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Reading Direction and Attention: Effects on Lateralized Ignoring

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The effects of the scan for the first element in reading (leftmost in English, rightmost in Hebrew) on the ability of subjects to ignore irrelevant stimuli in one visual field more than in the other were investigated. The hypothesis tested was that English readers would have a harder time ignoring irrelevant stimuli in the left visual field than in the right visual field, with the opposite pattern predicted for readers of Hebrew. The paradigm employed by Banich (Banich & Belger, 1990) was used with two letter matching tasks. The results showed that when an irrelevant letter was present, English readers responded more slowly in the right than in the left visual field, and Hebrew readers showed the opposite pattern (Experiment 1). This interaction did not occur when the irrelevant letter was deleted (Experiment 2). These findings are discussed in terms of their relation to eye movements and covert attention and to the use of bilateral displays in neuropsychological experiments.

The experiments reported here explore the effects of one aspect of reading scanning habits on performance asymmetry in a particular type of lateralized task. Heron (1957) proposed that there are two mechanisms that are involved in lateral preferences in recognition. The first is the left-to-right scan and the second is the scan for the leftmost element (for Latin scripts). The effects of the first mechanism on performance asymmetries in lateralized paradigms have been extensively investigated and discussed (Mishkin & Forgays, 1952; Orbach, 1967; Bradshaw, Nettleton, & Taylor, 1981; Bryden, 1986; Vaid, 1988; Faust, Kravetz, & Babkoff, 1993). The general conclusion is that the right visual field advantage (RVFA) for verbal stimuli is truly a reflection of underlying hemispheric asymmetry for the tasks, not of scanning habits. This paper presents an investigation of the possible effects of the second mechanism, the scan for the leftmost element (with Latin scripts). Specifi-

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cally, the hypothesis is that when stimuli are presented bilaterally (that is, when items are presented simultaneously in the two visual fields), it is harder for readers of a left-to-right language (e.g., English) to disregard an irrelevant stimulus that is presented to the left visual field (LVF) than one that is presented to the RVF, with the opposite pattern predicted for readers of a right-to-left language (e.g., Hebrew).

THE PARADIGM

Recently Banich and her colleagues (Banich & Belger, 1990; Banich, Goering, Stolar, & Belger, 1990; Belger & Banich, 1992) reported a series of experiments that explore the characteristics of interhemispheric transfer. All of these studies employ a lateralized display paradigm where the task (usually a same/different matching task) can be done by a single hemisphere or where the correct response can only result from some type of interhemispheric communication. This is done by presenting the pair of stimuli that match initially to the same hemisphere, or each one to a different hemisphere. The general finding is that for easy tasks responses are faster in the single hemisphere condition and for harder tasks responses are faster when each member of the matching pair is presented to a different hemisphere, the between-hemisphere condition. These authors have interpreted this as the result of an interaction between the costs of callosal transfer, the advantage of dividing processing load between the hemispheres, and task difficulty. An easy task is done more quickly when there is no need for callosal transfer, while the advantage of dividing the processing load on a more difficult task outweighs the costs of callosal transfer.

In order to control for left-to-right scanning habits and for perceptual load, the stimuli were presented in the manner shown in Fig. 1. This is an example of the stimulus configurations for a letter matching task using a nominal identity decision criterion. Two letters which always differ from each other are presented bilaterally, one in each visual field. The third letter, which is to be matched to one of the top letters is presented below them, less eccentric from fixation. In the match trials this letter is presented either in the same visual field to the one it matches (the WL and WR conditions) or in the opposite visual field (the BL and BR conditions). Thus all matching items are presented along a diagonal, reducing the effects of left to right scanning, and the same number of stimuli are presented in each visual field across the within-field and between-field conditions.

THE QUESTION

In terms of explicating the relationship between task difficulty and hemispheric division of labor, this paradigm has been very useful and consistent. Easy tasks usually result in a small within-field advantage while more difficult tasks usually result in a between-field advantage.

Stimuli requiring a "same" response in the Name Task

Within-hemisphere Conditions

Within LVF (WL)	Within RVF (WR)
a B + A	A B + b

Between Hemispheres Conditions

Bottom LVF (BL)	Bottom RVF (BR)
A b + B	A B + a

FIG. 1. The stimulus configuration used in the letter-matching tasks developed by Banich and her colleagues.

