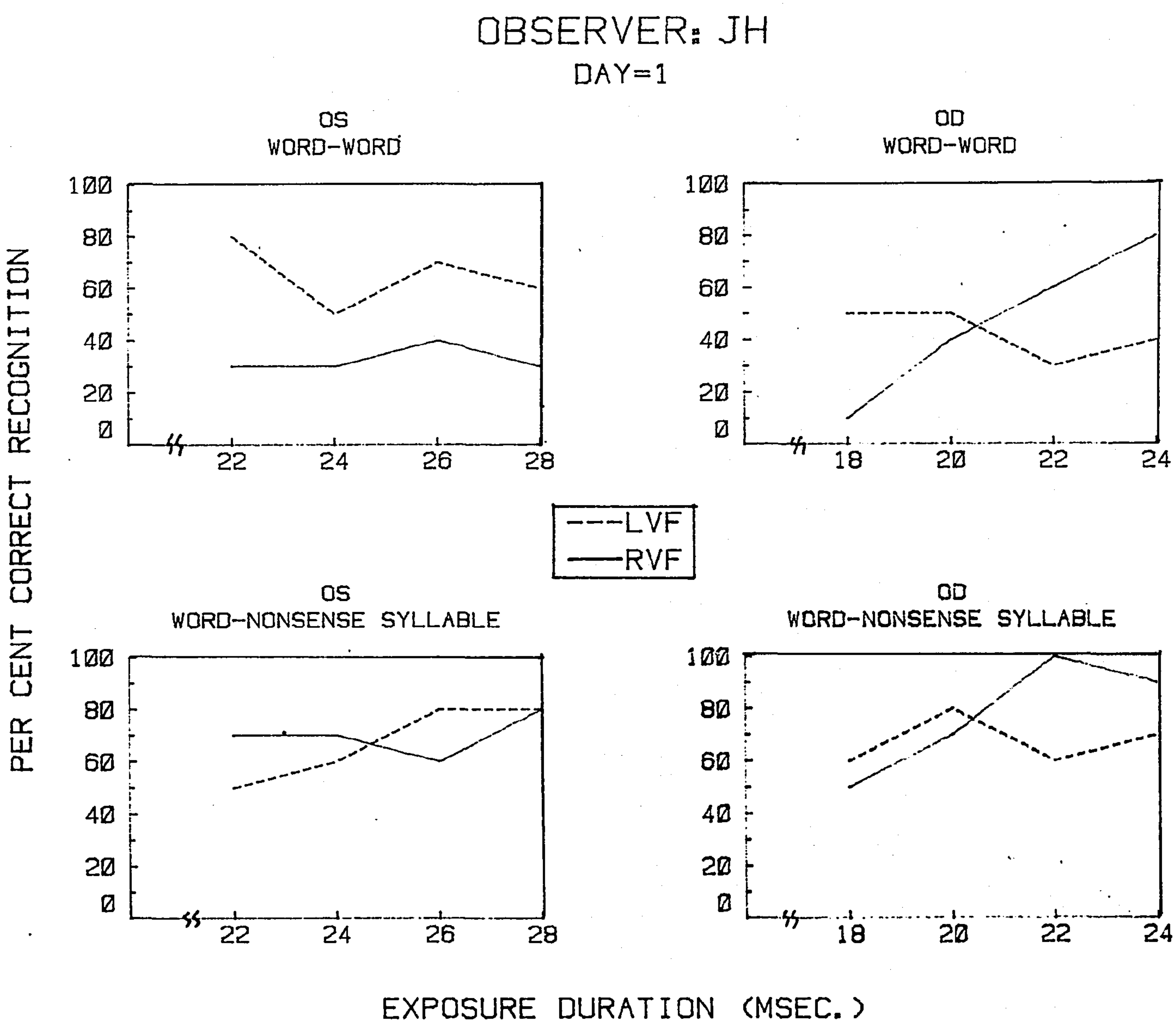

OBSERVER: JH
DAY=1
OS
WORD-WORD
OD
WORD-WORD
---LVF
—RVF
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
PER CENT CORRECT RECOGNITION
100
80
60
40
20
0
22
24
26
28
18
20
22
24
EXPOSURE DURATION (MSEC.)

Figure A12 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: JH for testing session 2 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

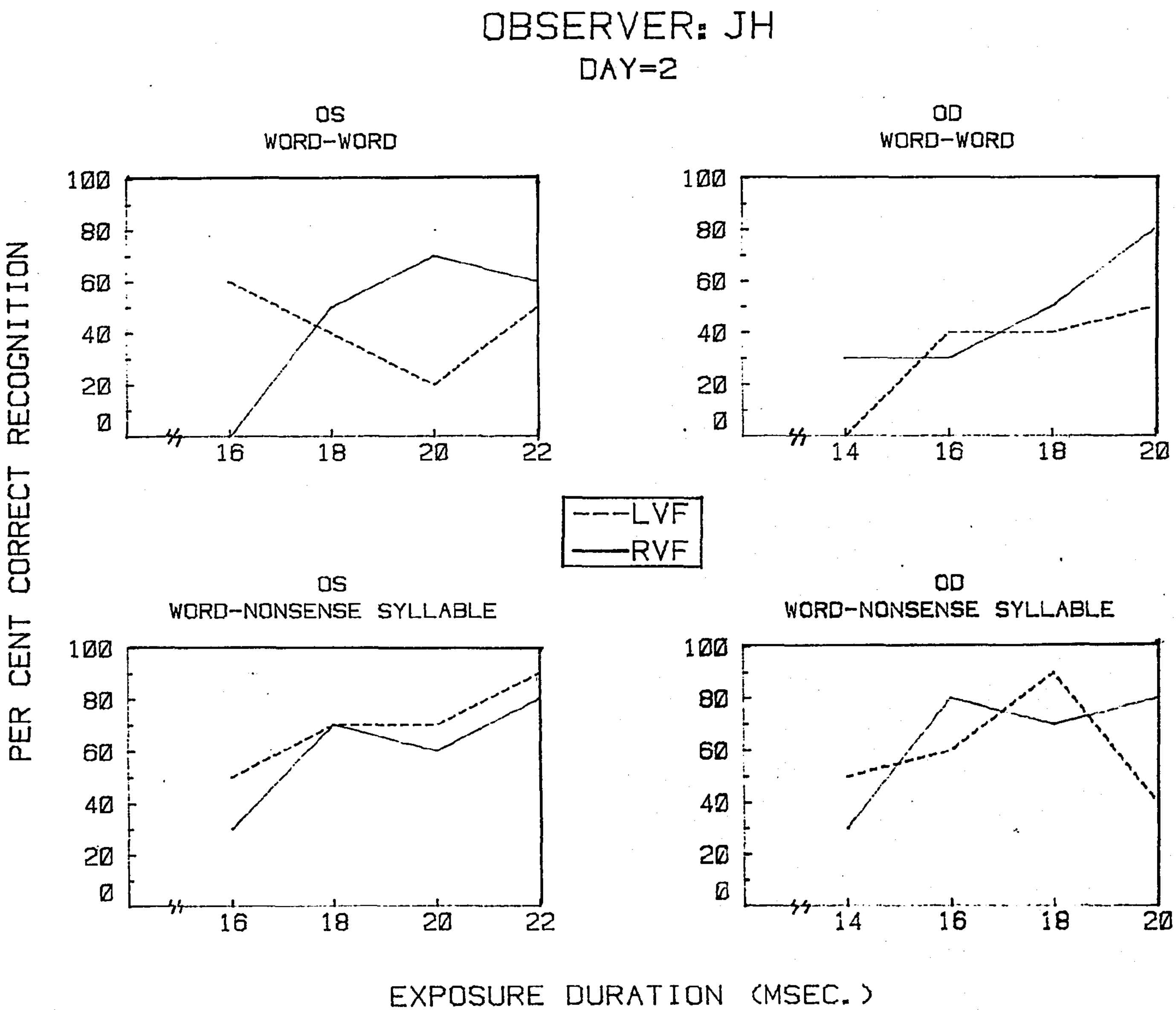

OBSERVER: JH
DAY=2
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
——RVF
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A13 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:JH for testing session 3 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

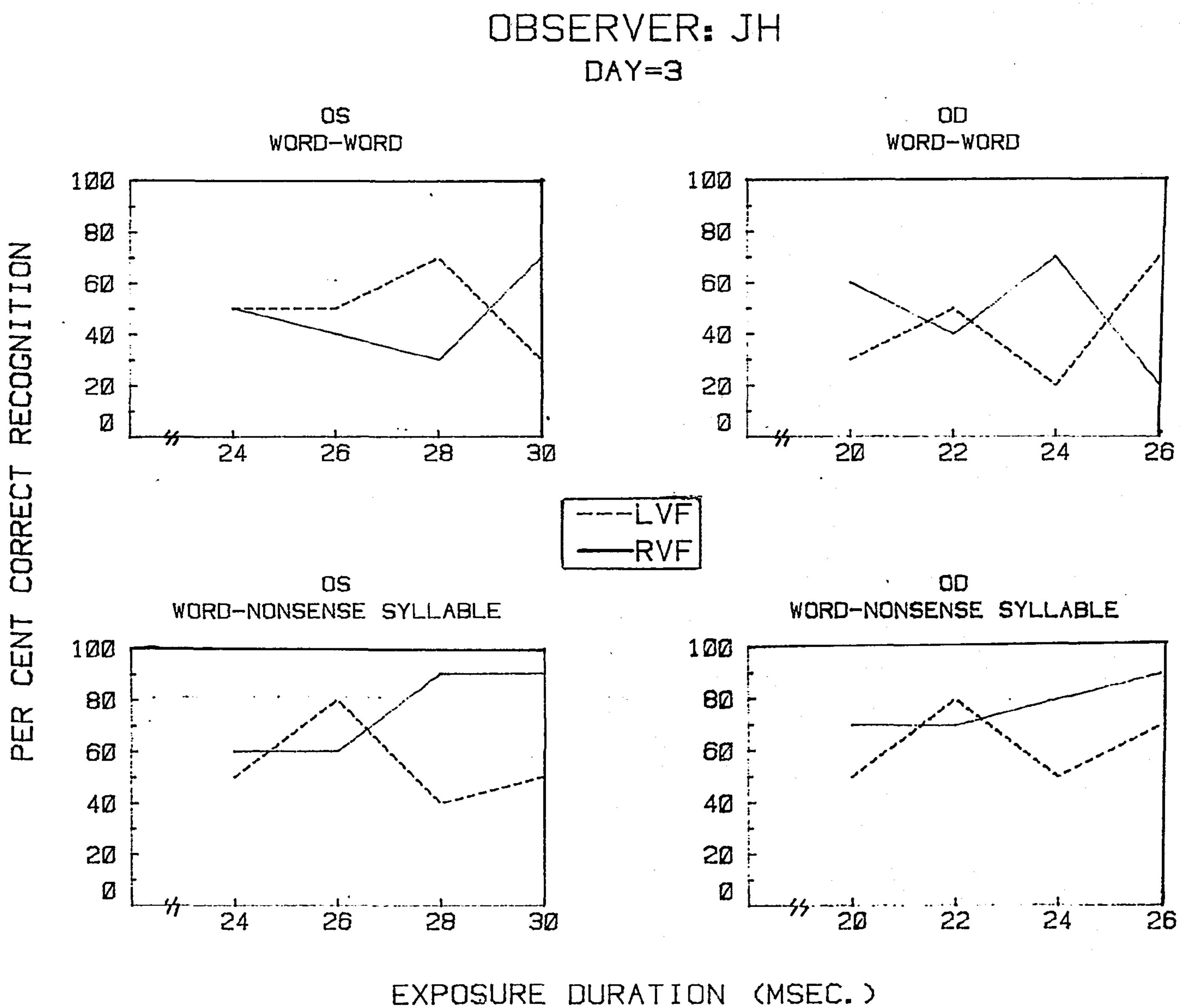

OBSERVER: JH
DAY=3
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
—RVF
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)
100
80
60
40
20
0
24
26
28
30
20
22
24
26

Figure A14 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: JH for testing session 4 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

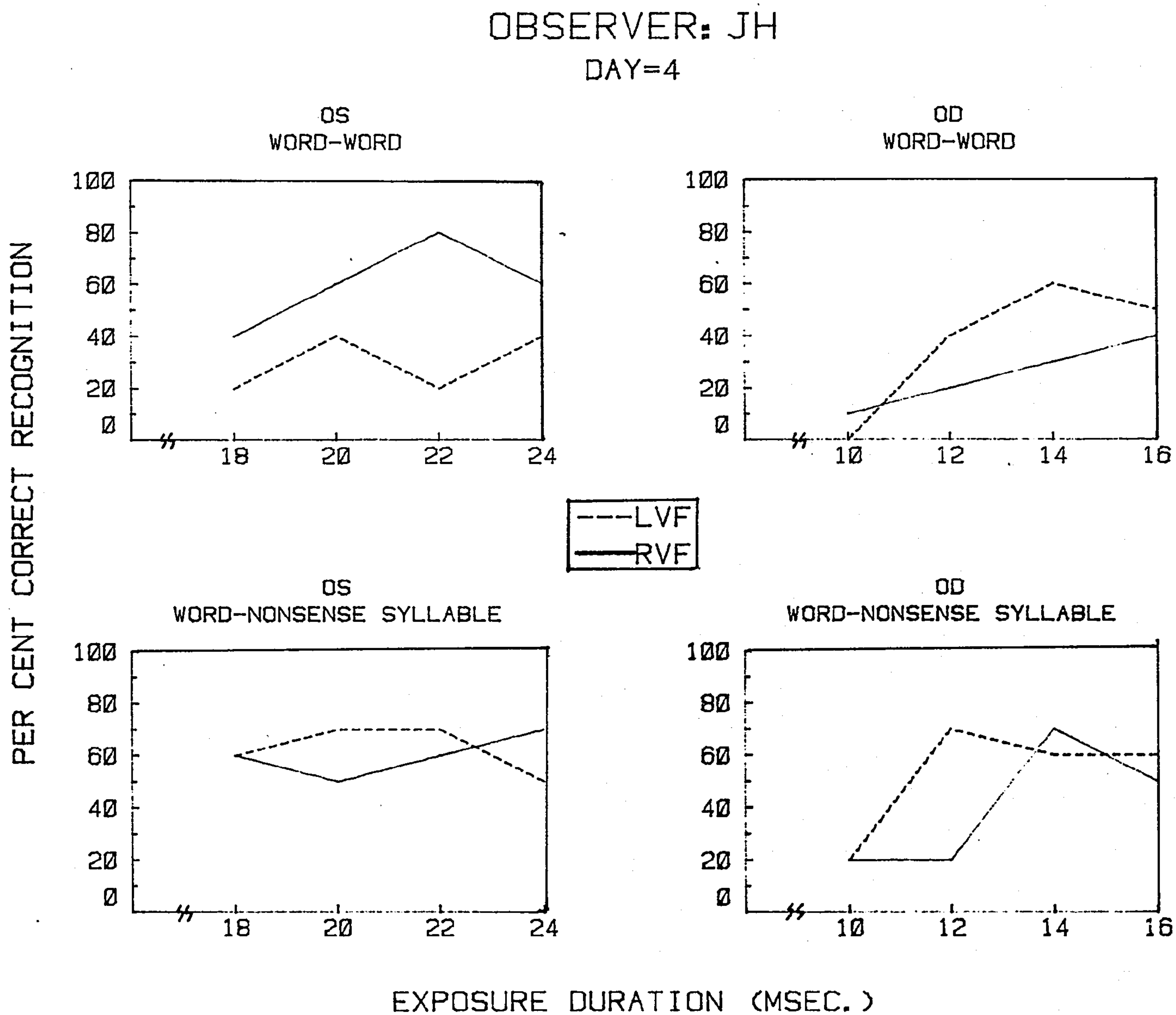

OBSERVER: JH
DAY=4
OS
WORD-WORD
OD
WORD-WORD
100
80
60
40
20
0
18
20
22
24
10
12
14
16
---LVF
RVF
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A15 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: JH for testing session 5 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

