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Lateralization effects in reading pointed and unpointed Hebrew

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Hebrew has two forms of spelling, pointed and unpointed. In the pointed spelling, diacritical signs (pointing) are added to consonantal letters to convey vowel information. These are omitted in the unpointed spelling. Since pointing conveys information that is critical for the prelexical derivation of phonology, it was hypothesized that its absence would prove detrimental for left hemisphere (LH) but not for right hemisphere (RH) reading and that, for the former, pointing effects would increase with increasing word length. Three experiments, one involving lexical decision and two involving word pronunciation, yielded little support for these hypotheses; rather, pointing had an overall adverse effect on performance, and this effect tended to be more pronounced for LH reading. In general, however, the results indicated an LH advantage. Since for central vision pointing has been found to aid performance under similar conditions, the results were seen to suggest a distinction between the visual and the phonological effects of pointing: pointing may impair early stages of visual analysis but may aid in the derivation of speech codes.

There has been a growing interest in recent years in the effects of different types of scripts on reading behaviour. It has been proposed that different cognitive processes are required for achieving reading proficiency in different writing systems (e.g. Hung & Tzeng, 1981). This idea has been explored in recent studies on word recognition, visual lateralization and dyslexia, and the results seem to throw light on some of the basic processes in reading (cf. Henderson, 1982).

One of the issues in reading research is whether or not a printed word must be recoded first into its phonological representation before its meaning can be accessed. According to the phonological recoding hypothesis, lexical access is always mediated by a phonological code, whereas the direct access hypothesis states that lexical access may be achieved directly from the graphemic representation. A third position assumes dual access: both processes are activated in parallel and lexical access is achieved by one of them depending on a variety of conditions. The experimental evidence in support of this latter position has been reviewed by McCusker *et al.* (1981).

Although the exact nature of the phonologically mediated access to the lexicon is not yet clear (cf. Coltheart, 1978; Kay & Marcel, 1981), converging evidence suggests that this access relies specifically on the left hemisphere language system. Thus, it is normally the case that non-words that are homophonic with English words require longer response times in a lexical decision task than control non-words (Rubenstein *et al.,* 1971). This effect, however, was found to hold only when the non-words were presented to the left hemisphere (Cohen & Freeman, 1979), suggesting that the right hemisphere does not normally perform phonological recoding of printed stimuli. Research with split-brain patients also indicates that the translation of print to phonology is specific to the left hemisphere. Thus, although the right hemisphere is able to comprehend single words, spoken or written, it cannot match a printed word with a picture that has a rhyming name or match two spelled words by sound (Zaidel, 1978; Zaidel & Peters, 1981). This pattern of results suggests that the right hemisphere lacks the capacity to translate print into sound, but may allow access to the meaning of a word directly from its orthography without an intermediate stage of phonological recoding.

It has been proposed that reading processes in the acquired dyslexic syndrome of 'deep dyslexia' are mediated predominantly by the right hemisphere (Coltheart, 1980; Saffran *et al.,* 1980). The ability of deep dyslexics to read simple concrete words combined with their total inability to read non-words suggests that lexical access is orthographically based. The occurrence of semantic errors is also compatible with the proposition that the phonology of words is derived post-lexically.

Taken together, these results suggest that phonologically mediated reading is specific to the left hemisphere which is also the major locus of 'direct' visual recognition. The right hemisphere, if it has any reading capacity at all (see Marshall & Patterson, 1983), seems to rely on the direct route from orthography to meaning.

There is substantial evidence that different orthographies yield differential lateralization effects, but the findings are difficult to interpret. Thus, the Japanese syllabic script *kana* was shown to display a right visual field advantage, much like English (e.g. Hatta, 1976), whereas the logographic *kanji* tended to produce a left visual field superiority, as did Chinese (Hatta, 1977; Tzeng *et aJ.,* 1979). This may be interpreted as indicating that the left hemisphere plays a more dominant role in the processing of phonologically based alphabetic and syllabic orthographies, whereas the right hemisphere makes a greater contribution to the reading of logographic scripts. However, this interpretation is complicated by the fact that these scripts also differ in their visual complexity. There has been some evidence that the right hemisphere is superior in early visual analysis of verbal stimuli (e.g. Hellige & Webster, 1979) and that this superiority increases with increased visual complexity of the stimuli (e.g. Bryden & Aflard, 1976; see Sergent, 1983). Since Chinese and *kanji* characters are visually more complex than *kana* characters, it is not clear whether the right hemisphere advantage found for these characters derives from their logographic nature or from their greater visual complexity.