The experiments reported here are concerned with the patterns of responses in the two within-field conditions. Figure 2 presents a summary of the results of six experiments using this paradigm with a difficult task. It can be seen that in all of them, there is a response time (RT) advantage for the between-field conditions. Five of these experiments were reported by

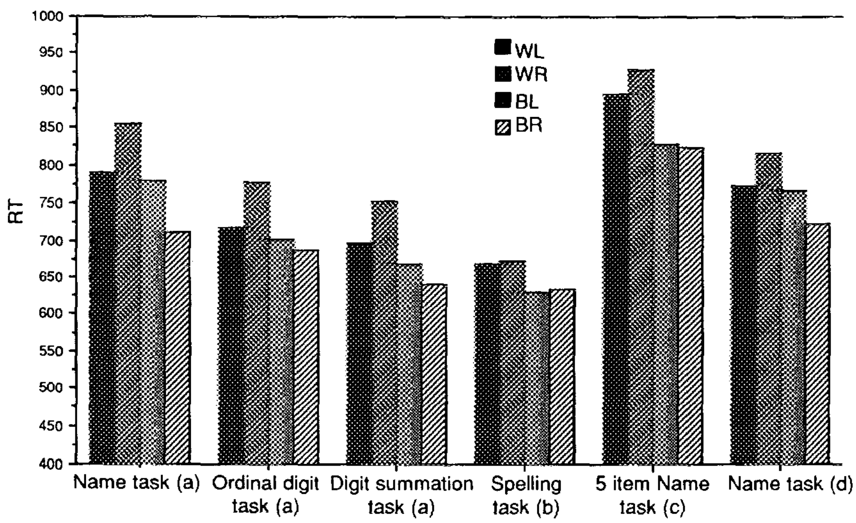

FIG. 2. A summary of the RTs reported in six experiments using the within/between paradigm (a) Banich & Belger (1990), (b) Banich et al. (1990); (c) Belger & Banich (1992), (d) Eviatar et al. (1994).

Banich and her colleagues, and one was performed by Eviatar, Hellige, and Zaidel (1995).

The issue under investigation here is the consistent elevation of RT in the within-RVF condition. As shown in Fig. 2, all of the experiments revealed that responses were slower when the matching stimuli were presented in the RVF (the WR condition). In both the within-field conditions one hemisphere saw the two matching stimuli, and the other hemisphere received one stimulus which was irrelevant to the match. The question is, why does it take subjects longer to decide that two stimuli in the RVF match when a third is presented to the LVF, than to decide that two stimuli match in the LVF and the third, irrelevant letter is presented in the RVF?

The hypothesis investigated here is that this elevated RT in the within-RVF condition is due to the second mechanism proposed by Heron, the scan for the leftmost element. That is, when stimuli are presented bilaterally, it may be the case that although subjects are fixating at the center, attention is somehow skewed toward the stimuli that appear in the LVF. One way of interpreting the elevated within-RVF RTs is that English-reading subjects must first disengage attention from the letter that appeared in the LVF, and only then transfer it to the matching pair in the RVF. If this is the case, then readers of Hebrew, who read from right to left, should show the opposite pattern: an elevation of RT in the within-LVF condition. Experiment 1 was performed to test this hypothesis. Native English readers performed an easy and difficult letter matching task in English, and native Hebrew readers performed the same tasks in Hebrew. If reading habits affect the ability of subjects to ignore stimuli differentially in the two visual fields, then we should find a language by visual field interaction in the within-field conditions.

EXPERIMENT 1

Method

Subjects

English readers. The subjects were eight student volunteers from the Overseas Program at the University of Haifa. All were from universities in the United States who were participating in the Study Abroad Program. The subjects were chosen from the beginning Hebrew classes, such that their knowledge of Hebrew and their Hebrew reading skills were minimal.

Hebrew readers. The subjects were eight students from the Introductory Psychology course at the University of Haifa. All were native Hebrew speakers who had their first exposure to a second language in the fourth grade, when they started learning English in school. The subjects received course credit.

All of the subjects were right handed, with normal or corrected-to-normal vision, and no history of neurological illness.

Design

Three factors were used in the experiment. The language in which the subjects were tested was a between-subject variable (English for the native English readers and Hebrew for the native Hebrew readers). Decision criterion (Shape vs. Name) and Visual Field (WL, WR, BL, BR) were varied within-subjects. Median response time (RT) in each decision by visual field (VF) condition was the dependent variable.