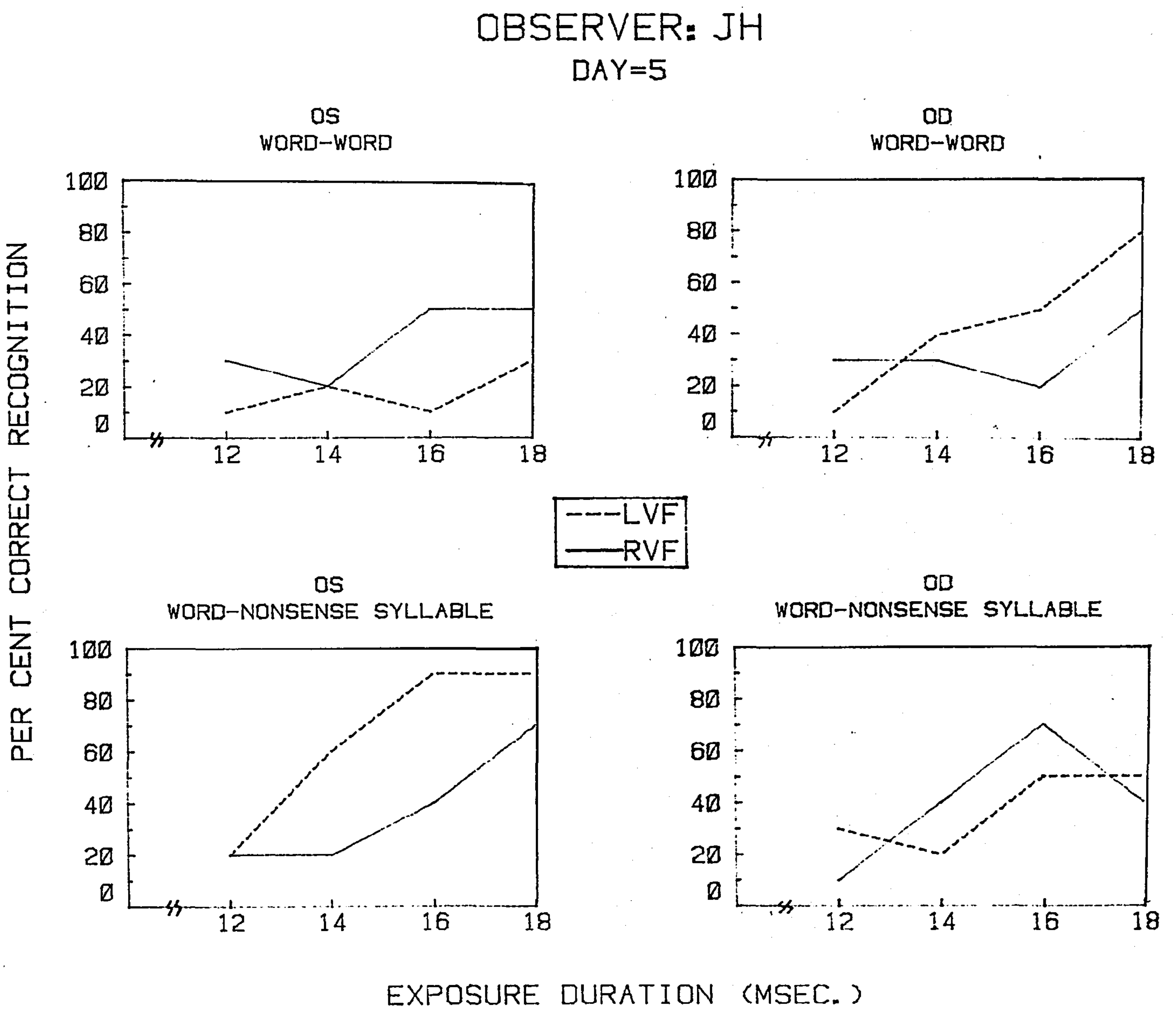

OBSERVER: JH
DAY=5
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
——RVF
100
80
60
40
20
0
12
14
16
18
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A16. Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: MW for testing session 1. The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: MW

DAY=1

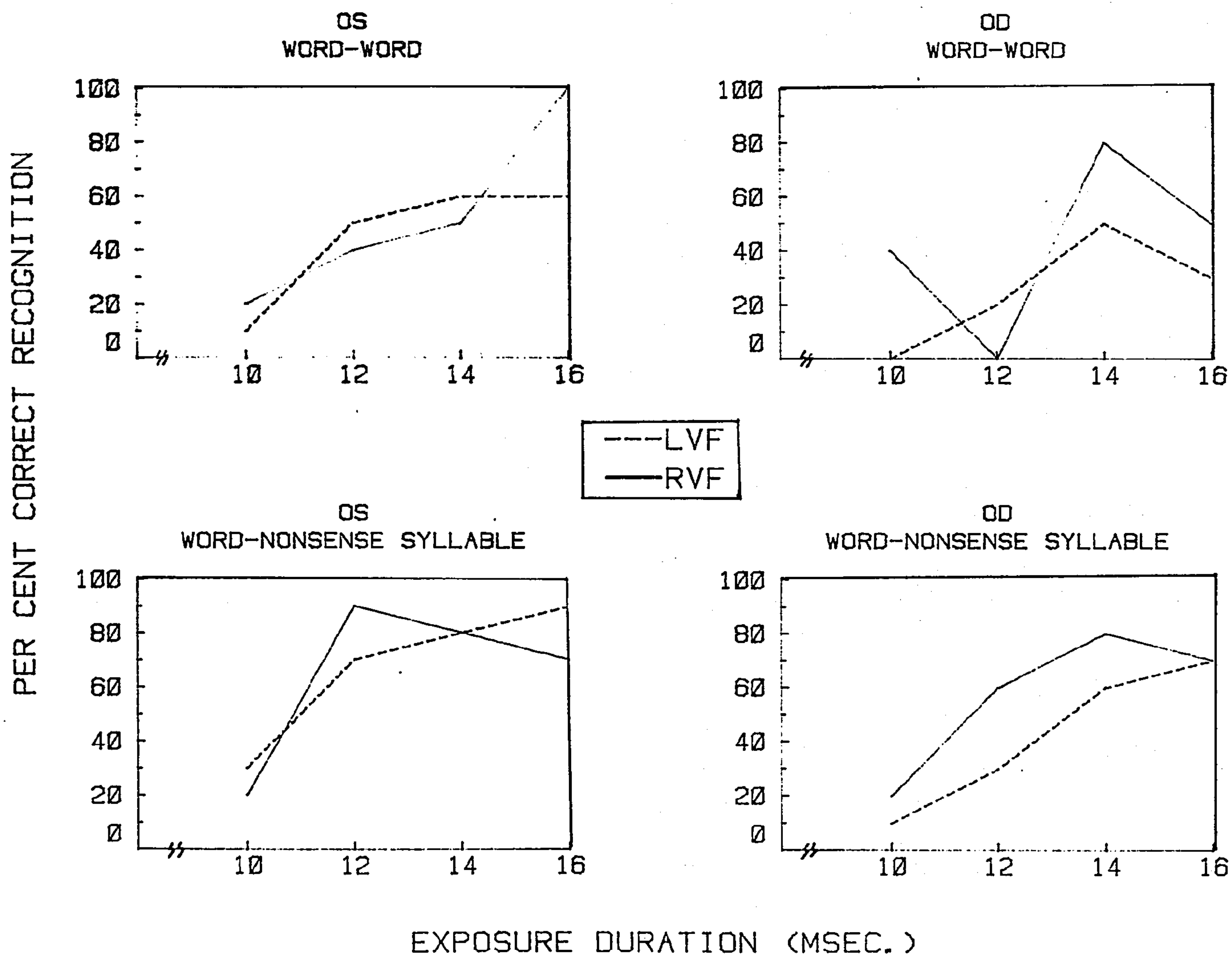


Figure A17 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:MW for testing session 2 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

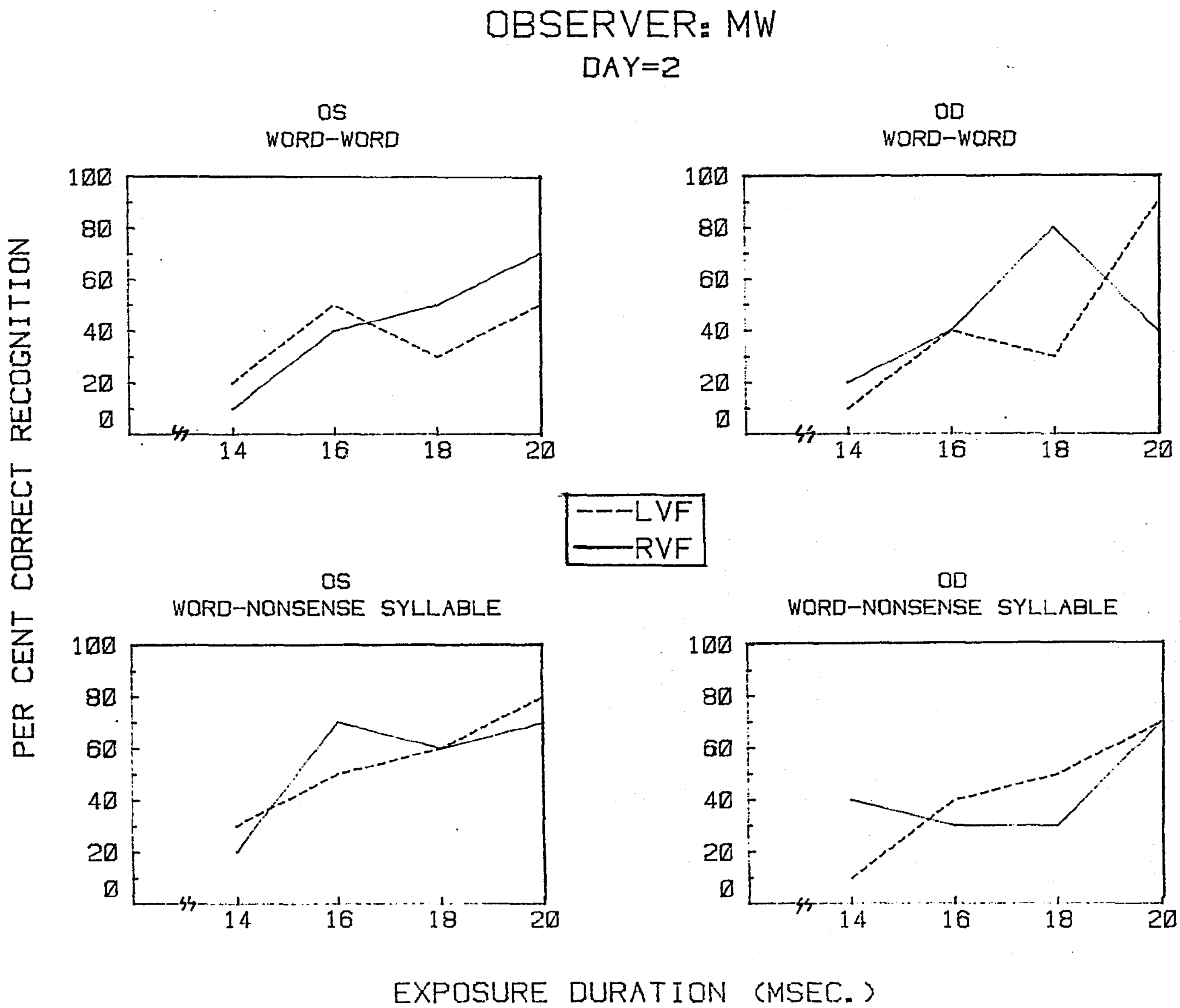

OBSERVER: MW
DAY=2
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
100
80
60
40
20
0
14
16
18
20
---LVF
—RVF
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A18. Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:MW for testing session 3. The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: MW

DAY=3

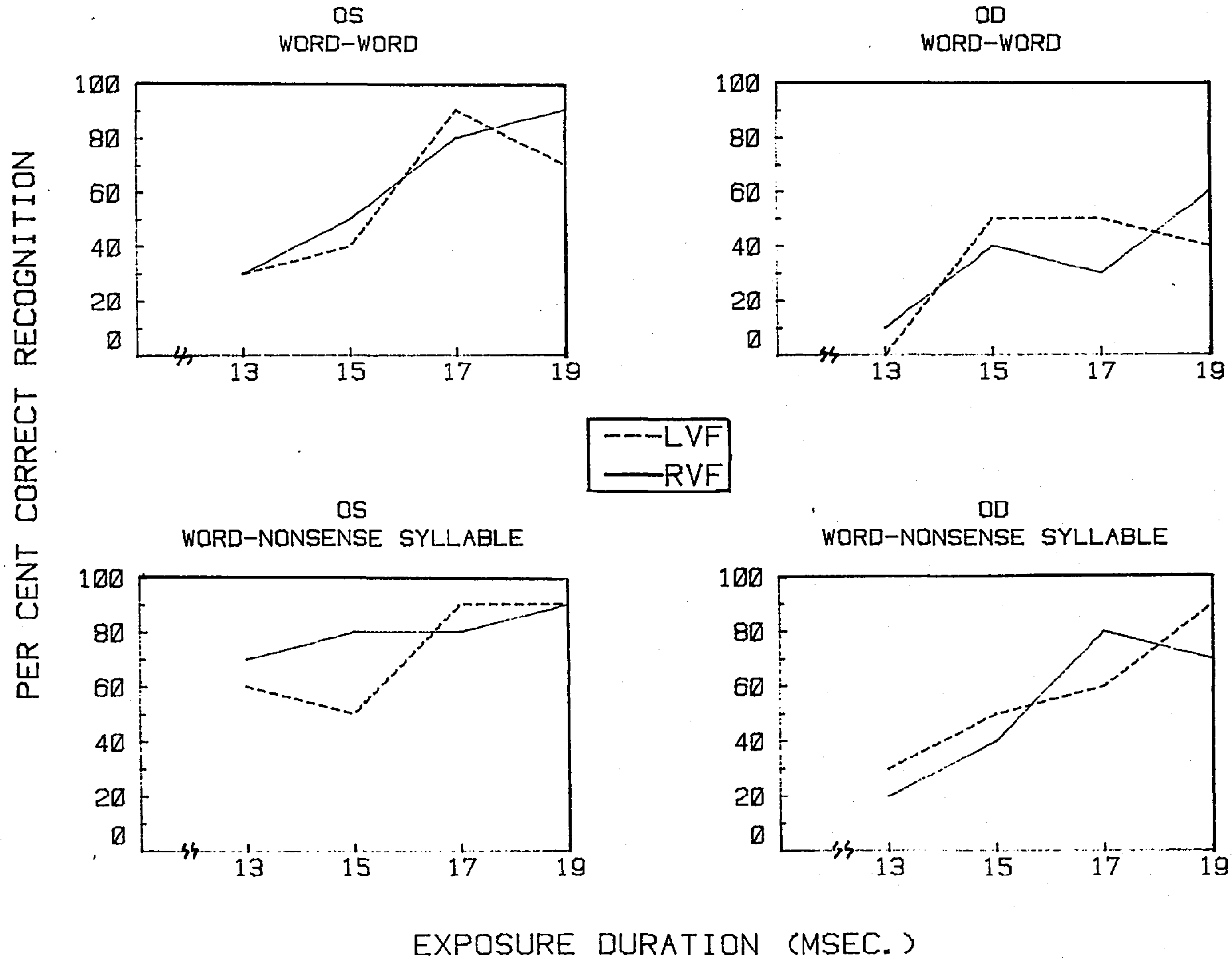


Figure A19 . Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O:MW for testing session 4 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

