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The role of eye movements in lateralised word recognition

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The present study examined the role of eye movements and attention in lateralised word recognition, where words and pseudowords are presented to the right or left of the fixation point, and participants are asked to decide whether or not the presented letter string is a word. In the *move* condition, our participants were instructed to launch a saccade towards the target letter string, which was erased from the screen after 100 ms (i.e., prior to the eyes reaching the target). It was assumed that a preparation of an eye movement simultaneously with an attention shift results in the attention being more readily allocated to the target. In the *fixate* condition, participants were asked to fixate on the central fixation point throughout the trial. The data on response accuracy demonstrated that word recognition in the LVF benefited from a preparation to make an eye movement, whereas the performance in the RVF did not benefit. The results are consistent with the attentional advantage account (Mondor & Bryden, 1992), according to which the performance deficit of RH for verbal stimuli may be overcome by orienting attention to the LVF prior to the presentation of a letter string.

When looking at a visual scene, an observer makes a series of eye movements and subsequent eye fixations on different parts of the scene. Eye movements are highly functional, as they make possible a detailed perception of scene details via the high-acuity foveal vision. Thus, there appears to be a relatively tight coupling between eye movements and attention shifts, so that the eyes move along with the ''attentional spotlight''. In the present study, we made use of this coupling to study lateralised word recognition. In the experiment, we presented to the left and right of the fixation point words and nonwords, to which participants were asked to make a lexical decision. This was done using two task

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instructions: (a) In the *fixate* condition, the participant was asked to fixate on the central fixation point throughout the trial; (b) in the *move* condition, the participant was asked to make an eye movement towards the target stimulus once it appeared on the screen. The idea behind this task manipulation was to vary the amount of attention allocated to the lateralised stimulus. When the eyes are allowed to move in tandem with the attention, relatively more attentional resources are assumed to be allocated to their joint target than when an attention shift and a gaze shift are decoupled. Before describing this assumption in more detail, we first summarise earlier studies on lateralised word recognition, focusing particularly on experiments where peripheral or central visual cues have been used to direct attention to either the right or left visual field.

The human visual system is organised in such a way that stimuli in the left visual field (LVF) are initially projected to the right hemisphere (RH), and stimuli in the right visual field (RVF) are projected to the left hemisphere (LH). The standard finding in lateralised word recognition is that words are recognised more accurately and faster in RVF than in LVF (Hellige, 1993; Springer & Deutsch, 1989). In addition, words are often recognised more accurately or faster than nonwords particularly in RVF. In other words, there is a larger lexicality effect in RVF than in LVF (e.g., Chiarello & Richards, 1992; Koivisto, 1997). This pattern of results is taken to suggest that LH is better able to process words (and verbal stimuli in general) than RH. However, there are studies strongly suggesting that there is a significant attentional component involved in the visual field asymmetry. In the following, we review the results of these studies.

Mondor and Bryden (1992) studied the effects of exogenous visual cues (the cues appeared right above the stimulus) that were presented either simultaneously with or 50 ms before the target letter string (Exp. 3). The two cueing conditions differed from each other in that only with the 50-ms stimulus-onset-asynchrony (SOA) was it possible to orient attention towards the cued location prior to stimulus presentation. Mondor and Bryden found that stimulus detection in a lexical decision task (i.e., responding ‘‘yes’’ to words and ‘‘no’’ to pseudowords) was more accurate in RVF than in LVF when the location of the stimulus string was not cued prior to its presentation, thus replicating the standard RVF advantage for verbal stimuli. More interestingly, however, in the presence of a prior peripheral cue, the RFV advantage was eliminated (i.e., LVF benefited more from attentional cueing than RVF). To account for these results, Mondor and Bryden made use of Kinsbourne’s (1973) *attentional bias* theory. According to this theory, the RVF advantage is a result of inherent activational asymmetry favouring LH in verbal tasks (see also Jones & Santi, 1978), which may be overcome by attentional cueing. As some of their other results (not discussed here) were inconsistent with the attentional bias theory, Mondor and Bryden put forth an *attentional advantage* account. According to this account, LH ‘‘has an attentional advantage for processing verbal stimuli when few attentional resources are allocated to the discrimination'' (1992, p. 551). By orienting attention to LVF prior to the presentation of a letter string, the performance deficit of RH may be overcome.