Materials

English. The letters used were from the set A, B, D, E, G, H, N, R, T. In the Shape task only capital letters were used. In the Name task both capital and small versions of these letters were used such that match pairs were always composed of a capital and small letter.

Hebrew. The letters used were from the set א,ב,ג,ד,ט,ל,צ,ש. In the Shape task, only the print form of the letters was used. In the Name task, the print and script form of the letters were used such that match pairs were always composed of the print and script form of the same letter.

The Shape and the Name task each included 160 experimental trials. The order of the trials and the specific pairs to be matched were randomly determined for each subject with the constraint that 80 out of the 160 triads contained a matched pair. These were equally distributed between the VF conditions with 20 trials in the WL, WR, BL, and BR conditions respectively.

The letters were presented as white letters on a gray background. Each letter was 1 cm × 1 cm in size, and subtended 1 × 1 degree of visual angle. The two top letters appeared 2.8 degrees of visual angle from fixation in the left and right visual field, 1.4 degrees above the horizontal meridian. The third, bottom letter appeared 1.4 degrees offset from fixation, either in the left or in the right visual field, and was 1.4 degrees below the horizontal meridian.

The stimuli were presented on a Silicon Graphics computer, model Personal Iris 4D30, which also collected the responses.

Procedure

The subjects sat with their head on a chin and forehead rest which held their eyes 57 cm from the screen. Half the subjects performed the Shape task first and half performed the Name task first. The tasks were explained to the subjects, and they were shown examples of all the types of stimulus configurations. They then ran a practice block of 40 trials, and then the experimental blocks. These were divided into four blocks of 40 trials, between which the subjects could take a break. The length of these breaks was not controlled. The subjects responded with their right hand by pressing the arrow keys on the keyboard with their index and middle finger. These were situated at midline, with the top key signaling "same" and the lower key signaling "different."

On each trial the sequence of events was the following: a tone of 1000 Hz was presented for 100 msec to alert the subject that the trial was beginning. Then the fixation cross appeared for 100 msec. The letters appeared around the fixation cross for 200 msec, and then the screen was blank until the subject responded or 3 sec had elapsed. After an additional 2 sec the next trial began.

Results

All of the subjects responded with above chance accuracy, the maximum error rate was 22% in all of the conditions. The median RTs in each condition are presented in Table 1. These data were subjected to a three-way analysis of variance with language (English vs. Hebrew) as a between-subject variable and task (Shape vs. Name) and VF (WL, WR, BL, BR) as within-subject variables. The analysis revealed a main effect of language, $F(1, 14) = 9.90$, $p < .01$, with Hebrew readers responding faster than English readers (891

TABLE 1
Median RTs in the language by task by visual field conditions for Experiment 1 (3 letters) and Experiment 2 (2 letters). Percent errors are in parentheses

	English				Hebrew			
	WL	WR	BL	BR	WL	WR	BL	BR
				Experiment 1				
Shape	986	1025	1030	1030	894	763	779	867
Task	(7.50)	(7.50)	(8.13)	(5.0)	(21.88)	(6.88)	(11.25)	(13.75)
Name	1202	1222	1117	1149	1107	903	866	950
Task	(22.50)	(18.13)	(13.13)	(13.75)	(20.63)	(13.75)	(12.50)	(11.88)
				Experiment 2				
Shape	893	896	923	917	768	752	710	758
Task	(5.0)	(5.0)	(5.0)	(3.75)	(15.63)	(10.0)	(6.25)	(11.25)
Name	1061	1051	1005	991	908	871	835	866
Task	(13.75)	(9.37)	(8.75)	(6.88)	(22.5)	(13.75)	(5.63)	(8.13)

msec vs. 1095 msec); a main effect of task, $F(1, 14) = 33.92$, $p < .0001$, with responses in the Shape task faster than in the Name task (921 msec vs. 1064 msec); and a main effect of VF, $F(3, 42) = 12.04$, $p < .0001$ (WL = 1047 msec, WR = 977 msec, BL = 948 msec, BR = 999 msec). Most importantly, the interaction between language and VF was significant, $F(3, 42) = 12.64$, $p < .0001$. This interaction is illustrated in Fig. 3A. Planned comparisons revealed that the contrast of interest, language by WL-WR, was significant, $F(1, 14) = 42.25$, $p < .0001$. In English, the WR condition was 28 msec longer than the WL condition. In Hebrew, the WL condition is 168 msec longer than the WR condition.