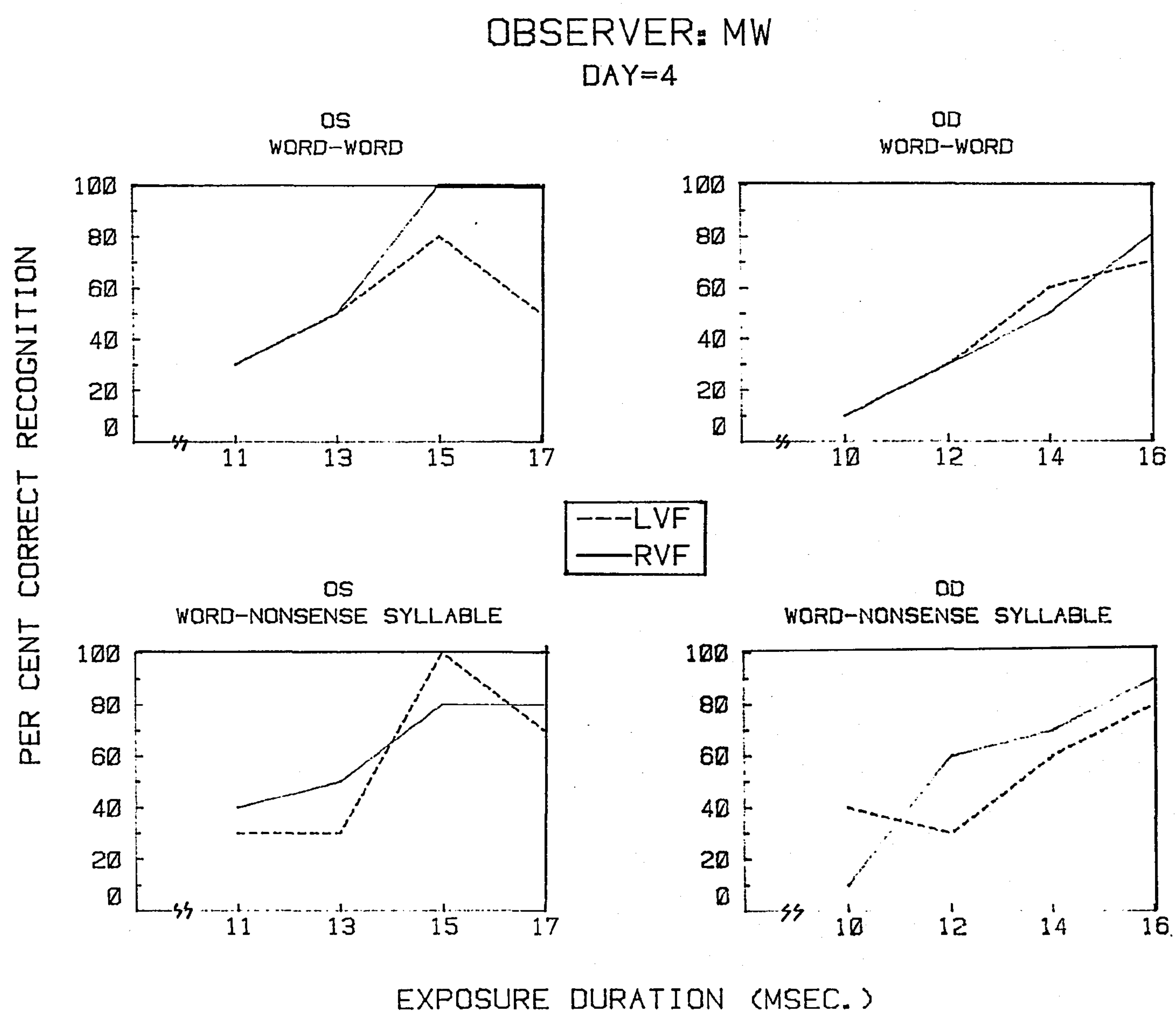

OBSERVER: MW
DAY=4
OS
WORD-WORD
OD
WORD-WORD
OS
WORD-NONSENSE SYLLABLE
OD
WORD-NONSENSE SYLLABLE
---LVF
—RVF
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)
100
80
60
40
20
0
11
13
15
17
10
12
14
16

Figure A20. Per cent correct recognitions of words in the left (dashed line) and right (solid line) visual half-fields as a function of exposure duration (in msec.) for O: MW for testing session 5 . The word-word (WW) condition is across the top; word-nonsense syllable (WN) condition is along the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

# OBSERVER: MW
DAY=5

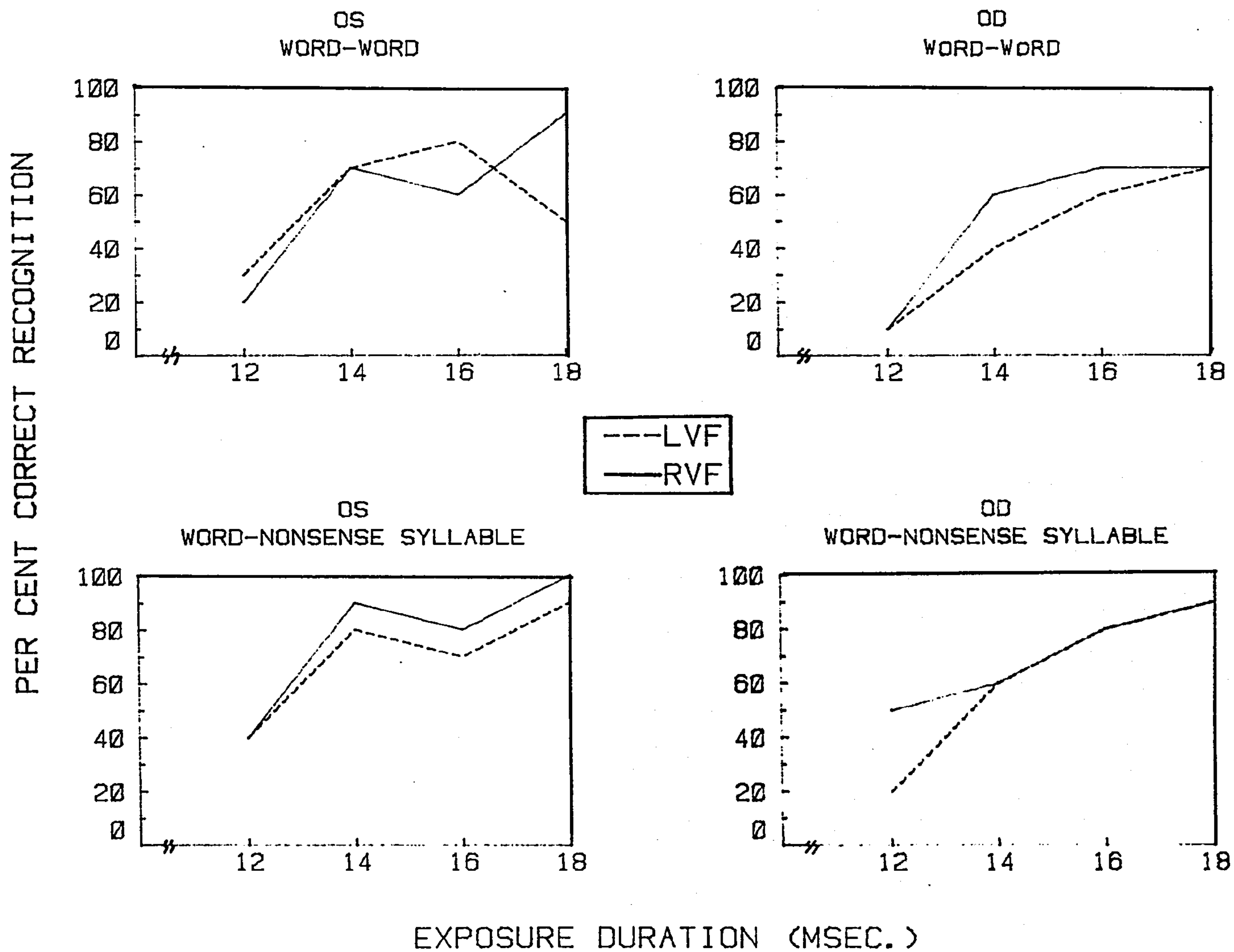


Figure A21. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG for testing session 1. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

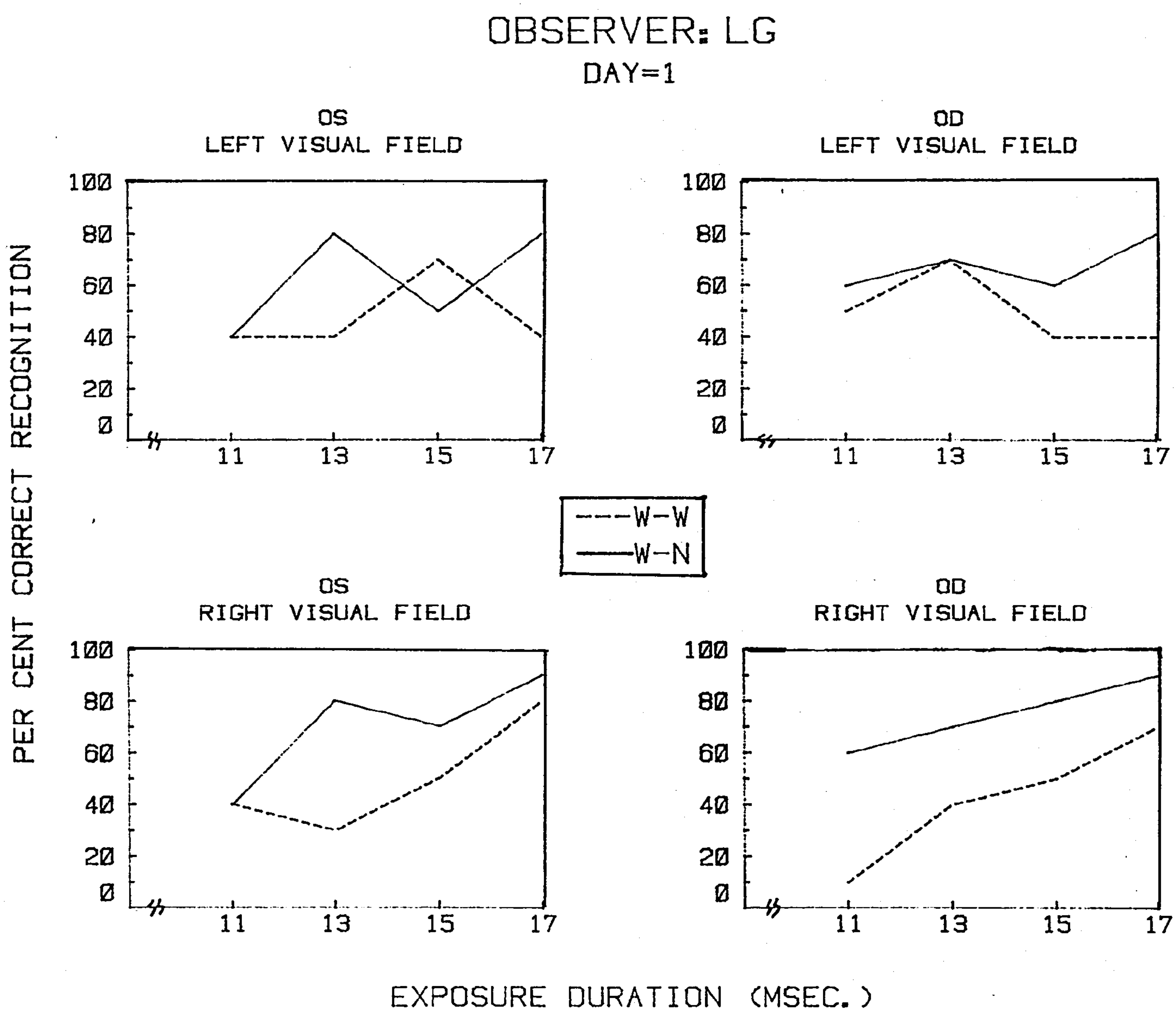
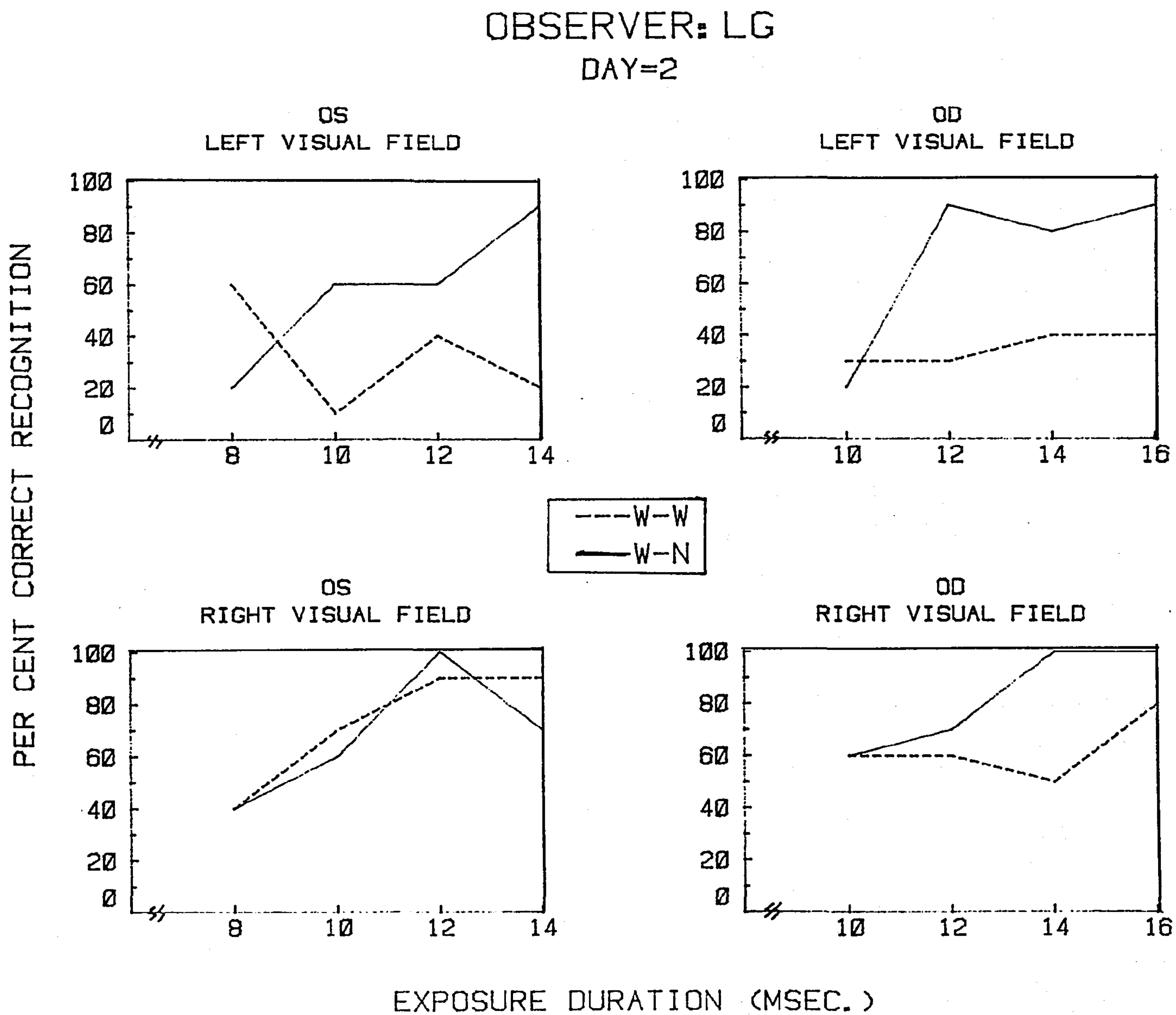