Nicholls and colleagues (Lindell & Nicholls, 2003; Nicholls & Wood, 1998; Nicholls, Wood, & Hayes, 2001) have provided further corroborating evidence for the attentional advantage account proposed by Mondor and Bryden (1992). Nicholls and Wood (1998) cued the spatial location of the target word by presenting an empty rectangle at the word's location either 84 ms before or concurrently with the target (Exp. 2). Naming latencies and errors were used as dependent variables. The results showed, similarly to Mondor and Bryden (1992), that peripheral spatial cueing improved recognition accuracy more for words presented to LVF than to RVF (for the effects of the position of peripheral cues, see Lindell & Nicholls, 2003), although the crucial interaction did not always reach statistical significance. Nicholls and Wood also found a stronger cueing effect for LVF than RVF when a purely temporal cue (a rectangle appearing simultaneously on both visual fields) was presented prior to the target word. These stronger cueing effects (for both spatial and temporal cues) observed for LVF were interpreted to support the attentional advantage account. Without cueing, LH demonstrates a processing advantage in word recognition over RH, whereas when attention is spatially cued the LH dominance is attenuated (or completely absent, see Mondor & Bryden, 1992).

Nicholls et al. (2001) also extended the aforementioned attentional cueing effect to endogenous visual cues (i.e., a centrally presented arrow pointing either to the left or right). Analogously to Nicholls and Wood (1998), word-naming latencies and errors were used as dependent measures. Nicholls et al. observed a stronger endogenous cueing effect in naming errors for words presented to LVF than to RVF. The effect primarily stemmed from the invalid trials where the target appeared in the opposite visual field to the one that was cued by the central arrow. In other words, significantly more naming errors were made when the target appeared in LVF preceded by an arrow pointing to RVF. On the other hand, invalid cueing did not bring about a performance decrement for words presented in RVF. In sum, the pattern of these results is consistent with the attentional advantage account of Mondor and Bryden (1992).

We next discuss the relationship between eye movements and attentional orienting. Over the years, the theoretical standpoints have varied widely (see Findlay & Gilchrist, 2003; Posner, 1980, for reviews). At one extreme is the complete independence view, according to which the two systems function independently of each other. At the other extreme is the complete dependence view, which assumes eye movements and shifts of visual attention to be governed by one and the same mechanism. Posner also distinguishes two intermediate positions, the functional relation view and the efference theory (Klein, 1980, calls the latter the oculomotor readiness theory). According to the functional relation view, an adaptive response of the visual system is to send the eyes to the attended location in space. This is particularly the case when high-acuity foveal vision is needed for successful task performance. However, according to this view visual attention and eye movements are governed by separate mechanisms, and thus they can be dissociated. On the other hand, the efference theory assumes an even tighter coupling between eye movements and attention shifts. The coupling takes two forms: (a) eye movements to the attended location are facilitated, and (b) readiness to move the eyes to a target improves target detection.

The earlier studies provided evidence consistent with the functional relation view (Klein, 1980; Posner, 1980; Remington, 1980). These studies demonstrated that attention shifts to peripherally presented visual cues are followed by an eye movement to the same location, whereas a central movement cue does not trigger an attention shift (see Remington, 1980). Klein provided evidence against the efference theory by showing that (1) readiness to make a saccade to a spatial location did not improve target detection at that location, and (2) attentional shifts are not necessarily accompanied by oculomotor readiness.

However, more recent studies have argued for a tight coupling of attention shifts and eye movements (Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler, Anderson, Dosher, & Blaser, 1995; Shepherd, Findlay, & Hockey 1986; for an earlier study, see Crovitz & Daves, 1962). Shepherd et al. (1986) provided evidence consistent with the efference theory. They demonstrated that target detection was speeded up by an instruction to prepare a saccade to the target position. Similarly, Hoffman and Subramaniam (1995) observed letter detection to be at its best when the target letter was located at the destination of a saccade independent of where the participants were instructed to attend. An analogous finding was also reported by Deubel and Schneider (1996). Thus, these studies provide evidence for an obligatory coupling between eye movements and visual attention. Kowler et al. (1995) reported evidence demonstrating that attention shifts cannot be dissociated from eye movements without incurring costs. When the participants were required to attend to one spatial location in order to identify a letter there and move the eyes to a different spatial location, the saccadic latencies were prolonged. Thus, it seems that the execution of a saccade requires a corresponding attentional shift to the saccadic target. The studies of Kowler et al. (1995) and Deubel and Schneider (1996) converge on the view that a shift of visual attention precedes a saccadic eye movement (see also, e.g., Godijn & Theeuwes, 2003; Henderson, 1992; Morrison, 1984; Reichle, Pollatsek, Rayner, & Fisher, 1998). On the other hand, the pre-motor theory of attention by Rizzolatti, Riggio, Dascola, and Umiltà (1987) turns the issue on its head. According to this view, an eye movement precedes an attentional shift.