The findings previously reported by Banich and her colleagues and by Eviatar et al. (1995) were replicated: there is a significant task by within/between field interaction, $F(1, 14) = 20.31$, $p < .0005$. In the Shape task there is no significant difference between the within and between conditions (within = 916 msec vs. between = 927 msec), $p > .5$. In the Name task, there is a significant between advantage, $F(1, 14) = 20.44$, $p < .0005$ (within = 1109 msec vs. between = 1020 msec). This pattern is the same in both language conditions, as there is no interaction between language, task, and within/between field conditions, $p > .5$.

Analysis of the error data revealed similar patterns, with the language by WL-WR interaction approaching significance, $F(1, 14) = 4.55$, $p = .051$.

Discussion

Readers of both languages reveal the expected task by within/between field interaction, suggesting that the use of this paradigm as an index of the

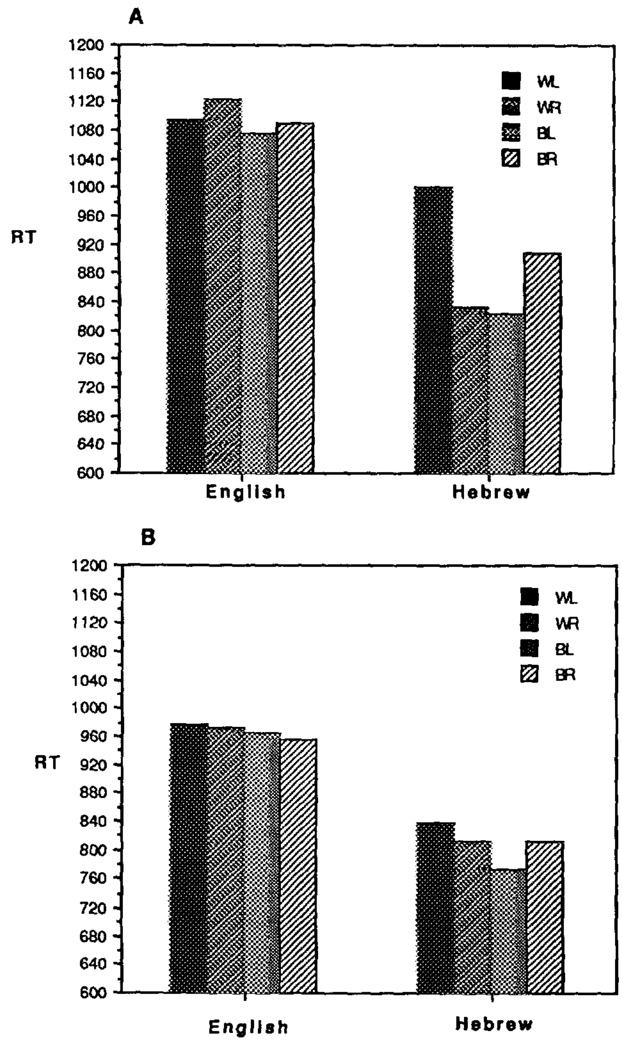

FIG. 3. (A) The interaction in median RTs between Language and Visual Field in Experiment 1, using three letters in each presentation. (B) Median RTs from Experiment 2, using two letters in each presentation. There is no interaction between Language and Visual Field.

interaction between task difficulty and the costs of callosal transfer is not compromised by reading scanning habits. However, the findings reported above support the hypothesis that the side from which a language is read can influence the ability of subjects to ignore a stimulus presented to that side. English is read from left to right, and native English readers responded more slowly to RVF stimuli when there was a letter in the LVF which they had to ignore. Hebrew is read from right to left, and the Hebrew readers responded more slowly to LVF stimuli when there was a letter in the RVF which they had to ignore. In order to test if the critical factor was indeed the third letter, Experiment 2 was conducted. Here all was the same as in Experiment 1, except that the third letter was deleted. Subjects saw only two letters on each trial. If the effect of language is due to the third letter, then the results should reveal no language by VF interaction.

EXPERIMENT 2

Method

All of the methods were the same as those reported for Experiment 1, except that only two letters appeared on each trial. Sixteen subjects (eight native English readers with minimal Hebrew skills and eight native Hebrew readers) who had not taken part in Experiment 1 were tested.