Unpointed	**Pointed**	**Pronunciation**
פר	פַּר	PAR
זפק	זֶפֶק	ZEFEK
מגלב	מַגְלֵב	MAGLEV
השתדל	הִשְׁתַּדֵּל	HISHTADEL

Figure 1. Example of pointed and unpointed words as used in Expts 1–3.

The present study concerns Hebrew. Hebrew has attracted particular interest in the study of hemispheric asymmetry because of the fact that it is written from right to left. The present study focuses on another peculiar feature of Hebrew, namely, the optional use of pointing to convey vowel information. Hebrew is an alphabetic script which has two forms, pointed and unpointed (see Fig. 1). In the unpointed form, the letters convey mostly consonantal information, with vowel information being largely implicit. There are a few letters (e.g. *yod* and *vav*) which in some contexts serve the same function as that of vowels in English but which in other contexts represent consonants. Thus, with the unpointed spelling, much of the information necessary for a prelexical derivation of phonology is not conveyed. In the pointed spelling, diacritical signs (referred to as 'pointing') are added.

These are placed below, above or inside the letters. Pointing supplies mostly vowel information, but may also contain some consonantal information (e.g. the voicing information necessary to distinguish /p/ and /f/). Although unpointed spelling is extremely ambiguous as far as phonological coding is concerned, pointed spelling is relatively unambiguous in comparison to languages such as English. Both forms of Hebrew spelling are normally in use. Children's reading materials are usually pointed, and children begin by learning to read pointed spelling. Much of adult reading material is, however, unpointed, although in some (e.g. poetry, prayer books) the pointed spelling is conventionally used.

The methodological advantage of Hebrew is that the amount of phonological information available to a reader can be manipulated by using either the pointed or the unpointed forms of the exact same words. In a previous study (Koriat, 1984) I examined the extent to which the presence of pointing aids lexical access. The idea was that, if phonological receding is a necessary precursor to lexical access, pointing, which reduces much of the phonological ambiguity, should prove beneficial. A lexical decision task was employed using words which had only one correct pronunciation whether pointed or not. Pointing, used as a between-subject factor, was found to have little effect on response latency. This, together with other findings, was interpreted as indicating that Hebrew word recognition is by and large direct rather than involving phonological mediation. Pointing, however, was found to have a significant effect on pronunciation latency, suggesting that it may aid in the presemantic derivation of phonology.

A second study (Koriat, in press) examined the idea that lexical access might still depend on phonological mediation when low frequency words are concerned. Using a wider range of word frequencies, a lexical decision task with a mixed list of pointed and unpointed strings indicated significant effects of pointing, and these effects were stronger for low frequency than for high frequency words.

Previous studies of lateralization effects in Hebrew (see Shanon, 1982) have probably used the unpointed spelling, although this is not always specified. None of the previous studies compared the two forms of spelling. The present study explores the possibility of a differential cerebral asymmetry for pointed and unpointed Hebrew orthographies. Since pointing provides most of the information necessary for prelexical phonological receding, its absence should prove detrimental for right visual field-left hemisphere (RVF-LH) presentation. Right hemisphere reading, on the other hand, should not necessarily be impaired by lack of pointing. Since among adult readers unpointed orthography is by far the more prevalent, this must be sufficient to afford direct orthographic access to the lexicon. It would be of interest to examine the remote possibility that unpointed Hebrew, though alphabetic in nature, might be processed under certain conditions much like logographic script. If this is so, we might expect left visual field-right hemisphere (LVF-RH) advantage for this orthography. This prediction assumes that the alphabetic-logographic distinction represents a variation along a continuum, rather than a dichotomy, and that alphabetic script* with very deep orthographies might be processed like logographic scripts.

A second aim of the study was to gain some insight regarding the nature of the process by which the phonology of a word is derived by the left hemisphere. Theories about the process by which print is translated into sound range from those which assume that the phonology of a printed word is obtained by the application of grapheme-to-phoneme conversion rules to those postulating whole-word access to phonology (see Coltheart, 1978 Kay & Marcel, 1981). If the left hemisphere derivation of phonology involves a serial, grapheme-to-phoneme translation (see Zaidel, 1978), we may expect that for left hemisphere reading the advantage of pointed over unpointed spelling should increase with increasing word length.