In sum, and most relevant for the present study, the majority of studies reviewed above demonstrate improved target detection when an eye movement is programmed towards the target, compared to the case when an eye movement is suppressed or an eye movement is prepared to a non-target location. By applying this finding to lateralised word recognition, it is assumed that a preparation of a gaze shift simultaneously with an attention shift results in the attention being more readily allocated to the target. This in turn is expected to improve word recognition accuracy. Moreover, if the attentional advantage account of Mondor and Bryden (1992) is correct, an improvement in word recognition will be more pronounced for words presented to LVF than to RVF.

In order to test these predictions, we compared the standard procedure used in lateralisation studies, where participants are asked to keep fixating on a central fixation point throughout the trial (the *fixate* condition), to a condition where participants are first asked to fixate on a central fixation point and then to make an eye movement towards the presented stimulus when it appears (the *move* condition). The presentation time was kept short (100 ms) so that when the eyes landed on the spatial location occupied by the word, the word was no longer there. (Those trials where the eyes reached the target prior to its extinction were excluded.) We used recognition accuracy (d') as our primary dependent measure. Although reaction times are also reported, those data should be interpreted cautiously due to the so-called psychological refractory period that has been observed when a manual response is combined with a saccadic response (i.e., the secondary manual response is delayed when preceded by a saccadic eye movement; Wolf, Deubel, & Hauske, 1984).

METHOD

Participants

A total of 23 university students (3 males) took part in the experiment as part of a course requirement. All participants except one were right-handed.

Apparatus

Eye movements were collected by the EyeLink eyetracker manufactured by SR Research Ltd (Canada). The eyetracker is an infra-red video-based tracking system combined with hyperacuity image processing. There are two cameras mounted on a headband (one for each eye) including two infra-red LEDs for illuminating the eye(s) to be registered. The headband weighs 450 g in total. The cameras sample pupil location and pupil size at the rate of 250 Hz. In the present study, registration was monocular and was performed for the dominant eye (almost always the right eye) by placing the camera and the two infra-red light sources 4–6 cm away from the eye. Spatial accuracy was better than 0.5 degrees. Head position with respect to the computer screen was tracked with the help of a head-tracking camera mounted on the centre of the headband at the level of the forehead. Four LEDs were attached to the corners of the computer screen, which were viewed by the head-tracking camera, once the subject was sitting directly facing the screen. Possible head motion was detected as movements of the four LEDs and compensated for on-line from the eye position records.

The stimuli were presented with the ViewSonic PS775 monitor with a vertical refresh rate of 150 Hz. The monitor has a medium-short persistence phosphor. The phosphor decay is no more than 2 ms (this was tested with an oscilloscope using a red rectangle as the stimulus).

Materials

The experimental materials comprised 80 Finnish words and 80 Finnish pseudowords. The words were four- to six-letter (29 four-letter, 43 five-letter, and 8 six-letter words; mean length 4.74 letters) high-frequency nouns (mean frequency 390 occurrences per million words; the minimum frequency 133 occurrences per million words). Word frequencies were computed using the WordMill program of Laine and Virtanen (1999). Pseudowords were constructed from real words by changing one or two letters. The pseudowords conformed to the phonotactic rules of Finnish and thus were pronounceable. The materials were divided into four blocks, and their presentation was counterbalanced between participants so that each list was presented equally often with the two task instructions. The stimuli were presented in capital letters horizontally to the right or left of the fixation point so that the inner edge of the stimulus was 2 degrees from the fixation point. In each block, the stimuli were presented in a pseudorandom order. Each stimulus item was presented only once to each participant. The experimental blocks were preceded with a short practice session. The viewing distance was 60 cm, which was maintained by instructing the participant to lean his/her head against a headrest attached to the back of the chair. The letter strings subtended 2.2–3.4 degrees of visual angle.