OBSERVER: LG
DAY=1
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
11
13
15
17
----W-W
——W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A22. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG for testing session 2. The left visual field (LVF) is across the top; the right visual field is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: LG
DAY=2
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
8
10
12
14
16
W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A23. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG for testing session 3. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: LG

DAY=3

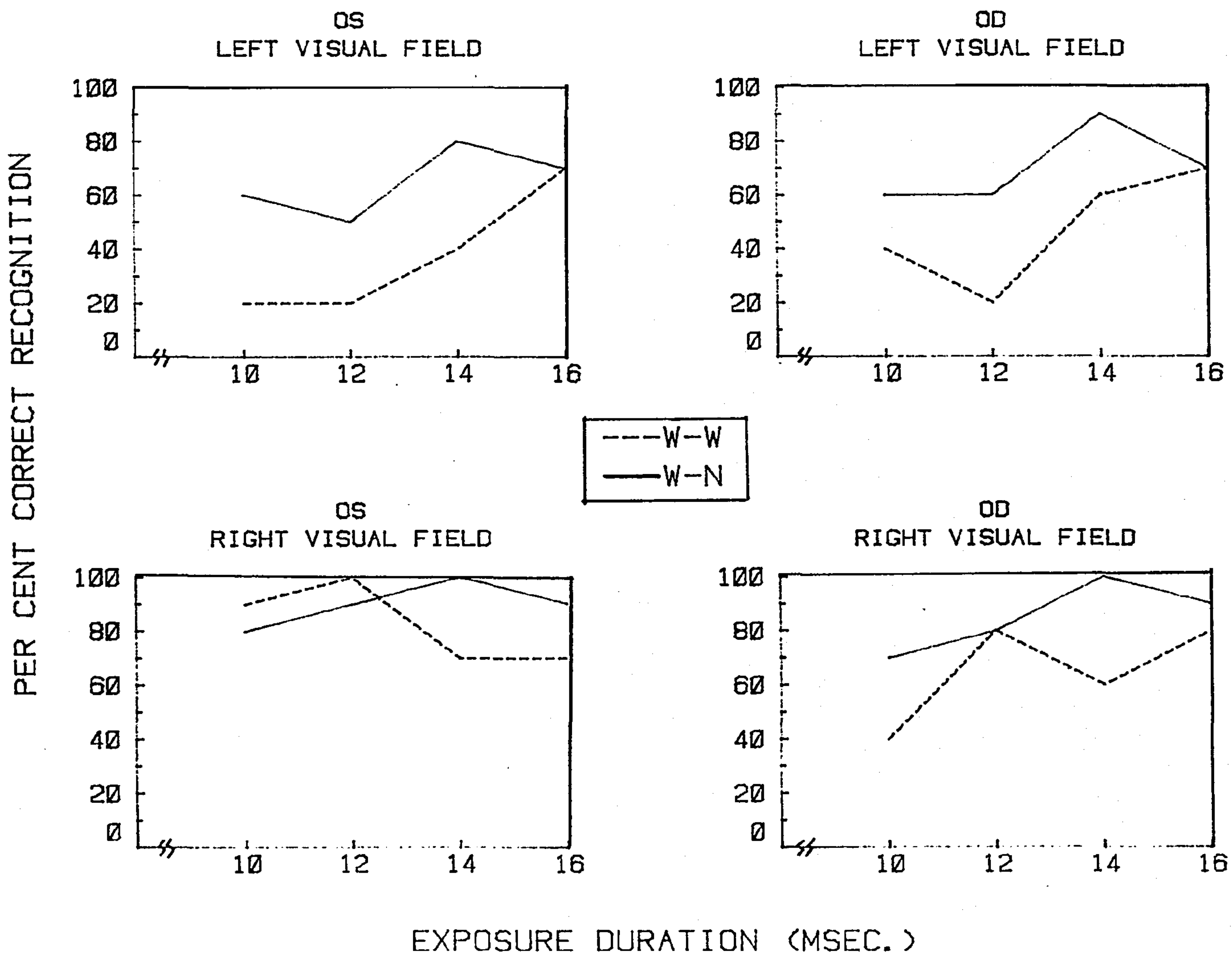


Figure A24. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line]: stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG for testing session 4. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye is on the right.

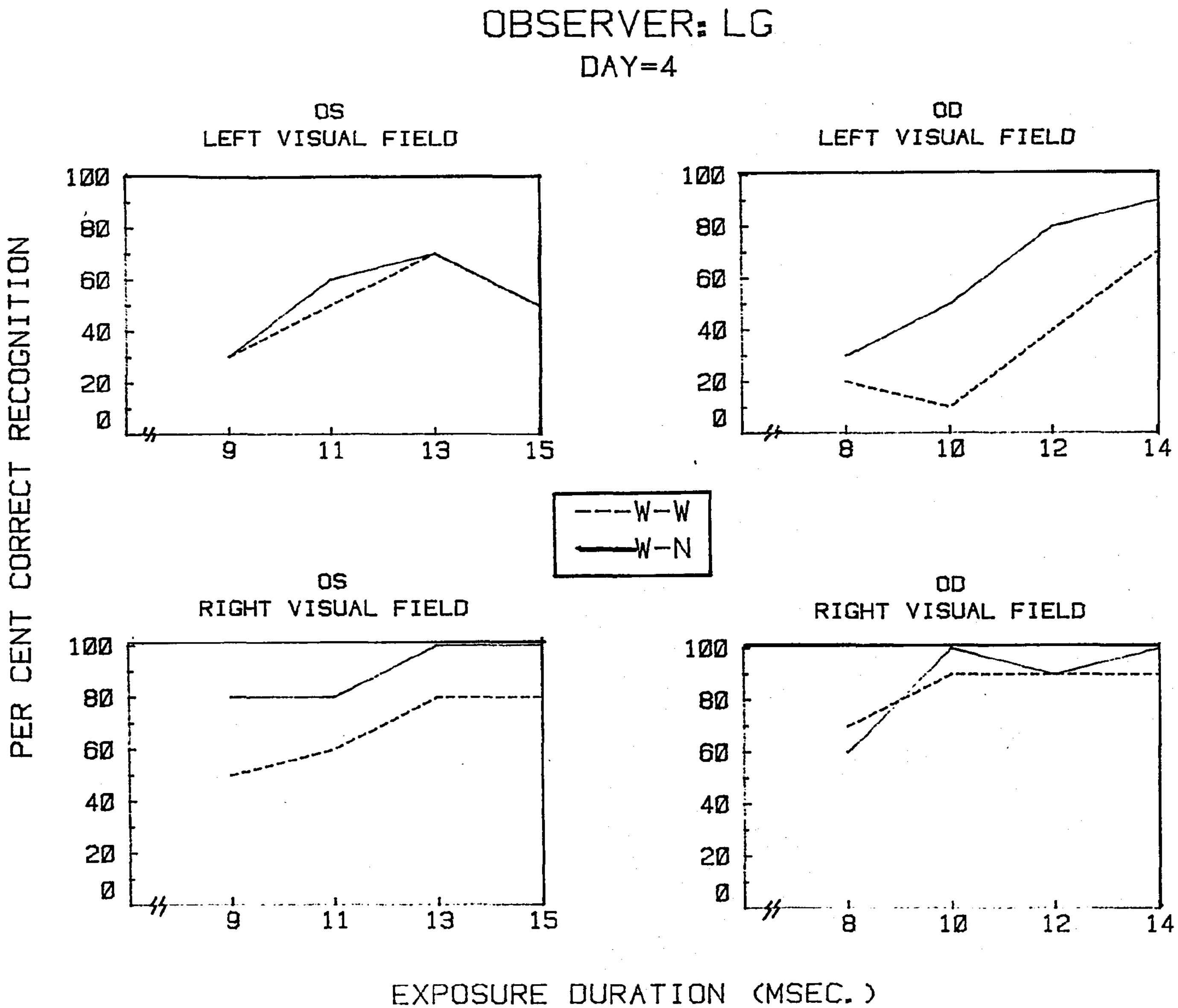

OBSERVER: LG
DAY=4
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
PER CENT CORRECT RECOGNITION
100
80
60
40
20
0
9
11
13
15
8
10
12
14
---W-W
W-N
EXPOSURE DURATION (MSEC.)

Figure A25. Per cent correct recognitons of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:LG for testing session 5. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