Experiment 1

Method

Stimulus list. A list of 144 strings was used which included 128 experimental targets and 16 filler targets. For the experimental targets, 128 Hebrew words were compiled, representing two levels of word frequency and four levels of word length, with 16 words in each cell. The high frequency words were selected from the most frequently used 3000 words with frequency of usage being over 8 in 200000 (Balgur, 1968). The low frequency words included either words that were listed in Balgur with a lower frequency of usage, or words not listed in this corpus and judged to be infrequently used but well within the vocabulary' of the student population. Word length varied from two to five consonantal letters. Thus, the word *pardes,* for example, is a four-letter word, since it is spelled as *prds.*

All words allowed for only one correct pronunciation when unpointed. None of them included the letters vav or *yod* which are often used to convey vowel information, and none included a mute (unpronounced) letter.

Eight words in each frequency x length cell were transformed into non-words by replacing one of the letters by another letter (not including *yod* and *vav*). In their pointed form, the non-words had the same pointing as the original words from which they were derived.

For the additional set of filler targets, 16 words were selected which contained the letters *yod* and *vov* with a vowel function. These wire included to make the list of targets more representative of Hebrew words. Eight of these were transformed into non-words by changing one of the letters except for the *yod or* the *vav*.

Apparatus. The experiment was controlled by a POP 11-34 minicomputer. The stimuli were presented on a VT-11 CRT graphic display unit

Design and procedure. The experiment included 144 trials, and each subject was presented with only one version (pointed or unpointed) of each string. Presentation mode was programmed so that each of the strings appeared in all pointing x visual field conditions across each group of four successive subjects. For each subject exactly two words and two non-words of each of the frequency x length combinations appeared in the same field x pointing conditions. Otherwise the targets appeared in a different random arrangement and order for each subject. The practice list included 20 words and 20 non-words randomly mixed and randomly assigned to different field x pointing conditions.

The experiment was conducted in a dimly fit room. Subjects were seated at a viewing distance of 80 cm from the screen. They were told that they had to classify letter strings as words or non-words, that each string would be either pointed or unpointed and that it would appear either on the right side or on the left side of a '+' fixation sign. They were informed that when a word was pointed, pointing was always correct, and that none of the non-words could make a word if its pointing were changed or eliminated.

Each trial began with a'-' sign which appeared at the centre of the screen. Subjects were instructed to fixate on this sign and, when ready, to press the space bar of a computer keyboard. The key press modified the '-' sign into «'+' sign (to signal that the response was received), and after 500 ms the stimulus appeared for 100ms followed immediately by a mask which lasted for 800 ms. The target strings appeared so that the centre of each string was 3-5 cm to the right or to the left of the fixation point (2-5°). Each fetter was about 0-6 x 0-6 cm with a 0-08 cm gap between letters. The mask was a 14 x 1-3 cm light rectangle, centred around the fixation point.

Subjects were instructed to respond quickly without making errors by pressing a key labelled 'word' with one index finger or another key labelled 'non-word' with the other index finger. They were allowed to proceed at their own pace.

Subjects. Forty-eight University of Haifa students, 16 males and 32 females, participated in the study for course credit. Hebrew was their primary language. They were all right-handed. Eighteen subjects responded with their right hand for 'word' and with their left hand for 'non-word', and the reverse was true for the remaining subjects.

Results

Because of an error in programming, the data collected did not allow the analysis of response time. The analyses to be reported are therefore based only on response accuracy.* There were few systematic effects of either sex or hand assignment on percentage errors and the analyses were based on all subjects combined. Only experimental targets were included in the analyses.

Preliminary analyses indicated several significant main effects for frequency level and string length, but none of these effects was in interaction with the effects of visual field or pointing. Although for non-words error rate showed little variation with string length (percentage errors for lengths 2-5 being 35, 33, 33 and 31 per cent, respectively), the results for words indicated a significant increase with increasing word length (the respective means being 27, 29, 37 and 41 per cent). Word frequency yielded significant effects for words and non-words. High frequency words elicited fewer errors (25-7 per cent) than low frequency words (40-7 per cent), and non-words derived from high frequency words elicited more errors (35-9 per cent) than non-words derived from low frequency words (29-9 per cent).

Since the effects of visual field and pointing were independent of those of frequency and length' the results were pooled across lengths and frequency levels. Figure 2 presents mean percentage errors for words and non-words as a function of visual field and pointing.