Task and procedure

Two experimental tasks were used. In the *Fixate* task, participants were asked to keep fixating on the fixation point; in the *Move* task, they were instructed to move their eyes towards the stimulus once it appeared on the screen. In both tasks, they were to decide as quickly and as accurately as possible whether or not the stimulus string was an existing Finnish word. The manual response was given by pressing one of the two designated buttons in the gamepad. Each participant carried out both tasks. The tasks were counterbalanced across participants for stimulus block and presentation order.

Each experimental trial was initiated by the presentation of a fixation point to check the calibration accuracy. The fixation point was a cross superimposed on a black circle. When a fixation was positioned on the cross, the experimenter pressed the space bar to initiate a trial. A possible calibration drift was automatically corrected. The drift correction point was replaced with an identical fixation point in the same location; the replacement was not noticeable to the participant. With a variable delay depending on the experimenter's acceptance of the fixation, a letter string was presented for 100 ms to the right or left of the fixation point. The fixation point remained on the screen throughout the trial. The participant was to press the ''Yes'' or ''No'' key in the gamepad. The trial was terminated by this key press; the trial was also terminated if no key was pressed within 1800 ms after which the stimulus string was cleared from the screen. In the fixate task, the participant was to stay fixating on the fixation point throughout the trial; in the move task (s)he was to move his/her eyes towards the stimulus string once it appeared.

RESULTS

When no response was given within the predefined time limit, the response was coded as an error. In the move condition, all trials were excluded in which the participant initiated a saccade to the stimulus string so quickly that a fixation started on the target before it was erased from the screen, or when the participant did not make an eye movement. There were 31.9% of such trials.

Repeated measures analyses of variance (ANOVA) were computed with the three independent variables, stimulus type (words vs pseudowords), presentation side (right vs left), and task instructions (move vs fixate), all being within-participant variables. The means for correct responses and reaction times are presented in Table 1. We also computed the parametric sensitivity index of d′ as an additional measure of detection accuracy (for the formula, see Gescheider, 1985). A possible response bias was estimated by the non-parametric criterion cutoff C (for the formula, see Snodgrass & Corwin, 1988). The latter two measures were analysed using presentation side and task instructions as the within-participant variables; the means for d′ and C are presented in Table 2.

TABLE 1
Probability of correct response and RT

	Move				*Fixate*			
	Right		*Left*		*Right*		*Left*	
Measure	*Word*	*Pseudo-word*	*Word*	*Pseudo-word*	*Word*	*Pseudo-word*	*Word*	*Pseudo-word*
Prob. of correct response	.818	.809	.793	.797	.777	.846	.617	.724
Reaction time	808	969	877	998	798	912	891	980

Probability of correct response and reaction time (in ms), as a function of task instructions (Move vs Fixate), presentation side (Right vs Left), and stimulus type (Word vs Pseudoword).

Probability of correct response

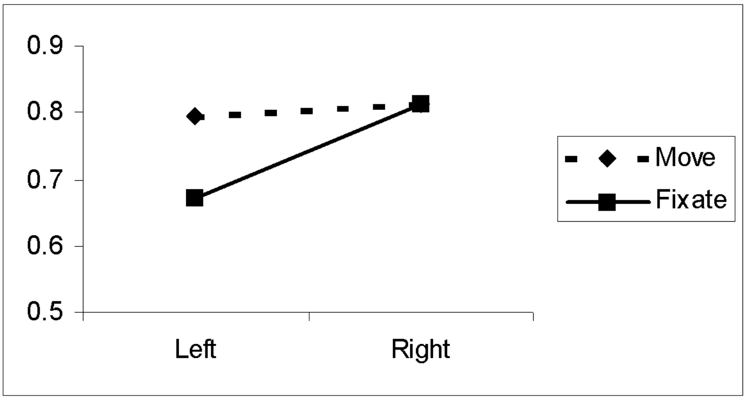
The analysis of the probability of correct response yielded a significant main effect of presentation side, $F(1, 22) = 28.28$, $p < .001$, and an almost significant main effect of task, $F(1, 22) = 3.97$, $p = .059$. Stimuli presented to the left of the initial fixation point produced more errors than those presented to the right. More importantly, stimuli presented with the *move* instructions produced fewer errors than those presented with the *fixate* instructions; the hit rate was 76.4% and 72.9% for the move and fixate conditions, respectively.