# OBSERVER: LG
DAY=5

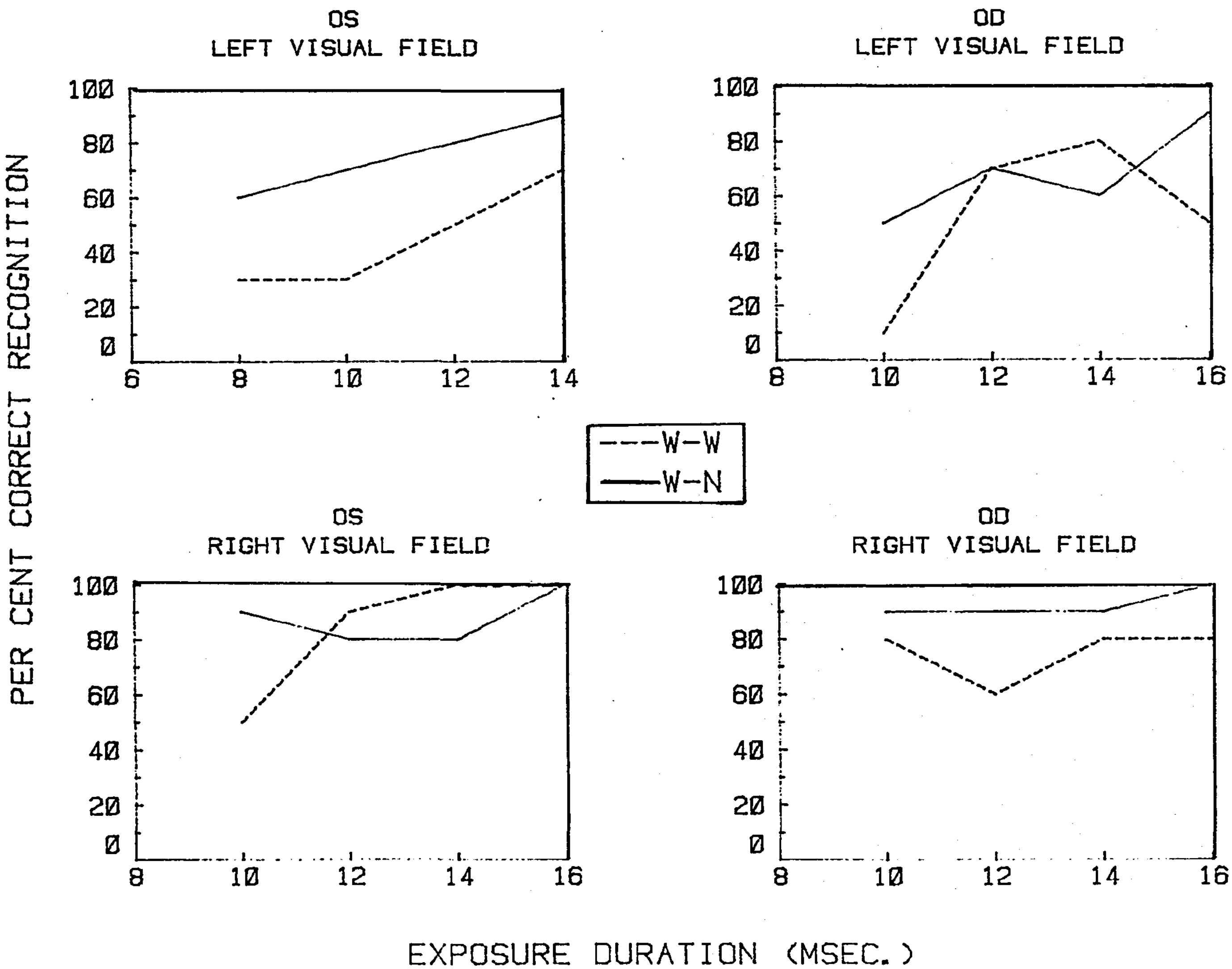
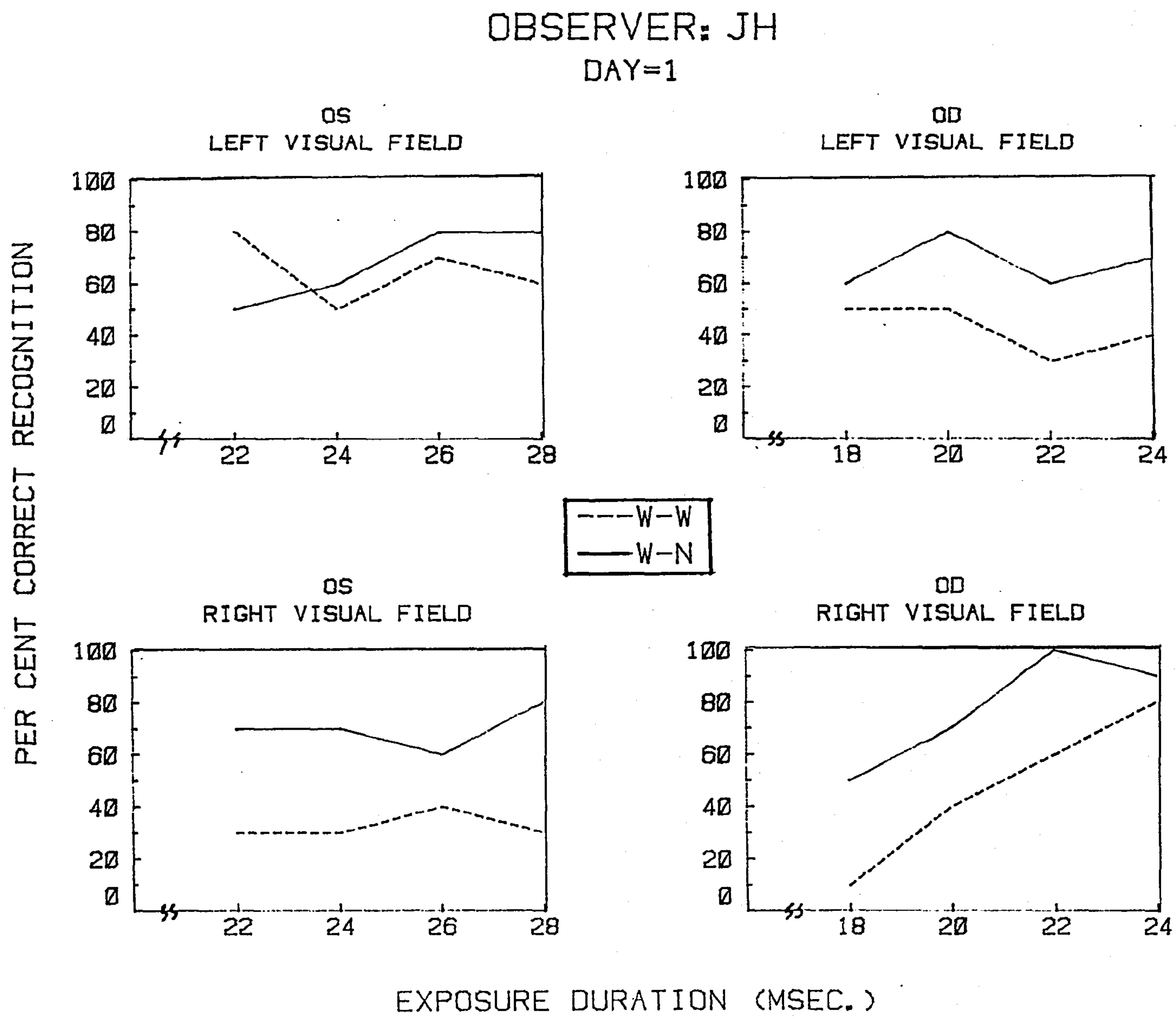
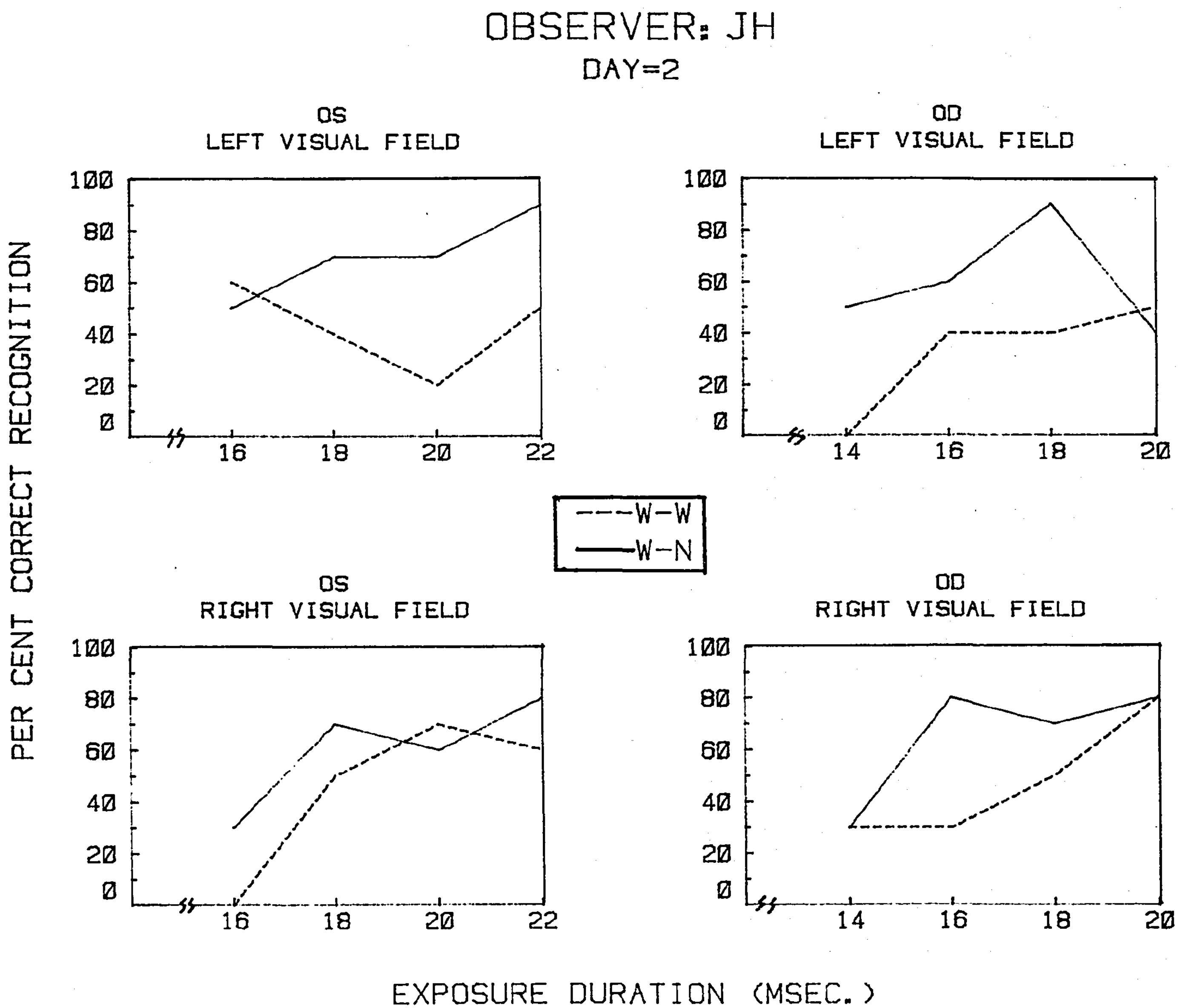


Figure A26. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:JH for testing session 1. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.


OBSERVER: JH
DAY=1
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
22
24
26
28
18
20
22
24
---W-W
——W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

FigureA27. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:JH for testing session 2. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: JH
DAY=2
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
100
80
60
40
20
0
16
18
20
22
14
16
18
20
W-W
W-N
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A28. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:JH for testing session 3. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

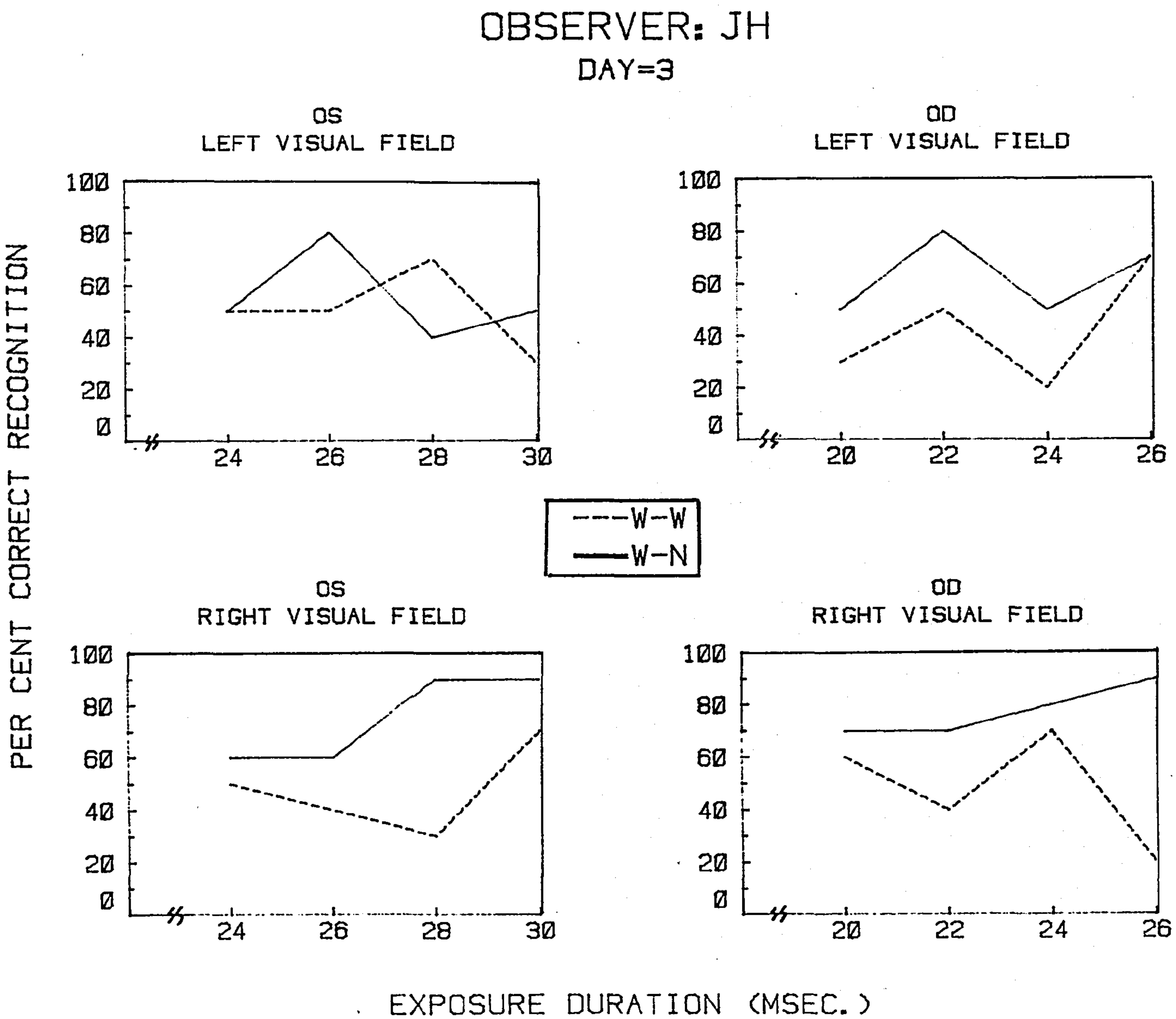

OBSERVER: JH
DAY=3
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
PER CENT CORRECT RECOGNITION
100
80
60
40
20
0
24
26
28
30
20
22
24
26
W-W
W-N
EXPOSURE DURATION (MSEC.)

Figure A29. Per cent correct recogntiion of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:JH for testing session 4. The left visual filed (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: JH