A two-way analysis of variance for words yielded *F*= 63-42, d.f. = 1,47, *P* < 0-0001 for pointing; *F*< 1 for visual field; and *F*= *2*-73, d.f. = 1, 47, n.s. for the interaction. Pointed words exhibited significantly *higher* error rates (39-3 per cent) than unpointed words (27-08 per cent), and this effect was somewhat more pronounced for RVF presentation. It should be noted that mean accuracy for RVF pointed words, though significantly better than chance, was quite low. This may suggest the possibility that the present results underestimate the effects of pointing, particularly for RVF presentation. A similar analysis on non-words indicated no effect for pointing *(F* = 2-20, d.f. = 1,47), and a near-significant RVF superiority *(F* = 3-60, d.f. = 1,47, *P* < 0-07).

As far as the effects of pointing are concerned, the results depicted in Fig. 2 may be summarized as indicating (a) that presence of pointing impairs recognition of words but tends to facilitate response to non-words, and *(b)* that both of these effects are more pronounced for RVF-LH than for LVF-RH presentation. These results suggest that when a word is presented peripherally the presence of pointing tends to destroy its familiar shape and to impair its recognition. Thus, on the average, pointed strings tended to elicit more 'non-word responses (54 per cent) than unpointed strings (46 per cent). Furthermore, pointing appeared to have the strongest adverse effect on left hemisphere reading. Considering LH-RVF presentation only, a *t* test comparing pointed (41-8 per cent errors) and unpointed words (26 4 per cent errors) yielded / = 6-84, d.f. = 47, *P* < 0-0001. The respective *t* test for LVF presentation yielded / = 1-92, d.f. = 47, *P* < 0-10. For pointed words there was a near-significant RH-LVF advantage (F= 3-17, d.f. = 1,47, *P* < 0-10).

Discussion

The results on the whole yielded little support for the expected pattern of stronger RVF advantage for pointed than for unpointed orthography and, if anything, suggested the reverse pattern. Presence of pointing impaired word recognition, and the effect was

•Due to a programming error I suspect that for some of the subjects response times in Expt I were measured only to the nearest 20 ms. The results for response time were therefore not reported, although I should point out that these results mimic rather closet)' those of the error rate. The response times in Expts 2 and 3 were measured to the nearest I ms.

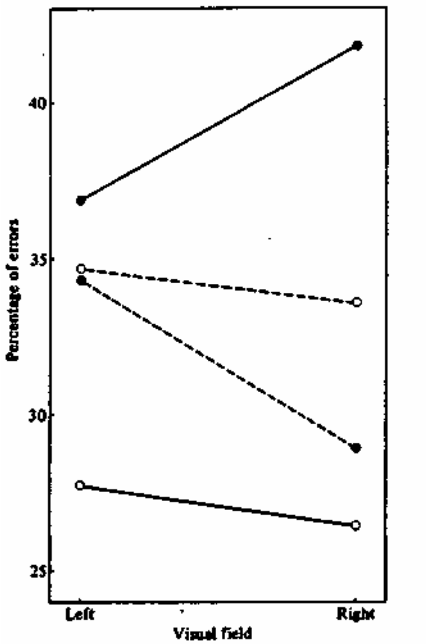

Figure 2. Mean percentage errors for words and non-words as a function of pointing and visual field (Expt 1). ●—●, words: pointed; O—O, words: unpointed; ● ----●, non-words: pointed; O---- O non-words: unpointed.

strongest for RVF presentation. Thus, as far as cerebral asymmetry is concerned, the results for the phonetic, pointed spelling are more similar to those usually found for *kanji* than to those found for *kana.*

These results are difficult to accommodate with the findings obtained with a central presentation of the stimuli. In a previous study (Koriat, 1984) using high frequency Hebrew words, I found no effect of pointing on latency of lexical decision, but a significant advantage for pointed orthography on pronunciation latency. With low frequency words, on the other hand, an advantage for pointing was found even for lexical decision (Koriat, 1984). Both of these sets of findings are consistent with the idea that pointing is beneficial whenever phonological receding is involved (as when pronunciation is required or when a low frequency word is accessed). Thus, some advantage for pointed orthography might have been expected at least for RVF presentation.