Results

All of the subjects responded with better than chance accuracy, and the maximum percentage of errors was 18% in all of the conditions. The median RTs are presented in Table 1. These data were subjected to a three-way ANOVA with language (English vs. Hebrew) as a between-subject variable and task (Shape vs. Name) and VF (WL, WR, BL, BR) as within-subject variables. A preliminary test revealed that there was not compound symmetry in the data set, $\chi^2(34) = 59.08$, $p < .005$, so the Pillai–Bartlett Trace (V) was used as the test statistic when VF was analyzed.

The analysis revealed a main effect of language, $F(1, 14) = 6.87, p < .05$, with Hebrew speakers responding faster than English speakers (808 msec vs. 967 msec); and a main effect of task, $F(1, 14) = 28.29$, $p < .0005$, with the Shape task being responded to faster than the Name task (827 msec vs. 948 msec). The expected task by within/between field interaction was significant, $F(1, 14) = 6.57$, $p < .05$, and as in the previous experiment, this effect did not interact with language ($p > .08$). Most importantly, there was no language by VF interaction ($p > .09$), and no language by WL-WR interaction ($p > .5$). The patterns are illustrated in Fig. 3B. Analysis of the error data showed that the language WL-WR interaction was not significant, $p > .16$.

An analysis of the combined RT data from both experiments revealed a significant three-way interaction between language, experiment, and visual field, $F(3, 84) = 4.75, p < .005$. The interaction of experiments, language, and WL-WR is significant, $F(1, 28) = 13.00, p < .005$.

Discussion

The data reported above support the hypothesis that reading habits, specifically the scan toward the side of space from which reading begins, affect

TABLE 2
Illustration of the Processing Sequence under the Hypothesis That Active Ignoring Is Not Occurring for the Irrelevant Stimulus on the Side at Which Reading Begins
(x = Fixation Point)

	Condition			
	WL AaxB	WR AxbB	BL AbxB	BR AxaB
	English			
Order of processing	1 2	1 23	1 2 3	1 2
RT (ms)	1094	1122	1074	1089
	Hebrew			
Order of processing	3 2 1	2 1	2 1	3 21
RT (ms)	1001	833	823	908

subjects' responses to stimuli in the visual field on the opposite side. Readers of a left-to-right language took longer to respond to RVF stimuli and readers of a right-to left language took longer to respond to LVF stimuli. The hypothesis presented here has two distinct parts: the first is that subject's attention is skewed toward the side from which they usually begin to read; the second is that irrelevant stimuli on this side are actively ignored. These two parts are asymmetrically related, the first is necessary for the second, but the second does not necessarily arise from the first. That is, in order to show that the stimulus on the side from which reading usually begins is actively ignored, we must show that preattentive orienting is skewed by reading habits. However, even if this is true, it is not necessary that active ignoring occurs for this stimulus. An alternative interpretation of these results (Hellige, personal communication) is that processing always begins on the side from which reading usually begins, and terminates when a match is found. If we assume that the letters are processed serially in the order of their eccentricity (top letter, bottom letter, second top letter), this hypothesis also predicts that the effect of reading habits will disappear when only two letters are presented, as in Experiment 2. Illustrations of these conditions are shown for English and Hebrew in Table 2. This alternative hypothesis also predicts other outcomes, which make it possible to test. For example, it predicts that in English, the WL and BR conditions will result in approximately equal RTs, and that together, they will be faster than the WR and BL conditions. This is because in both the WL and BR conditions processing can terminate after the second letter has been processed, while in the other two conditions, all three letters must be processed before the match is found. It can be seen in Table 2 that the predictions for Hebrew are the opposite: The WR and BL conditions should be faster than the WL and BR conditions. Planned comparisons reveal that these predictions are not borne out in full. In English, there is no difference between the RTs of the WL and BR conditions and those of the WR and BL conditions (WL + BR = 1092 msec vs. WR + BL = 1098 msec, $p > .5$). In addition, although the WL and BR conditions are not significantly different ($p > .5$, there is a trend toward a significant difference between the WR and BL conditions $F(1, 14) = 4.31$, $p < .056$. In Hebrew, the WR and BL conditions are significantly faster than the WL and BR conditions (WR + BL = 826 msec vs. WL + BR = 954 msec, $F(1, 14) = 60.52$, $p < .0005$). However, although the WR and BL conditions don't differ from each other ($p > .5$), there is a significant difference between WL and BR, $F(1, 14) = 12.47$, $p < .005$. Thus, there seems to be reason to believe that more than a simple sequential scan is occurring. Whether active ignoring is occurring for the third letter is an empirical question and will be explored in further experiments.