DAY=4

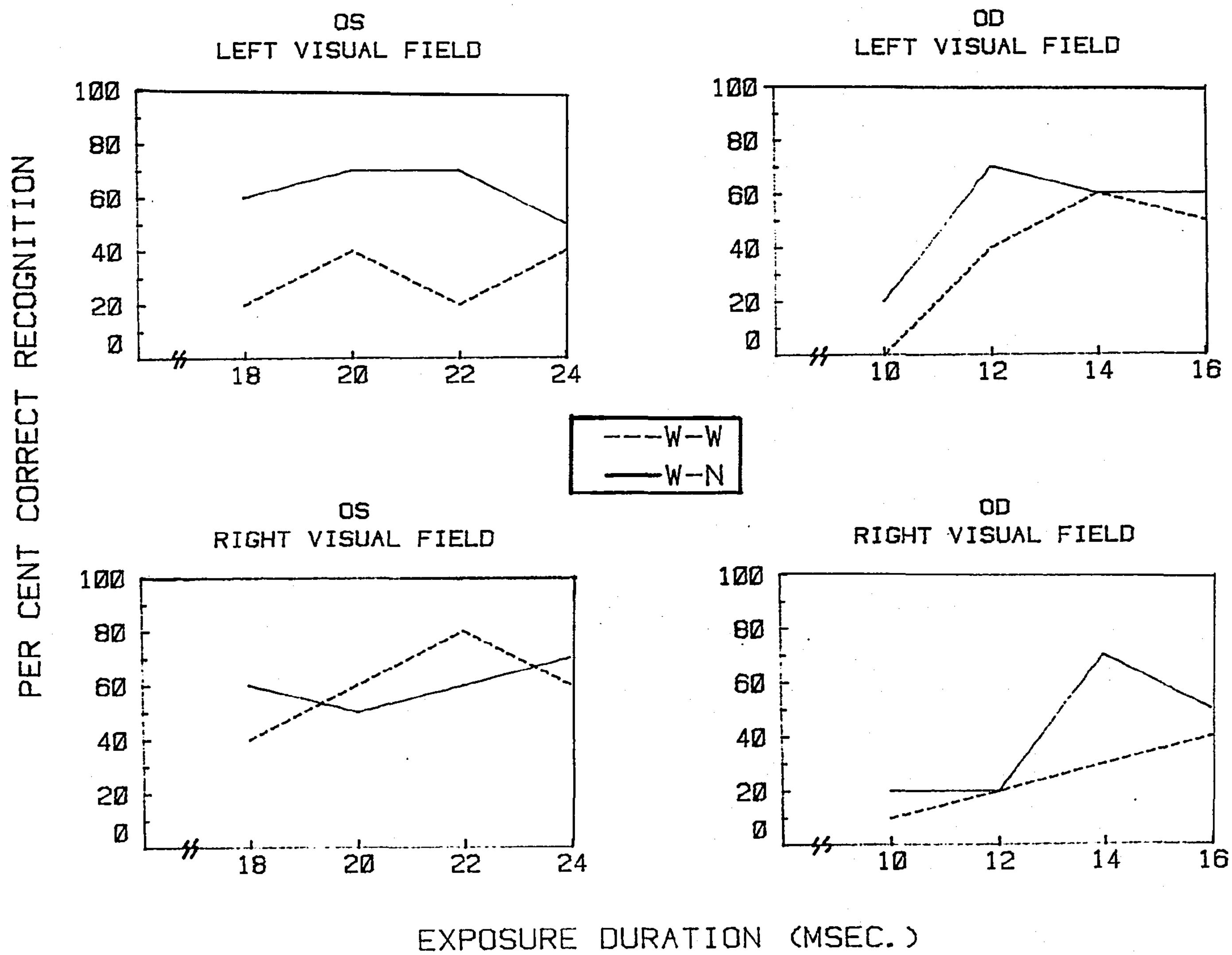
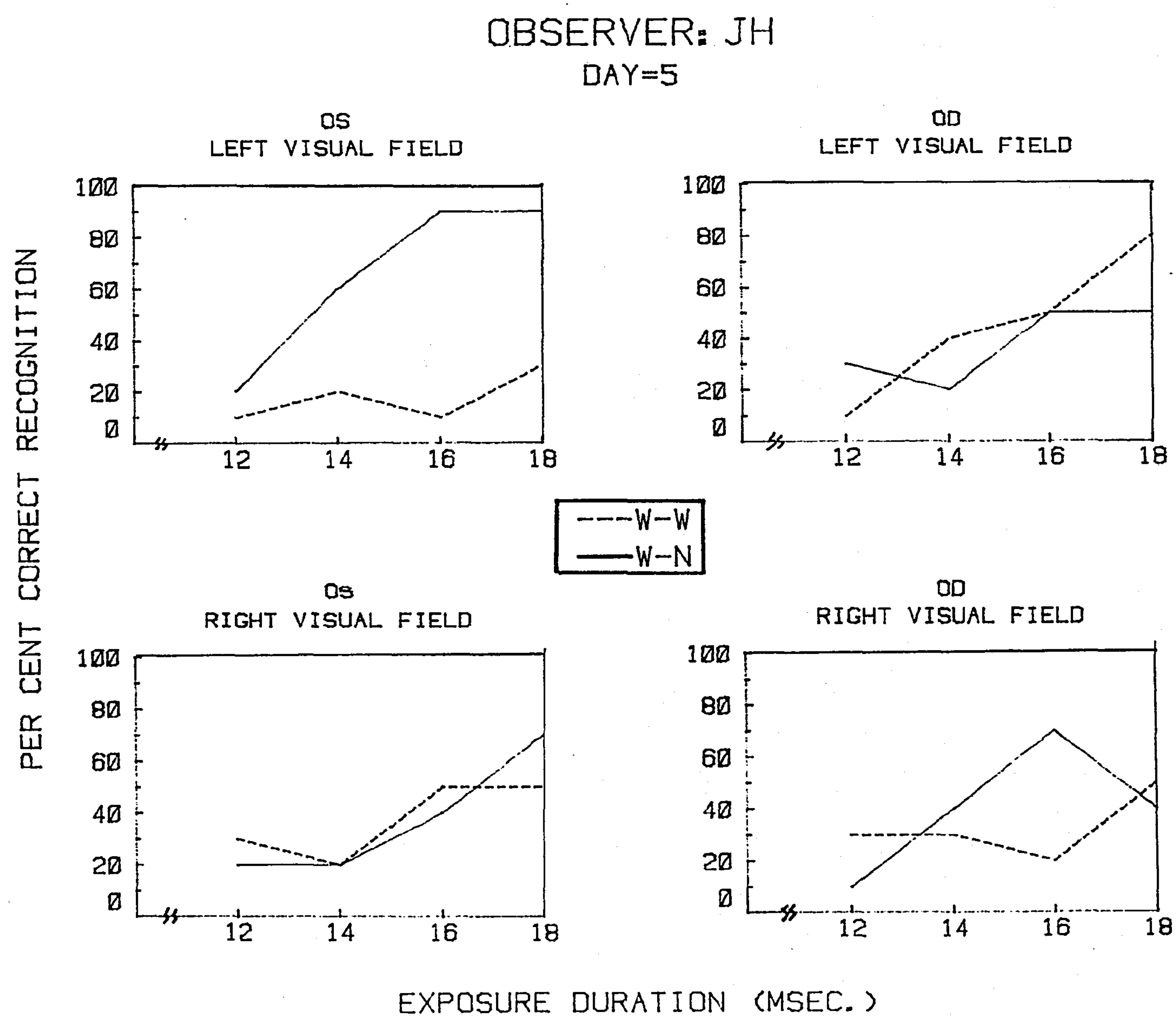
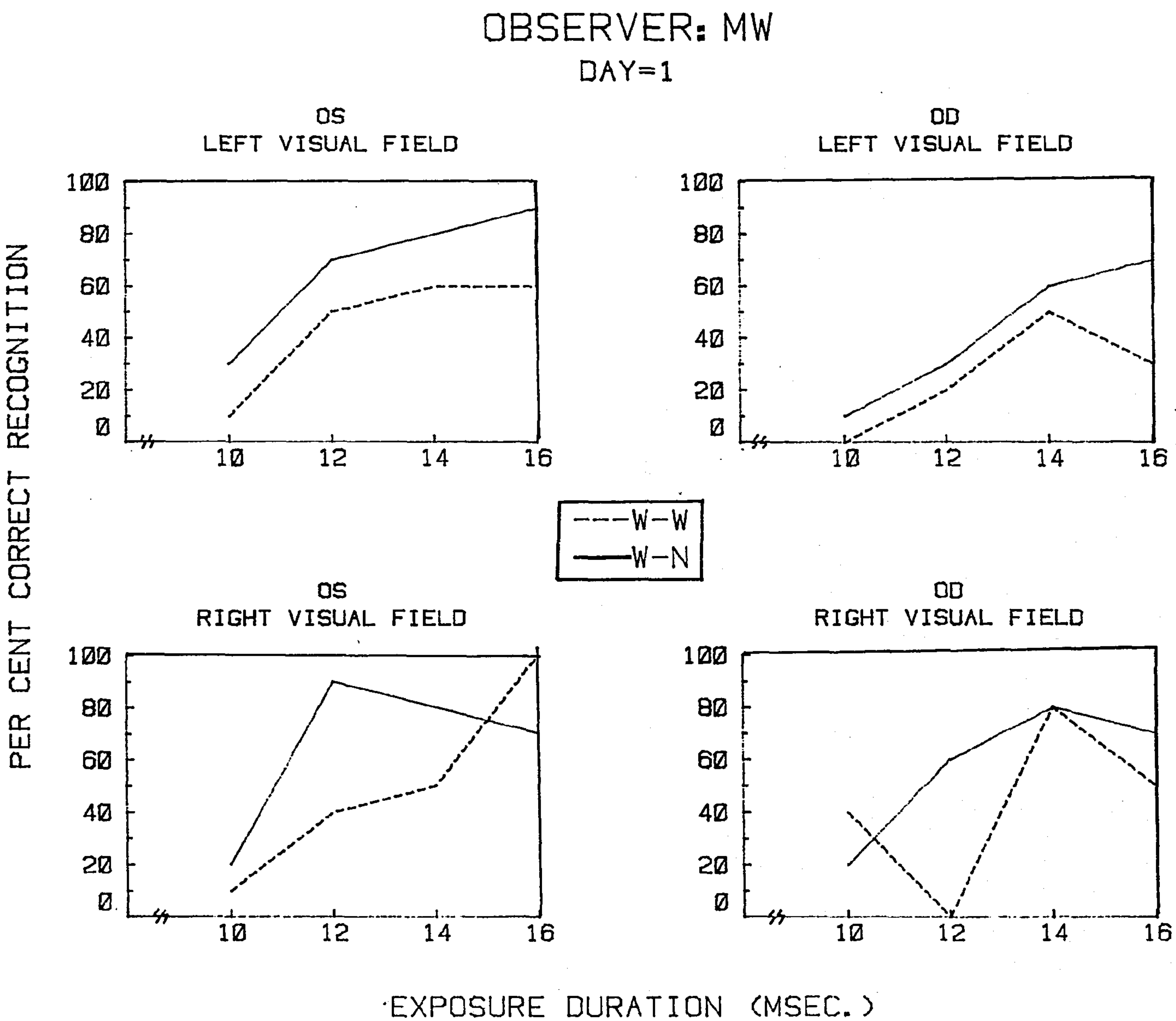


Figure A30. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN)[solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:JH for testing session 5. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: JH
DAY=5
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)
100
80
60
40
20
0
12
14
16
18

Figure A31. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditons as a function of exposure duration (in msec.) for O:MW for testing session 1. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: MW
DAY=1
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
10
12
14
16
---W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A32. Per cent correct recogntion of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:MW for testing session 2. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

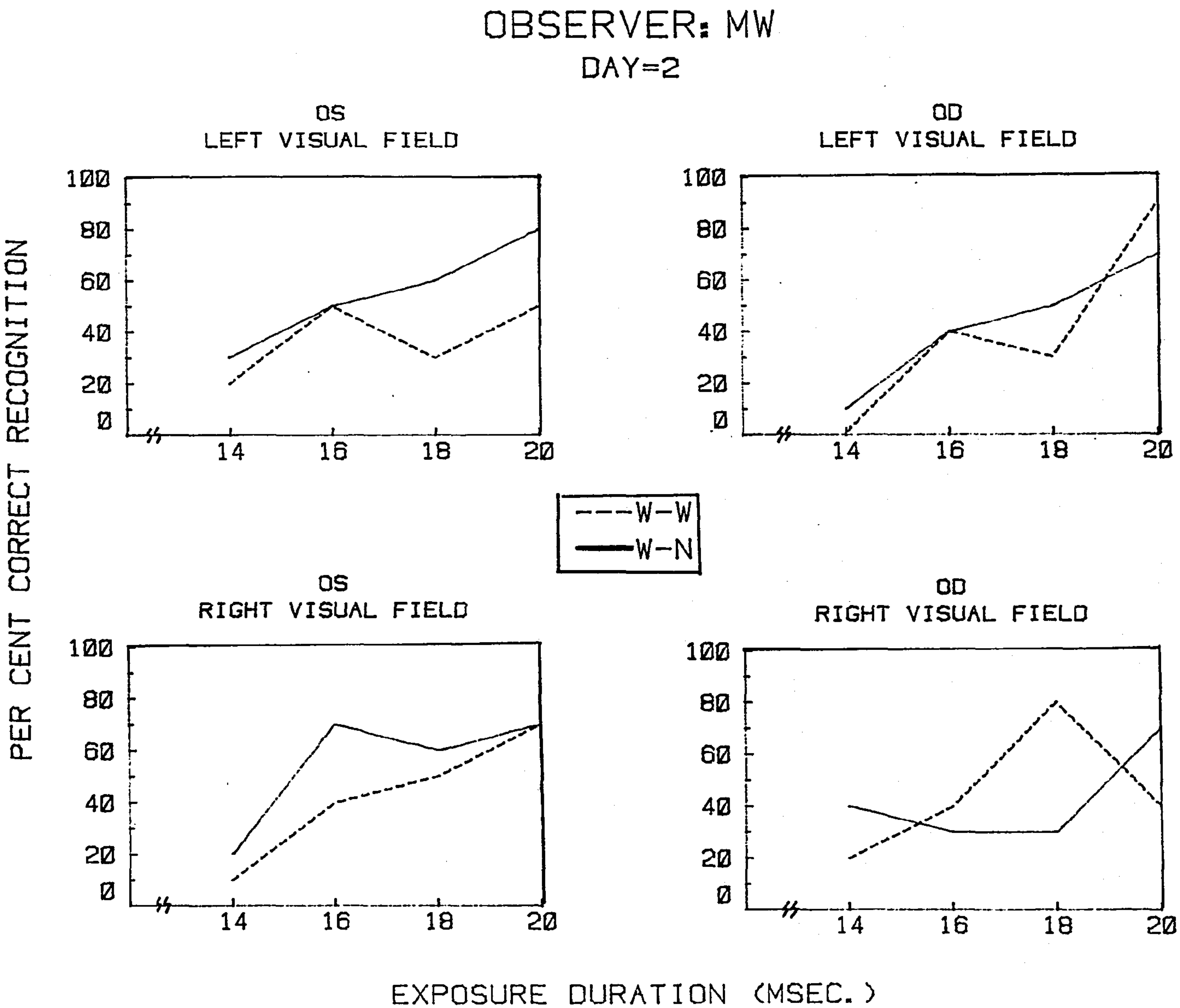

OBSERVER: MW
DAY=2
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
---W-W
W-N
PER CENT CORRECT RECOGNITION
100
80
60
40
20
0
14
16
18
20
EXPOSURE DURATION (MSEC.)