The list of words-employed in the present study was very similar to that employed in Koriat (in press), except that in the previous study each target was preceded by a prime. The observation that pointing aids recognition of centrally presented words but impairs recognition of peripherally presented words may suggest a distinction between phonological and visual effects of pointing. With long exposure-central vision presentation, pointing seems to aid derivation of a phonological code. With peripheral vision, on the other hand, presence of pointing seems to impair visual analysis. Such impairment appears

to offset whatever phonological benefit might accrue to pointing. Consistent with this interpretation is the interaction between lexicality and pointing (Fig. 2), which suggests that the presence of pointing destroys the familiar visual pattern of words and impedes their parafoveal recognition, but does not impair response to non-words.

It is somewhat surprising, however, that an RVF advantage was not found for words. As already noted, studies involving Hebrew have generally indicated an RVF superiority (e.g. Shanon, 1982), but these studies appeared to have used the unpointed spelling, and for this spelling our results suggest a slight RVF advantage (Fig. 2). The RVF advantage has indeed been found less consistently for lexical decision than for oral naming (see Beaumont, 1982). Perhaps a task which requires oral reading rather than just lexical access should bring to the fore the phonological superiority of the left hemisphere, and might reveal a stronger RVF advantage for pointed orthography.

Experiment 2

Method

Stimulus list. The stimulus list consisted of the 144 words compiled for Expt 1. Thus, the list contained only words, and included 16 filler words and 128 experimental words. The latter represented all combinations of word frequency and word length, with 16 words in each cell.

Design and procedure. The order of the words was the same for all subjects. This order was random except ^hat each block of 18 successive trials included two filler words and 16 experimental words, two of each of the frequency x length combinations. Presentation mode (i.e. visual field and presence of pointing) was programmed so that each of the words appeared in all side x pointing conditions across each group of four males or females. Presentation mode was otherwise random with the constraint that each set of eight successive trials contained exactly two stimuli in each field x pointing condition. Thus, for each subject there were exactly eight words in each of the frequency (2) x length (4) x pointing (2) conditions.

Subjects were told that they had to read aloud laterally presented words as fast as they could without mailing errors, and were informed that some would be pointed and some would not The sequence of events in each trial and the size and location of letters were the same as in Expt I. The only differences were that the words were presented for 200 ms and that a pronunciation response was required. Reaction times were measured from word onset until the subject spoke into a voice-activated microphone. There were 42 practice trials before the experiment began. The entire experiment was self-paced.

Subjects. Thirty-six University of Haifa students, 12 males and 24 females, participated in the study for course credit. They were all right-handed, and spoke Hebrew as their primary language. None had participated in the previous experiment.

Results

Only the experimental word targets were included in the analyses described below. Since preliminary analyses yielded few systematic differences between males and females the results are reported for both sexes combined. About 1-8 per cent of all responses were outside the range 300-2500 ms and were excluded from the analyses. A preliminary analysis on reaction time means yielded significant effects for word length, but these effects did not interact with either pointing or visual field. On the average, response times for lengths 2-5 were 682, 708, 754 and 760 ms respectively. The corresponding error rates were 9-6, 6-5, 7-1 and 7-9 per cent respectively.

Pooling data over words of different lengths, a three-way frequency x field x pointing analysis of variance on subject mean response time was carried out. The results yielded $F < 1$ for pointing; $F = 7\text{-}60$, d.f. = 1, 35, $P < 0\text{-}01$ for visual field; F= 14 53, d.f. = 1, 35,

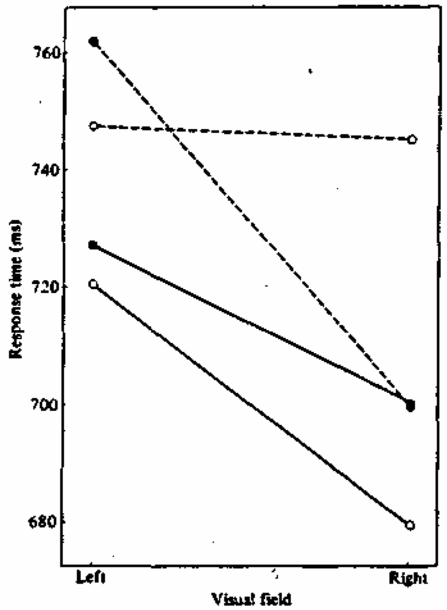

Figure 3. Mean response latency for reading low frequency and high frequency words as a function of pointing and visual field (Expt 2). ●—●, high frequency: pointed; O—O, nigh frequency: unpointed; ●---●, low frequency: pointed; O---O, low frequency: unpointed.