These findings are relevant to two separate but related issues in cognitive neuropsychological research. The first is the relationship between eye movements and the mechanisms that control the allocation of covert visual attention, and the second has to do with the use of bilateral versus unilateral displays in lateralized paradigms.

Eye Movements and Attention

Recently a number of authors have explored the relationship between eye movements and the mechanisms involved in the movement of covert visual attention (e.g., Rizzolatti et al., 1987; Tassinari et al., 1988; Muller & Rabbitt, 1989; Crawford & Muller, 1992). One of the conclusions from these studies is that there seem to be two kinds of covert visual orienting mechanisms that are related to eye movements: reflexive, or automatic orienting in response to peripheral cues (the critical factor here is abrupt visual onset of the cue (Jonides & Yantis, 1988)), and voluntary, or controlled orienting in response to centrally presented cues (Muller & Rabbitt, 1989). The hypothesis presented here is that in the automatic condition, both eye movements and preattentive covert orienting are related to Heron's second mechanism, the scan toward the first element according to reading direction.

This hypothesis is supported by two possibly related findings. Abrams and Jonides (1988) measured saccadic latencies in a cued paradigm. They were interested in the mechanism by which saccades are programmed, and presented their subjects with cues that specified the direction and amplitude of the saccades separately, in different combinations. In the display used in their Experiment 1 the cues were presented in the visual field opposite the direction they indicated. That is, a cue that the next saccade was to be made to the right was presented in the LVF, and vice versa. Interestingly, they report that the latencies of saccades towards the 3 degrees RVF position were the longest. Their interpretation of this finding is that movement in this condition is the most similar to movements during reading and so may be controlled by different mechanisms. Under the hypothesis proposed here, the reason for longer latencies toward the RVF is that the cue was in the LVF and skewed preattentive orienting toward it. This interpretation is supported by the results of their Experiment 6, where the same displays as in Experiment 1 were used, but cues were in the compatible visual field (cues toward the right were in the RVF and toward the left were in the LVF). In that experiment, the longer latency toward the right was eliminated.

The hypothesis that reading habits can affect aspects of visual processing is also supported by a recent report by Morikawa and McBeath (1992). They showed a sequence of displaced stimuli that results in an ambiguous perception of apparent motion to readers of left-to-right languages (English and Japanese) and readers of right-to-left languages (Arabic, Urdu, and Farsi). They report that English and Japanese readers evince a significant bias to report leftward motion, while readers of languages read in the opposite direction did not. All of the latter group of subjects were skilled readers of English and French, suggesting that the predicted rightward bias was attenuated by experience with a left-to-right language. Interestingly, left- and right-handed readers of English did not differ in the degree of leftward bias, supporting the author's conclusion that this effect is not related to hemispheric asymmetry. This leftward bias was also apparent whether the displaced stimuli were shown in the left or the right visual field.

Their interpretation of this finding in terms of reading habits is interesting. They proposed that when readers of English make rightward saccades during reading, the projected image shifts leftward relative to fixation, and that these retinal images are similar to the displaced stimuli in their experiment. During reading, these images are cancelled, or suppressed, causing the visual world to appear stationary. However, they speculate that although there is no experience of movement during saccades, habitual exposure to leftward displacement of images biases the visual system toward the preception of leftward motion.

These studies support the contention that reading habits can affect quite early processes of visual perception. How these are related to covert visual attention and to higher cognitive processes are empirical questions to be explored.

Bilateral Displays and Hemispheric Specialization

The results of Experiment 2 suggest that reading habits only affect performance in the bilateral condition: there was no language by visual field interaction when stimuli were presented unilaterally, only to the left or the right hemisphere. Boles (1990) has reported a series of experiments in which he compared performance asymmetries that resulted from unilateral lateralized displays, or from bilateral displays, where each hemisphere is shown a different stimulus, and the subject is cued (usually by a center arrow) to which side he or she is to respond. He reports that bilateral displays consistently result in larger performance asymmetries. Thus, when subjects performed a linguistic task, the expected right visual field advantage (RVFA) was larger in the bilateral display condition. When subjects performed a spatial task, the expected LVFA was also larger in the bilateral than in the unilateral condition. Boles goes on to test hypotheses about why this might occur. The relevant issue to the present experiments is that if reading habits affect performance with bilateral displays, we would expect to find an attenuated RVFA for readers of English relative to unilateral displays. Why is this not the case? There are several possible (nonexclusive) reasons for this seeming contradiction.