Figure A33. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:MW for testing session 3. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: MW

DAY=3

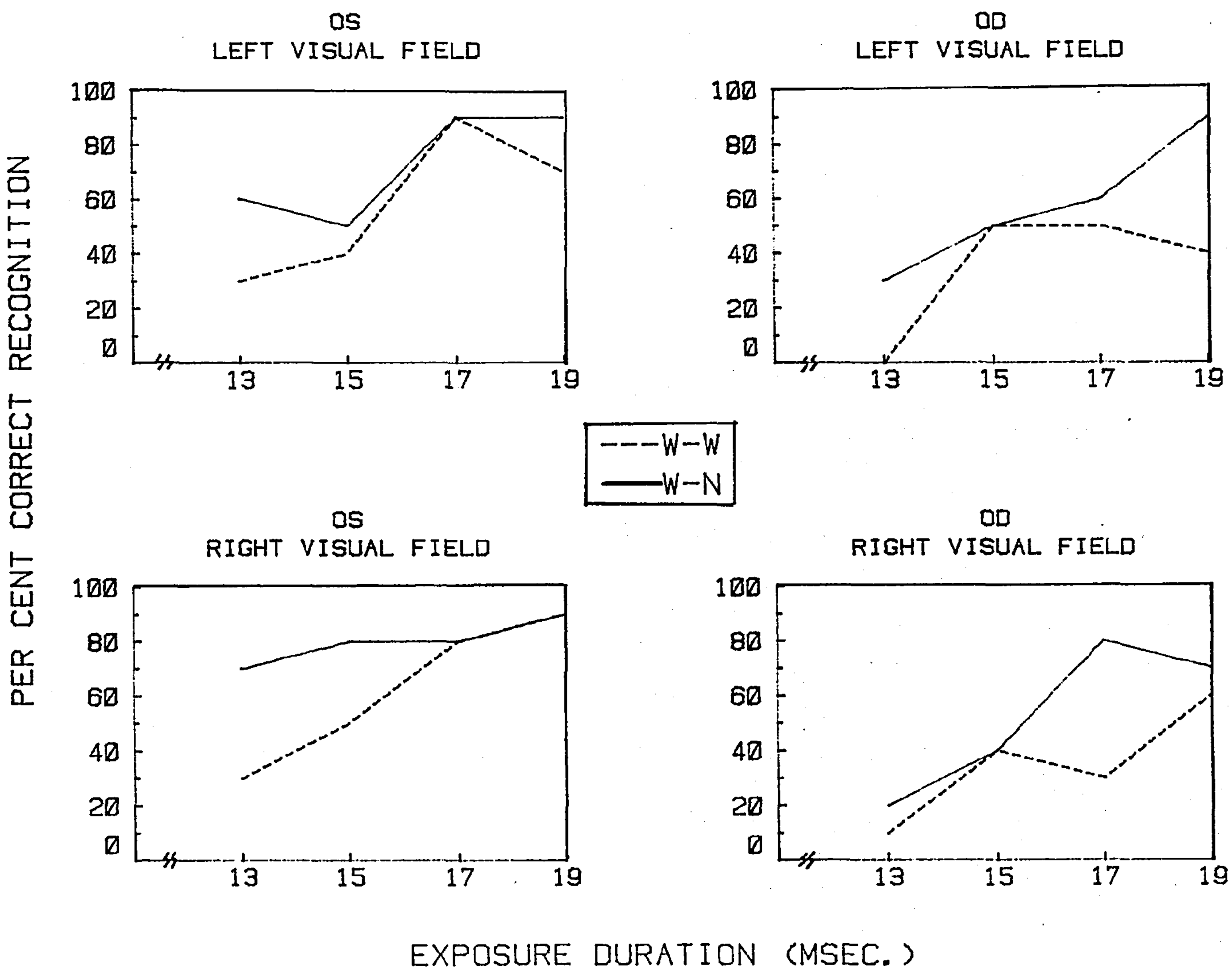


Figure A34. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:MW for testing session 4. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

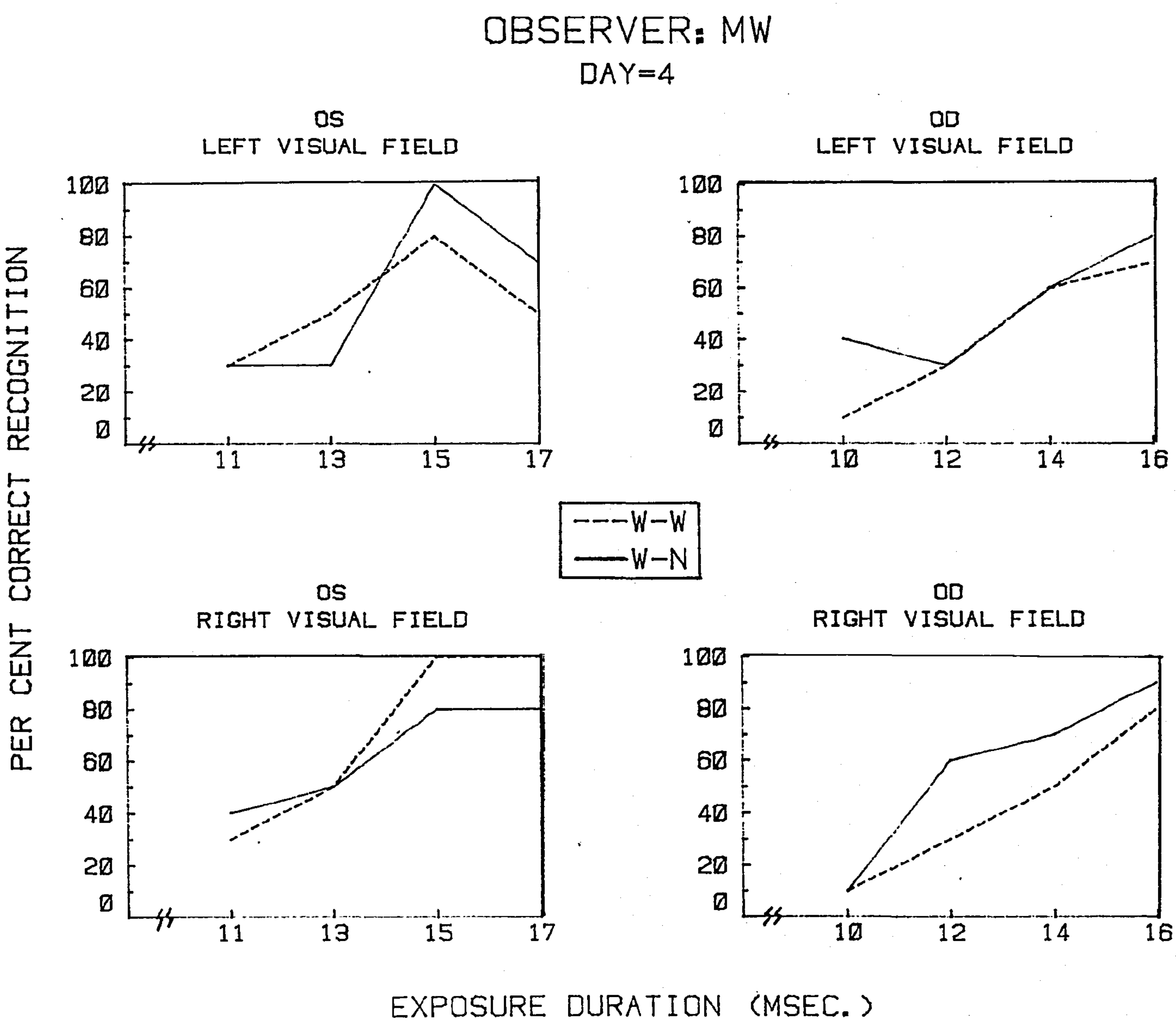

OBSERVER: MW
DAY=4
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
11
13
15
17
10
12
14
16
---W-W
—W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A35. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:MW for testing session 5. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

OBSERVER: MW

DAY=5

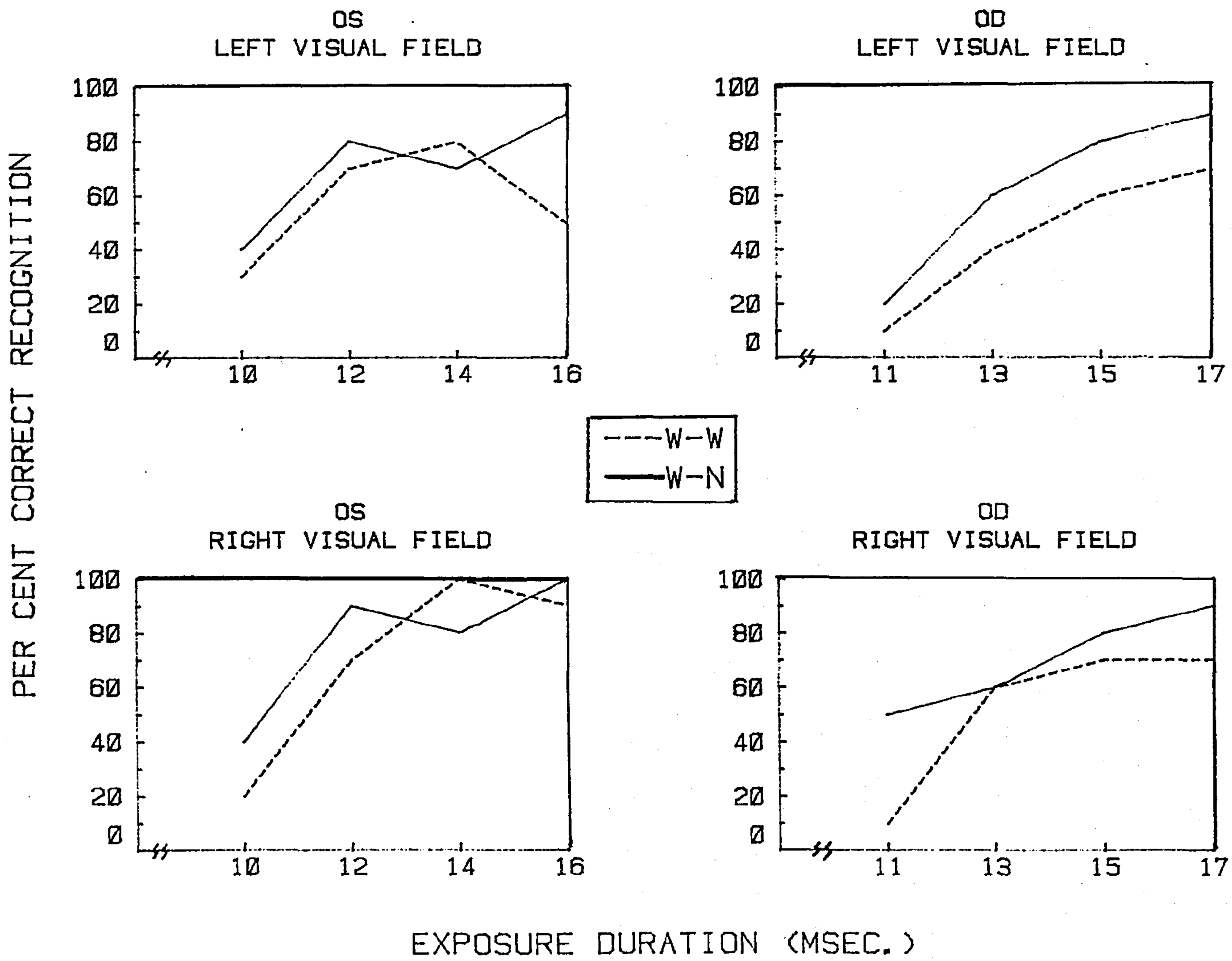


Figure A36. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC for testing session 1. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

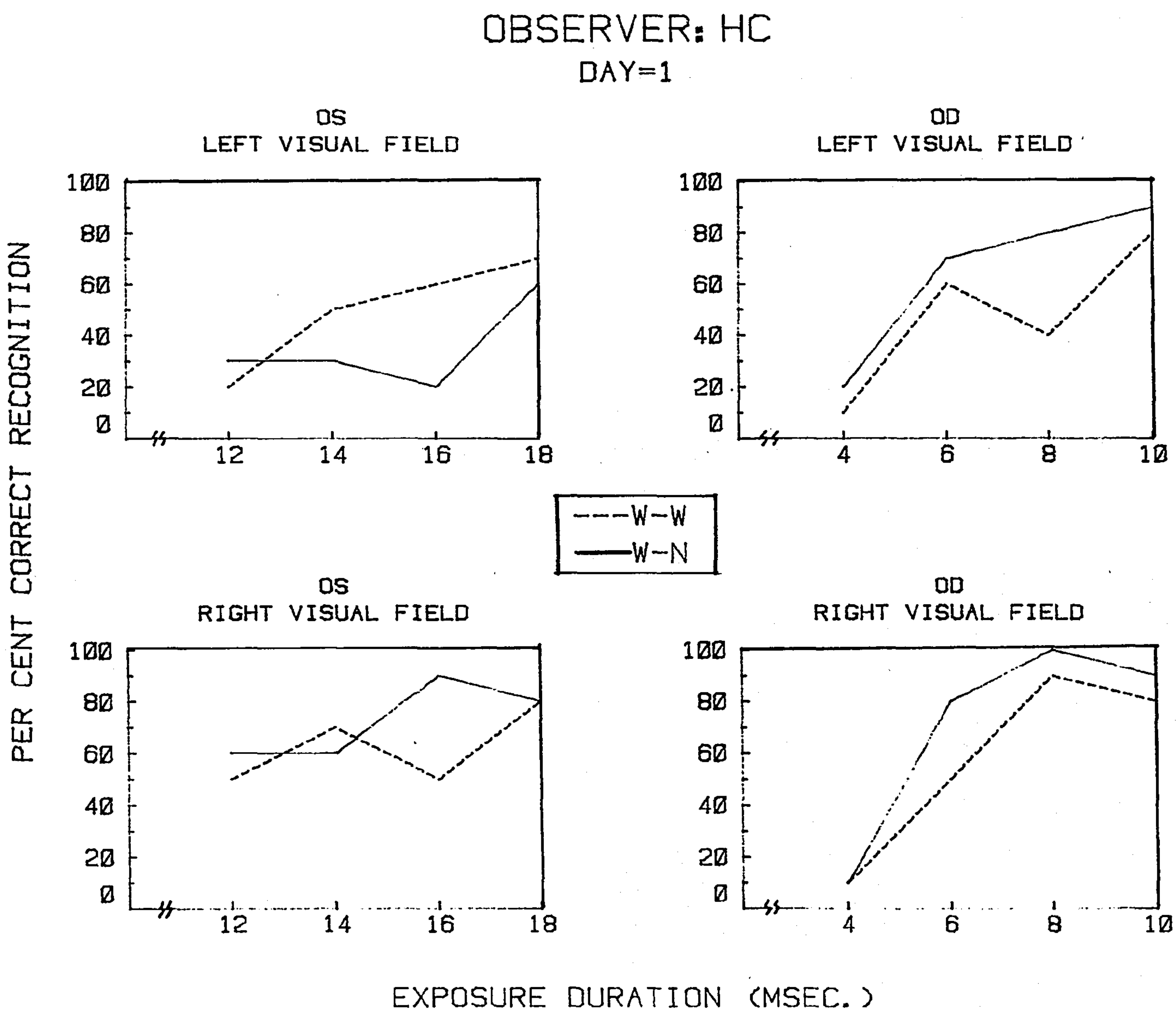

OBSERVER: HC
DAY=1
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
12
14
16
18
4
6
8
10
W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A37. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC for testing session 2. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