P < 0.0005 for frequency; and *F*= 4.31, d.f. = 1, 35, *P* < 0.05 for the frequency x pointing x field interaction.

There was on the average a 35 ms RVF advantage. As Fig. 3 indicates, however, the effects vary as a function of word frequency and pointing. For high frequency words the RVF advantage is obtained uniformly for pointed and unpointed orthography. For low frequency words, on the other hand, unpointed words evidence little lateralization effect, whereas pointed words exhibit a substantial RVF advantage. In fact, pointing seems to have a generally adverse effect on response time except for the RVF presentation of low frequency words where it appears to aid recognition. To substantiate these conclusions, two-way visual field x pointing analyses of variance were carried out for high and low frequency words separately. For high frequency words the results indicated *F* = 10.05, d.f. = 1, 35, *P* < 0.001 for visual field, and no other significant effects. For low frequency words the results indicated *F*= 4 26, d.f. = 1, 35, *P* < 0.05 for visual field; and *F*= 7.08, d.f. = 1, 35, *P* < 0.02 for the field x pointing interaction.

Analyses involving word length indicated that, although low frequency words presented in the RVF yielded the strongest benefit from pointing, these effects did not interact with word length.

Analysis of variance on proportion of mispronounced words indicated slightly more errors for LVF (10.1 per cent) than for RVF (7.3 per cent) presentation (F= 5.09, d.f= 1, 35, *P* < 0.05), and for unpointed (97 per cent) than for pointed (7.7 per cent) orthography (f= 3 78, d.f. = 1, 35, *P* < 0.10).

Since it has been proposed that the RH possesses a selective ability to process concrete words (see Lambert & Beaumont, 1983), the words employed in Expt 2 were also classified as concrete or abstract. Thirty-two of the low frequency words and 31 of the high frequency words were classified as concrete and the remainder as abstract. A three-way, concreteness x field x pointing, analysis of variance yielded significant effects for visual field but no other effects. A similar analysis involving percentage errors yielded a significant effect for visual field, a significant effect for concreteness *(F*= 6 10, d.f. = 1, 35, *P < 0.02),* but no significant interactions. Percentage errors for concrete and abstract words were 7·7 and 9·7 per cent, respectively.

Discussion

The results of Expt 2, where a pronunciation task was employed, yielded the typical asymmetry with a 35 ms RVF-LH advantage. Pointing tended to impair recognition except for an RVF presentation of low frequency words. For these words it aided recognition significantly. This latter finding is of particular interest in view of the contention (see McCusker *et al.,* 1981) that low frequency words seem to require phonological receding for their access. Low frequency words were also found to evidence the strongest advantage for pointed orthography in a lexical decision, central presentation task (Koriat, in press).

In comparing the results of Expts 1 and 2 we may note that Expt 1 yielded significant effects of pointing but no significant effects of visual field whereas Expt 2 indicated the reverse pattern. This suggests that a pronunciation task which requires the retrieval of speech codes both increases the contribution of left hemisphere reading and augments the possible benefit from the presence of pointing. This latter benefit might offset the disadvantage that pointing might have for visual analysis.

It is instructive to note that, as in Expt 1, the effects of word length did not interact with the effects of visual field. This was true even for low frequency words, which evidenced an advantage for pointing for RVF-LH presentation.

Experiment 3

In Expts 1 and 2 pointed and unpointed orthographies were mixed within the same list. The advantage of this procedure is that it prevents the adoption of different strategies for the different types of orthographies. This might, however, encourage the adoption of a reading strategy which is common to both orthographies (e.g. ignoring pointing), and thus prevent the emergence of systematic differences between pointed and unpointed spellings.

In Expt 3 pointing was blocked within one list. Subjects were presented with one list of pointed words and another list of unpointed words. It was anticipated that this procedure might encourage stronger reliance on pointing when available and might yield stronger benefit for pointing with RVF presentation.

The words used in Expt 3 were selected to represent two levels of word frequency, two levels of concreteness and four levels of word length, with an equal number of words in each combination.

Method

Stimulus list. Two lists of words (A and B) were compiled. Each list contained eight filler words and 64 experimental words. *The* latter represented two levels of concreteness (abstract vs. concrete), two levels of frequency and four levels of word length, with four words in each combination. Frequency and length were defined as in Expts 1 and 2. All experimental words had only one correct pronunciation, and none contained the letters *yod* and *vav* or a mute letter. The order of presentation of each list was such that each block of 18 successive trials included a random arrangement of two filler words and 16 experimental words, two of each of the concreteness x frequency x length conditions.