Two interactions, Task $\times$ Presentation Side, $F(1, 22) = 18.22$, $p < .001$, and Task $\times$ Stimulus Type, $F(1, 22) = 9.66$, $p < .01$, were also significant. The nature of the interactions, depicted in Figure 1, is similar in the sense that they show that the fixate condition is affected by presentation side and stimulus type, whereas the move condition is not. This was confirmed by a separate analysis of the two conditions. For the move condition, no effect approached significance, whereas for the fixate condition, the main effect of presentation side was highly significant, $F(1, 22) = 50.27$, $p < .001$, and the main effect of stimulus type just missed significance, $F(1, 22) = 3.91$, $p = .061$. In the fixate task, stimuli presented to LVF were associated with a less accurate performance than stimuli presented to RVF; moreover, words produced more errors than pseudowords (see the response bias analysis below).

Sensitivity index d′ and response bias index C

Performance accuracy can also be estimated in the context of signal detection theory. The sensitivity index d′ takes into consideration not only the hit rate but also the false alarm rate. Thus, it may be considered a better estimate of response accuracy than the mere probability of correct response. For this analysis, all responses that were not given within the predefined time limit were eliminated. The index was computed by using the hit rates for words and the false alarm rates for pseudowords. The means (see Table 2) were subjected to a two-way repeated measures ANOVA. All effects were highly significant: the main effect of presentation side, $F(1, 22) = 11.31$, $p < .01$, the main effect of task, $F(1, 22) = 9.78$, $p < .01$, and the presentation side $\times$ task interaction, $F(1, 22) = 9.19$, $p < .01$. Word detection was better in RVF and in the task where an eye movement was required to be launched towards the stimulus. Analogous to the probability of correct response, the interaction reflects the fact that word detection was particularly difficult in the fixate condition when the stimuli were presented to LVF. Separate analyses for the visual fields revealed that the move condition was associated with a more accurate performance than the fixate condition for LVF, $t(22) = 4.05$, $p = .001$, but not for RVF, $t < 1$.

To estimate a possible response bias in performance, we computed the criterion cutoff C (see Snodgrass & Corwin, 1988; See, Warm, Dember, & Howe,

A


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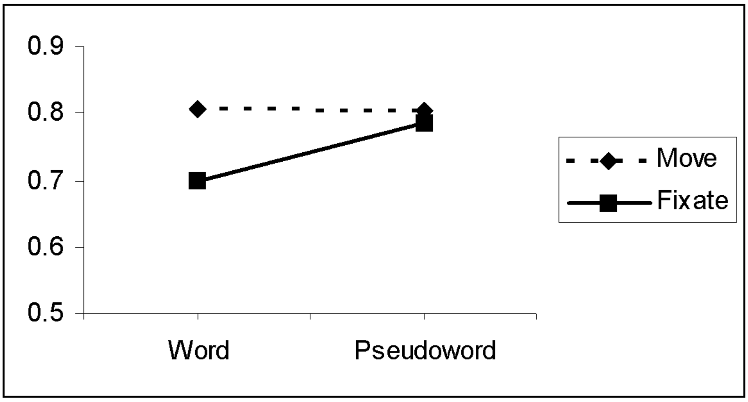

Figure 1. (A) Probability of correct response, as a function of task (move vs fixate) and presentation side (left vs right). (B) Probability of correct response, as a function of task (move vs fixate) and stimulus type (word vs pseudoword).

1997, for why C should be favoured over the traditionally used β). This index is 0 when there is no response bias, positive when there is a conservative bias (i.e., a bias towards responding ''no'' to words), and negative when there is a criterion shift to a more lenient one (i.e., a bias towards readily accepting stimuli as words). The condition means for C are given in Table 2. In the ANOVA, only the main effect of task was significant, $F(1, 22) = 5.71$, $p < .05$. In the move

TABLE 2
Sensitivity index and response bias index

	Move		Fixate	
Measure	*Right*	*Left*	*Right*	*Left*
d′	2.37	2.20	2.19	1.19
C	–.02	.03	.16	.22

Sensitivity index d′ and response bias index C, as a function of task instructions (Move vs Fixate), and presentation side (Right vs Left).

condition there was no response bias, whereas in the fixate condition a conservative bias was observed (i.e., a bias towards recognising letter strings as pseudowords).