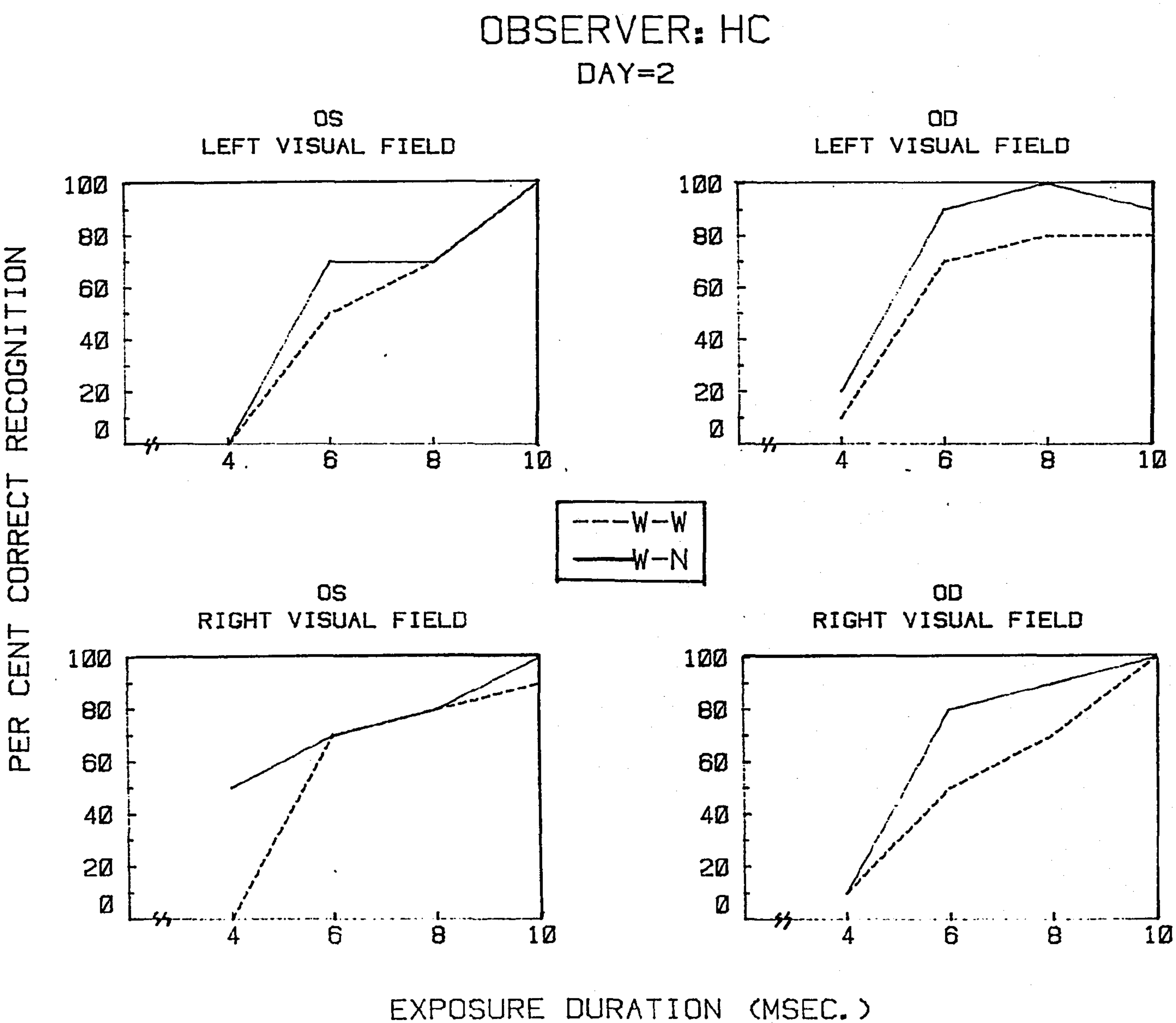

OBSERVER: HC
DAY=2
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
100
80
60
40
20
0
4
6
8
10
W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

Figure A38. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC for testing session 3. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

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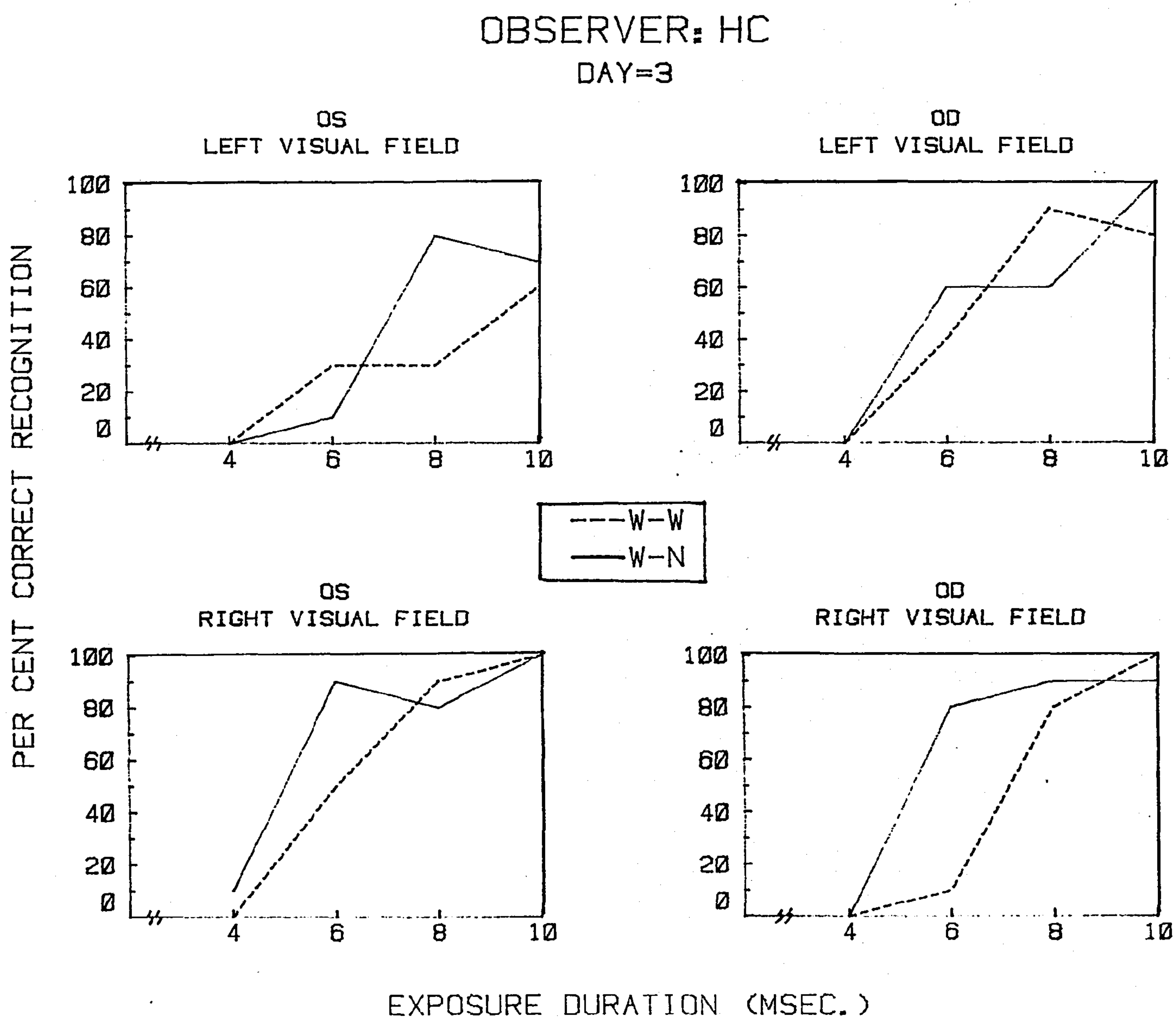


Figure A39. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC for testing session 4. The left visual field (LVF) is across the top; the right visual field is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.

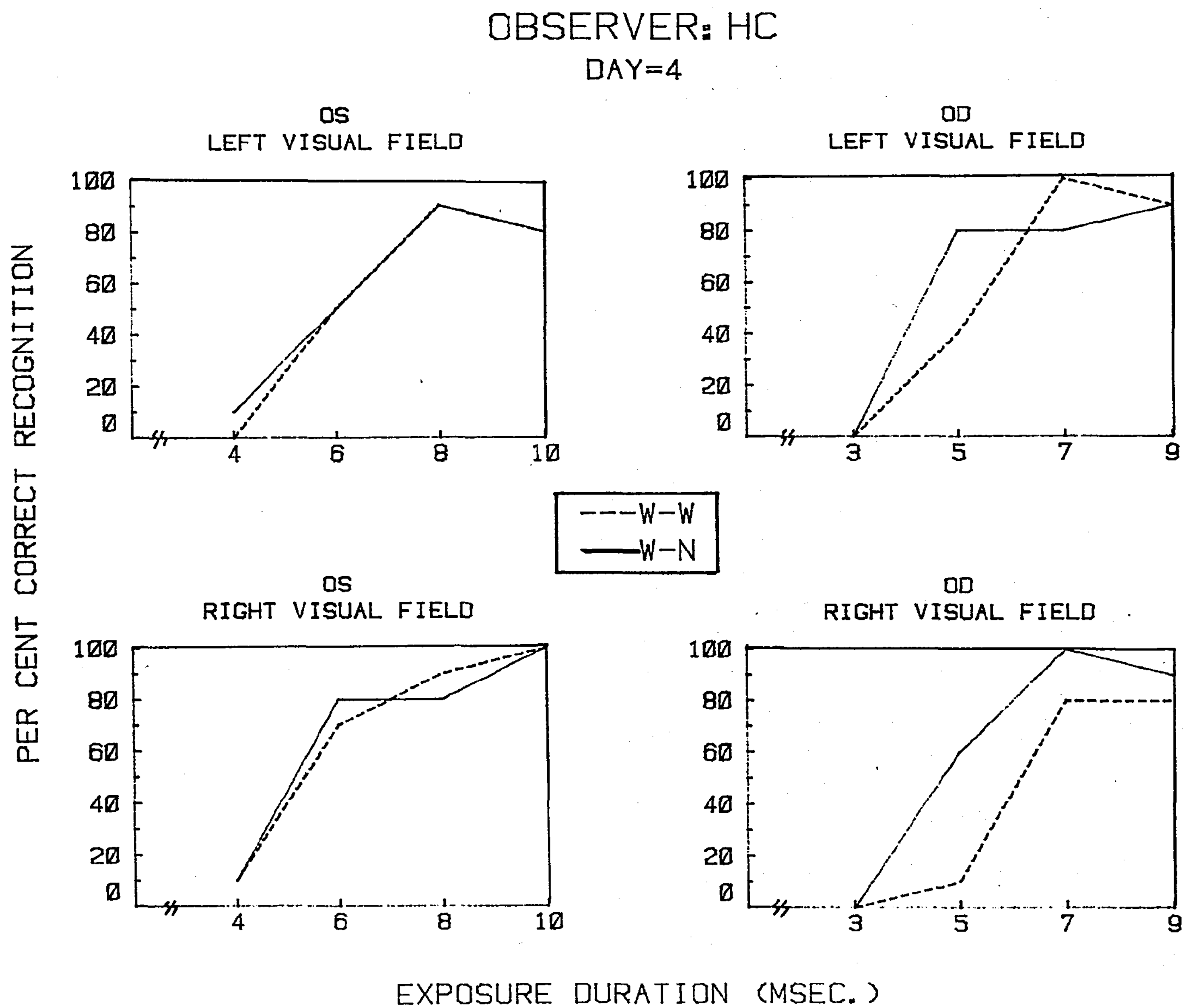
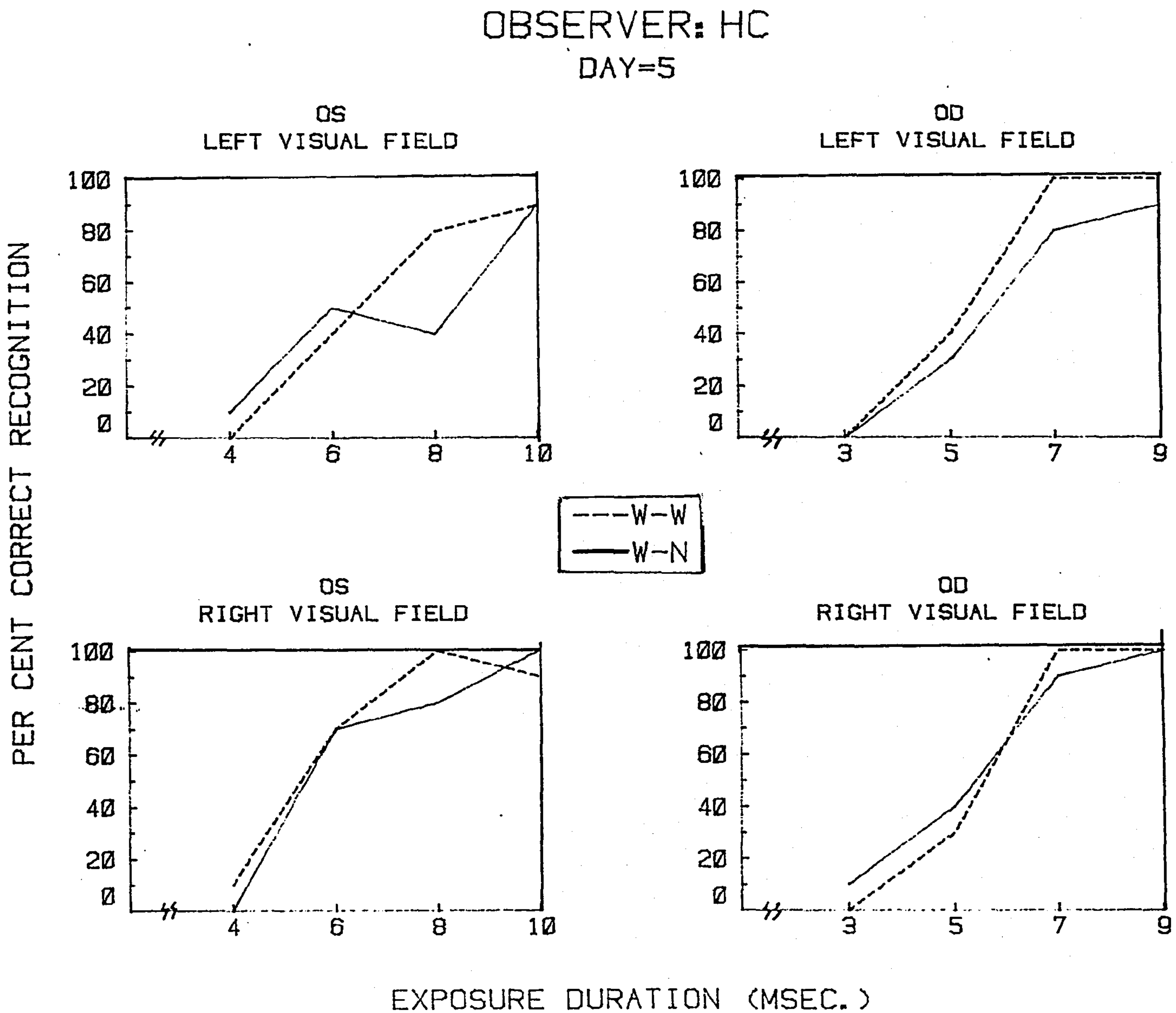

OBSERVER: HC
DAY=4
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
---W-W
W-N
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)
100
80
60
40
20
0
4
6
8
10
3
5
7
9

Figure A40. Per cent correct recognition of words in the word-word (WW) [dashed line]; and word-nonsense syllable (WN) [solid line] stimulus exposure conditions as a function of exposure duration (in msec.) for O:HC for testing session 5. The left visual field (LVF) is across the top; the right visual field (RVF) is on the bottom. Left eye (OS) is on the left; right eye (OD) is on the right.



OBSERVER: HC
DAY=5
OS
LEFT VISUAL FIELD
OD
LEFT VISUAL FIELD
OS
RIGHT VISUAL FIELD
OD
RIGHT VISUAL FIELD
---W-W
W-N
100
80
60
40
20
0
4
6
8
10
3
5
7
9
PER CENT CORRECT RECOGNITION
EXPOSURE DURATION (MSEC.)

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