Design and procedure. The procedure was similar to that of Expt 2 except that pointing was manipulated between fists. Each subject received both lists, one pointed and the other unpointed. The order of the two lists and the order of the pointed and unpointed conditions were counterbalanced across subjects. Visual field was manipulated within list so that *(a)* across all subjects each word appeared equally often in each of the fields for the pointed and unpointed conditions, and *(b)* for each subject exactly two words of each concreteness x frequency x length condition appeared in each field in each of the two lists. As in Expt 2, each subject saw only one version of each word.

The instructions and the procedure were similar to those of Expt 2 except that subjects were informed whether the words to be presented were pointed or unpointed. The experiment began with a training block which included 36 words. These appeared pointed or unpointed depending on the condition. When the first list was over, subjects were given new instructions and a new training block before the second list was presented.

Subjects. Forty-four University of Haifa students, 16 males and 28 females, participated in this study for course credit. They were all right-handed and all spoke Hebrew as their primary language. None had participated in the previous experiments.

Results

Only responses to experimental words were considered and, since there were no systematic sex differences, the following analyses are based on al! subjects combined. About 1 per cent of all response times were outside the range of 300-2500 ms and were eliminated. Preliminary analyses indicated highly significant effects for word length but these effects did not interact with either pointing or visual field. Mean response times for lengths 2-5 were 656, 676, 742 and 765 ms, respectively. The respective error rates were 10-5, 9-7, 11 -5 and 10-0 per cent.

A four-way, concreteness x frequency x field x pointing analysis of variance for response time yielded the following significant effects: pointing (F= 5·47, d.f. = *1,43, P*< 0·05), visual field (f= 5·64, d.f. = 1, 43, *P* < 0·05), frequency *(F* = 27·34, d.f. = 1, 43, *P* < 0·0001), concreteness x pointing (F= 10·07, d.f. = 1, 43, *P* < 0·005),

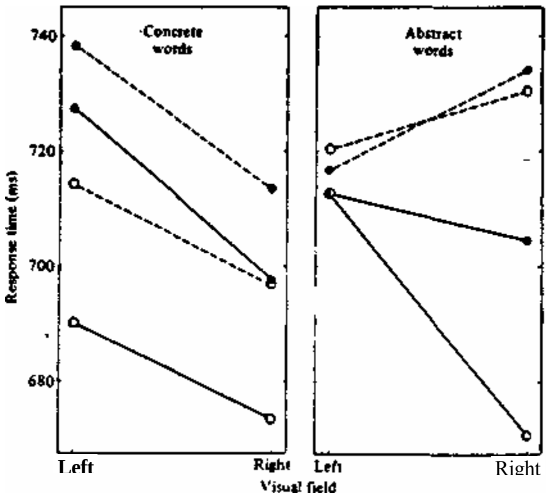

Figure 4. Mean response latency for reading low and high frequency concrete and abstract words as a
function of pointing and visual field (Expt 4) ●—●. high frequency: pointed;

concreteness x field *(F* = 6.66, d.f. = 1, 43, *P* < 0.02), frequency x field *(F* =6.08, d.f. = 1, 43, *P* < 0.02), concreteness x field x pointing *(F* = 6.62, d.f. = 1, 43, *P* < 0.02) and concreteness x frequency x field *(F* •= 4.18, d.f. = 1, 43, *P* < 0.05). The means from this analysis are presented in Fig. 4.

The results may be summarized as follows. For concrete words the effects of frequency, visual field and pointing were generally additive. A three-way analysis of variance for these words only yielded significant effects for frequency *(F*= 8.29, d.f. = 1, 43, *P* < 0.01), for visual field *(F* = 13.68, d.f. = 1, 43, *P* < 0.001) and for pointing *(F*= 10.01, d.f. = 1, 43, *P* < 0.005). None of the interactions was significant. Thus, overall, the results for concrete words indicate an RVF advantage and an adverse effect for pointing.

For abstract words, on the other hand, the same three-way analysis yielded significant effects for frequency *(F* = 23.33, d.f. = 1, 43, *P* < 0.0001) and for the field x frequency interaction *(F*= 19.23, d.f. = 1, 43, *P* < 0.0001). The field x pointing and the frequency x pointing interactions also neared the commonly accepted significance level *(P* < 0.06). It may be seen that the pointing and the visual field effects are entirely confined to the high frequency words, whereas low frequency words evidence no pointing effects and, if anything, an LVF advantage. For the high frequency abstract words provision of pointing had little effect on LVF presentation, but slowed reading latency significantly for RVF presentation *(F* = 13.95, d.f. = 1, 43, *P* < 0.0005).