Reaction times

The reaction times for correct responses yielded a reliable main effect of presentation side, $F(1, 22) = 19.55$, $p < .001$, and stimulus type, $F(1, 22) = 37.88$, $p < .001$. Stimuli presented to LVF were associated with longer reaction times than stimuli presented to RVF (958 ms vs 896 ms). Pseudowords produced longer response latencies than words (993 ms vs 860 ms). Moreover, the task × stimulus type interaction was also reliable, $F(1, 22) = 4.60$, $p < .05$. This interaction reflects the fact that response latencies for words were not much affected by the task (the move task produced 18 ms longer reaction times than the fixate task), whereas for pseudowords the task effect was more noticeable (the reaction times were 80 ms longer in the move than in the fixate condition).

Saccadic latency in the move condition

We also analysed the saccadic latency in the move condition as a function of presentation side and stimulus type. However, all effects remained clearly nonsignificant, all *F*s < 1.5. The mean saccadic latency was 156 ms. This is surprisingly short, but it may be explained by the fact that (a) there was only one saccadic target present at a time, (b) the location of the target was highly predictable, and (c) no (or minimal) length adjustment was needed for the saccadic amplitude (the letter strings were positioned in an equal distance to the left and right from the fixation point).

Control experiment

As the final phase of the study, we examined participants' spontaneous behaviour in the lateralisation task. This was done to ensure that the coupling of attention shifts with corresponding gaze shifts was a spontaneous one and not forced upon the participants in the experiment proper. If this were not the case, it would question our assumption that attention is more readily deployed when the eyes are allowed to move in tandem (or in close succession) with attention shifts.

We asked 10 independent participants to carry out the stimulus detection task without giving them any instructions as to whether or not they should stay fixating on the fixation point. If they explicitly brought up this issue, they were told that they were free to choose either option (i.e., stay fixating or move their eyes). To estimate their preferred strategy (move vs fixate), we categorised each trial as either a move or a fixate trial using a cutoff point of 500 ms (i.e., a trial was considered a move trial if the fixation was terminated within this time limit; if not, it was coded as a fixation trial). Out of the 10 participants, a clear majority adopted the move strategy. Eight participants showed a clear move preference (more than 75% of the trials were move trials), one participant showed a strong fixate preference (88% of his trials were fixate trials), and one showed no clear preference (46% were fixate trials). Overall, participants were somewhat more likely to initiate an eye movement when a letter string was presented to LVF than to RVF (the probability of making an eye movement was 0.84 for stimuli presented to the left and 0.80 for stimuli presented to the right). This small tendency is generally in line with the main result of the experiment proper; participants aimed to allocate additional attentional resources to stimuli appearing in LVF to compensate for the fact that words were more difficult to recognise in LVF.

We also compared their performance to that of the participants of the experiment proper. The overall probability of correct response was .77 for the participants of the control experiment, which compares favourably with that of the move condition in the actual experiment (.80). Also, the overall reaction times were comparable (943 ms vs 913 ms). All in all, the control experiment clearly demonstrates that the move task given to the participants in the experiment proper did not divert the task behaviour from the spontaneous one.

DISCUSSION

In the present study, the role of eye movements was studied in lateralised word recognition. Two task instructions were employed: (a) instructions typically used in the lateralisation studies in which the participant is asked to remain fixated on the central fixation point throughout the trial (the fixate condition), and (b) instructions requiring the participant to prepare and perform an eye movement (the move condition) towards a letter string presented briefly (100 ms) to the left or right of the central fixation point (a short presentation duration was used so that the stimulus was erased before the eyes reached the target location). Word recognition accuracy in these two experimental conditions was compared to examine whether there is an attentional component involved in the RVF advantage standardly observed for verbal stimuli. More specifically, we wanted to test the attentional advantage account originally proposed by Mondor and Bryden (1992) and subsequently developed by Nicholls and colleagues (Nicholls & Wood, 1998; Nicholls et al., 2001). According to the attentional advantage account, LH has an attentional advantage for processing verbal stimuli only when few attentional resources are allocated to the discrimination, but when attention is oriented to LVF prior to the stimulus presentation, the performance deficit of RH may be overcome.