The first has to do with the relationship between reading scanning habits and hemispheric specialization. This relationship is probably nonexistent. Both the finding that transfer of attention across both the horizontal and the vertical meridians involve high costs in a covert attention paradigm (Rizzolatti et al., 1987), and the null effects of handedness and visual field on bias in the perception of apparent motion (Morikawa & McBeath, 1992) suggest that hemispheric specialization is not involved. This conclusion also makes general sense, as many functional and anatomical hemispheric asymmetries are apparent early in development (Hellige, 1993), before humans generally learn to read. Thus it may be expected that the effect of the scan towards the leftmost or rightmost element will only appear when the task does not draw upon specialized abilities. Eviatar and Zaidel (1992, 1993) have shown that both of the letter matching tasks used here are done equally well and in a similar manner by the two hemispheres.

In addition, both Boles (1990) and Liederman and her colleagues (Merola & Liederman, 1990) have shown that performance asymmetry is maximized when the hemispheres are given simultaneous homologous tasks—when they have to perform the same type of processing at the same time. This did not occur in the present paradigm, as the single irrelevant letter need not have been processed at all in the within-field conditions. Whether the third letter entered into the comparison process is an empirical question. As can be seen in Fig. 3, the presentation of a third letter lengthened response times in both the within-field and the between-field conditions. However, whether this is due to additional comparisons or to perceptual load is not clear.

An additional explanation of the null effects of reading direction in Boles's studies may be the use of a central cue in his bilateral paradigm. Subjects are given a central cue telling them which visual field to pay attention to. In the present experiments, no such cue was given. Instead, a stimulus that was irrelevant to the task appeared in one visual field at the same time that the relevant stimuli were presented to the other visual field. Thus, in the bilateral displays used by Boles, cues resulted in controlled orienting, while in the experiments presented here, the third letter appeared in the periphery and involved automatic, or reflexive orienting. This distinction is also an empirical issue and will be investigated in future studies.

CONCLUSIONS

The findings reported here involve the effects of reading habits in the perception of lateralized stimuli. It is important to distinguish these from those reported by Nachshon and his colleagues (Nachshon, 1985), where the emphasis is put on the order in which subjects reproduce horizontal sequences of stimuli. Nachshon reports that there is a developmental trend in the preference for directionality in reproducing horizontal arrays, with the right-to-left preference predicted by Hebrew reading being attenuated as subjects have more experience with left-to-right reading situations (arithmetic and English). The phenomena under investigation here differ, in that the focus of interest is perception rather than reproduction, and that the processes underlying performance are assumed to be early and automatic, rather than late and controlled.

The findings reported here support the conclusion that there is a mechanism which biases reflexive attentional orienting towards the side at which reading usually begins. This mechanism will affect performance asymmetries under the following conditions:

(1) There is no central cue—the manipulation of attention involves the mechanisms of reflexive visual orienting, not the controlled central processes.

(2) The task does not involve abilities for which the hemispheres are specialized. That is, both hemispheres can perform the task with equal ability and in the same manner.

It is probable that this phenomenon is not related to the organization of higher cognitive functions in the cerebral hemispheres. It does seem to be related to earlier, more perceptual processes. Several interesting avenues are open for further investigation. First, it is important to explore the differences between reflexive and controlled movements of both overt and covert visual attention. For example, Zeevi, Wetzel, and Geri (1988) report that subjects have a preferred direction towards which their saccadic latency is reliably shorter. This preference is related to perception as well, as subjects perceive targets appearing in their preferred visual field as occurring sooner, even when they lag after targets in the nonpreferred visual field by as much as 50 msec). The status of these responses in terms of automatic or controlled processes is not clear, and it will be interesting to clarify this and to test the types of subject variables that may be related to the direction of preference.

Second, the conditions under which hemisphere-specific mechanisms override these perceptual biases will be explored. Both task-specific factors and the characteristics of the visual presentation must play a role in limiting these conditions.

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