General discussion

The present study examined lateralization effects in two forms of Hebrew orthography differing in terms of the presence or absence of pointing, i.e. signs that mostly convey vowel information. The hypothesis was examined that, since pointing supplies information that is critical for the prelexical derivation of phonology, its absence should prove more detrimental for left hemisphere reading than for right hemisphere reading. The three experiments reported in this paper generally failed to support this hypothesis. However, they yielded several interesting findings as outlined and discussed below.

First, lateralization effects were not found in the lexical decision task of Expt 1, but were demonstrated for reading aloud in both Expts 2 and 3, the pattern being that of an RVF-LH superiority. This is consistent with previous studies on lateralization effects in Hebrew which indicated an LH advantage (e.g. Carmon *el al.,* 1976).

Secondly, for both Expts 1 and 3 significant effects of pointing were found for words. Surprisingly, however, presence of pointing had a detrimental effect on reading. This result is to be sharply contrasted with the finding that for central presentation pointing was found to aid pronunciation (Koriat, 1984), and that when low frequency words were included pointing aided lexical decision as well (Koriat, in press). Since the list of words employed in the present study were similar in overall word frequency level to the list employed in Koriat (in press), we expected to find an advantage for pointed spelling in all three experiments.

These results suggest a distinction between the visual effects and the phonological effects of pointing. When words are presented in central vision pointing appears to aid the derivation of a phonological code. As this derivation is important for reading aloud in general and for lexical access of low frequency words, presence of pointing has a facilitator} effect in such tasks. With brief parafoveal presentation, on the other hand, presence of pointing seems to load the early stages of visual feature extraction and feature interpretation. The addition of pointing might be particularly detrimental in view of the fact that the consonantal characters and the pointing signs in Hebrew are generally spatially separated and involve different visual features (see Fig. 1). This may increase the likelihood of 'illusory conjunctions' in peripheral vision (see Treisman & Gelade, 1980).

Since with peripheral presentation visual analysis might be critical for word recognition, the possible contribution of pointing to the derivation of speech codes might be entirely offset by its interfering with the early stages of feature extraction.

Thirdly, there was little support for the expected interaction of stronger pointing effects for left hemisphere than for right hemisphere reading. This pattern was found to hold for the low frequency words in Expt 2, consistent with the idea that phonological mediation is involved to a greater extent in the processing of low frequency than in the processing of high frequency words (McCusker et al., 1981) However, in both Expts 1 and 3 there were trends suggestive of just the reverse pattern, namely that the detrimental effects of pointing on word recognition might actually be stronger for RVF-LH than for LVF-RH reading. Thus, in Expt I pointed words exhibited an almost significant LVF-RH advantage. This pattern is consistent with the finding of an RH superiority in the extraction of visuo-spatial information (see Sergent, 1983). This superiority has been found to hold even with verbal material, suggesting that the right hemisphere is more efficient than the left hemisphere in the initial stages of reading, i.e. those involving the extraction of visual features (e.g. Hellige & Webster, 1979).

The possibility of a stronger LVF advantage for pointed Hebrew deserves further investigation, as it may have some bearing on the results obtained with other orthographies. Thus, in contrast to Japanese where the ideographic *kanji* is visually more complex than the phonetic *kana,* in Hebrew it is the more phonetic pointed orthography that is the more complex. The results of Expt 1 suggest that the lateralization pattern for pointed Hebrew might actually be more similar to that found for *kanji* than to that found for *kana.*

In conclusion, the results of the present study suggest that the effects of pointing, the effects of visual field and the interaction between them might depend greatly on the delicate balance between the relative contribution of visual and phonological factors to reading. When the stimuli are peripheral or perceptually degraded, we may expect an LVF-RH advantage, and an adverse effect of pointing which is more pronounced for RVF-LH presentation. As visual analysis becomes less critical (as in central vision and long exposure), and as the role of phonology becomes more important (as when pronunciation is called for or when low frequency words are involved), the pattern should shift to one indicating RVF-LH superiority, and an advantage for pointed orthography which is more pronounced for left hemisphere reading.

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