As attention is more readily shifted to a target when an eye movement to the target location is prepared simultaneously with an attention shift (Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler et al., 1995; Shepherd et al., 1986), we assumed that the move condition would be associated with better word recognition performance than the fixate condition. On the basis of the attentional allocation account, we made the further prediction that words presented to LVF would benefit from the preparation of an eye movement towards the target stimulus, whereas words presented to RVF would not. The results of the present study turned out to be just as the attentional advantage account predicted. When words were presented to LVF, word recognition was improved when an eye movement was allowed to be made to the attended location, whereas allowing an eye movement to be prepared (and subsequently executed) to RVF did not improve performance. In other words, the LH advantage was observed in the fixate condition, whereas in the eye movement condition, the performance was equally good in both hemifields (i.e., the RH disadvantage was overcome). An improvement observed in the eye movement condition for LVF showed up both in the probability of correct response and in the sensitivity index d′ (d′ takes into account not only the hit rate but also the false alarm rate). These findings were corroborated by the analysis of response bias (the non-parametric C), which demonstrated a conservative response bias (i.e., a tendency to treat words as nonwords) in the fixate condition. The fact that there was no visual field effect in response bias indicates that the better performance for RVF in the fixate condition and the equally good performance across the two visual fields in the move condition are genuine recognition effects not mediated by a shift in the response criterion.

Why is an attention shift to LVF helped by an accompanying gaze shift, while an attention shift to RVF does not benefit from an eye movement preparation? We think there may be two reasons for this. First, this is probably because in processing written stimuli, attention is as a default biased to the right. Lateralised word presentation may thus activate skills acquired in reading of continuous text. It has been shown (see Rayner, 1998, for a review) that in languages that are read from left to right (such as Finnish, the language used in the present study), readers' attention is heavily biased towards RVF (i.e., readers clearly obtain more information from the right than from the left). Thus, anything that helps direct attention to LVF (such as peripheral visual cues or a preparation of an eye movement) will facilitate word detection in LVF but not in RVF. Second, the left hemisphere's specialisation in language processing probably also contributes. Words presented to RVF project first to the left hemisphere, and thus less attentional resources may be needed to successfully recognise words, which in turn results in there being little room for ''a gaze shift benefit''. On the other hand, the less dominant RH does benefit from recruiting attentional resources to LVF.

The above reasoning is in line with Kinsbourne (1973) who has subsumed attentional bias effects under cerebral dominance by assuming that attention is directed towards the visual field contralateral to the hemisphere specialised for the task in question. This view also finds support in the study of Jordan, Patching, and Milner (1998). These authors registered locations of eye fixations in a standard lateralisation procedure, where participants are asked to fixate on the central fixation point throughout the trial. It was observed that participants did not always fixate directly at the centre; when off the centre, the fixation was more likely located to the right than to the left—a finding in line with a rightward attentional bias. In sum, we suggest that an attentional bias towards RVF, coupled with the left hemisphere dominance for linguistic stimuli, help each other out to produce the observed result in the *fixate* condition.

Before closing, we discuss the results of Jones and Santi (1978) as they appear to run counter to those of the present study. Jones and Santi examined the recognition of letters presented laterally either to the left and right visual field. Analogously to the present study, an ''Eyes Fixed'' condition was compared to an ''Eyes Move'' condition using a signal detection estimate of sensitivity. Similarly to the present study, a reliable Visual Field $\times$ Task interaction was observed. However, the nature of the interaction was different from what we obtained. Jones and Santi observed that letter recognition was hampered for LVF in the move condition, whereas in the fixate condition there was no effect of visual field. Jones and Santi took that as evidence for an attentional bias towards the right visual field, when eye movements are allowed. This discrepancy in results may be a result of different procedures used for controlling fixation position in the eye movement condition. In the present study, the target stimulus was presented only when the participant was fixating on the central cross, whereas in the Jones and Santi study the participants were free to make eye movements and also fixate other locations than the central position at the time of stimulus presentation. As noted above, Jordan et al. (1998) showed that a good portion of fixations occurs to the right of centre when the fixation position is not controlled for. Therefore anticipatory fixations to the right may have decreased the recognition accuracy for the stimuli presented to LVF in the eye movement condition of Jones and Santi.

In conclusion, the present study demonstrates that by preparing an eye movement to a letter string presented briefly either to the left or right of fixation improves subsequent word detection in LVF but not in RVF. This improvement in recognition wiped out the LH advantage, which was observed when an eye movement was not allowed. These results are consistent with the attentional advantage account (Mondor & Bryden, 1992), which posits that a performance deficit of RH with verbal stimuli may be overcome when sufficient attentional resources are allocated to the discrimination.

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