

Lateral Asymmetries in the Naming of Words and Corresponding Line Drawings

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Laterally displaced line drawings and the words which name these drawings were tachistoscopically presented to adult subjects. For words, as expected, a right visual field-left hemisphere advantage was obtained. For line drawings, in contrast to previous studies which have typically reported a right visual field-left hemisphere advantage, no visual field asymmetry was found. The absence of a visual field asymmetry for line drawings is consistent with reports of a shift toward greater right hemisphere involvement in the recognition of pictographic as compared to phonetic writing systems and concrete/imageable words as compared to abstract/nonimageable words. Further, the present results seem consistent with findings on picture recognition and naming abilities in brain-damaged patients.

Research on hemispheric specialization with normal subjects, unilaterally brain-damaged patients, and commissurotomy patients generally supports differential involvement of the left cerebral hemisphere in verbal analytic tasks and the right cerebral hemisphere in spatial-gestalt tasks (e.g., Klein, Moscovitch, & Vigna, 1976; Sperry, 1974; Teuber, 1974; Levy, 1969; Kimura, 1967; Milner, 1958).

A common method of investigating hemispheric specialization in normal subjects is lateralized tachistoscopic presentation of visual stimuli. Such tachistoscopic studies have clearly demonstrated a right visual field (RVF)-left hemisphere advantage for the recognition of words under both unilateral and bilateral presentation conditions, when proper precautions are taken to control fixation (e.g., MacKavey, Curcio & Rosen, 1975; McKeever & Huling, 1971). Tachistoscopic recognition of line drawings presented to lateral view has also been studied, but much less thoroughly. Most of these studies, like those with words, have reported

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a RVF advantage (Young, Bion, & Ellis, 1980; McKeever & Jackson, 1979; Bryden & Rainey, 1963; Wyke & Ettliger, 1961). However, no visual field asymmetry for the recognition of line drawings was reported in one study (Kimura & Durnford, 1974; Kimura, personal communication) and a left visual field (LVF) advantage was reported in another study (Schmuller & Goodman, 1980). Unfortunately, a variety of methodological problems make the results of most studies investigating lateral asymmetries for the recognition of line drawings difficult to interpret. These methodological problems include inadequate control over fixation (Schmuller & Goodman, 1980; Bryden & Rainey, 1963; Wyke & Ettliger, 1961), failure to use mirror images of line drawings (Schmuller & Goodman, 1980; McKeever & Jackson, 1979; Bryden & Rainey, 1963; Wyke and Ettliger, 1961), and small stimulus set size (McKeever & Jackson, 1979; Wyke & Ettliger, 1961). Failure to use mirror images results in different visual information falling at equivalent distances from the fovea in the two visual fields. Using a small number of stimuli repeatedly has been reported to increase left hemisphere involvement in the task of letter recognition (Miller & Butler, 1980), and may have similar effects on picture recognition.

Although the majority of laterality studies with both words and line drawings report a RVF advantage for the recognition of these stimuli, no study to date has directly compared lateral asymmetries for the recognition of line drawings to lateral asymmetries for the words that name these drawings. While corresponding words and line drawings have the same verbal labels, they certainly differ in their visuospatial characteristics. This difference suggests that there may be distinct patterns of hemispheric involvement in the recognition of words vs. line drawings. In fact, results of previous studies indicate that the visuospatial complexity of stimuli, regardless of their nameability, is a major determining factor of right hemisphere involvement in a task. For example, patients with unilateral damage to the right hemisphere have been found to be impaired in recognizing such visuospatially complex but nameable stimuli as overlapping and incomplete pictures of realistic objects (Warrington & James, 1967; De Renzi & Spinnler, 1966). Similarly, in normals, the right hemisphere has been shown to be differentially involved in recognizing such complex stimuli as Braille letters (Rudel, Denckla, & Spalten, 1974; Hermelin & O'Connor, 1971), the time on a clock face (Berlucchi, Brizzolara, Marzi, Rizzolatti, & Umiltà, 1979), and familiar colleagues' faces (Leehey & Cahn, 1979), even though these stimuli are nameable.

If one assumes that line drawings are of greater visuospatial complexity than the words that name them, then one might expect greater right hemisphere involvement in the recognition of line drawings than words. Support for this prediction comes from the finding that Japanese subjects show a RVF advantage for the recognition of phonetic *kana* but either

no visual field advantage (Sasanuma, Itoh, Mori, & Kobayoshi, 1977) or a LVF advantage (Hatta, 1977) for the recognition of pictographic *kanji*. For English-speaking subjects, moreover, greater right hemisphere involvement has been reported in the recognition of concrete-imageable words than in the recognition of abstract/nonimageable words (Day, 1979; Hines, 1978; Ellis & Shepherd, 1972). It seems plausible that since there is a shift toward greater right hemisphere involvement in the recognition of both a pictographic orthography in Japanese and highly imageable concrete nouns in English, there should be at least as great a shift for pictures themselves.

In the present study we directly compare visual field asymmetries for the naming of line drawings and the words that name these drawings. A naming task rather than a recognition task was chosen because of the difficulty of equating distractor similarity across words and line drawings in a recognition task. Moreover, despite what one might expect on the basis of findings that show the isolated right hemisphere of commissurotomy patients can recognize but not name visuospatial stimuli (Sperry, 1974), requiring a naming response versus recognition from an array apparently has no effect on the magnitude or direction of visual asymmetries for visuospatial stimuli in normal subjects (e.g., Leehey & Cahn, 1979; Berlucchi et al., 1979). Thus, the finding of a Stimulus Type \times Visual Field interaction using a naming task would provide strong evidence for different patterns of hemispheric involvement in the processing of words versus corresponding line drawings.

METHODS

Subjects. Thirty-two adult subjects, sixteen males and sixteen females, were tested. All were right-handed with right-handed parents and siblings, and had vision corrected to 20/20.

Stimuli and apparatus. Stimuli were bilaterally presented to binocular view in a Gerbrands two-channel tachistoscope (Model T-2B1). Stimuli consisted of 80 line drawings of common objects and the 80 four- or five-letter words which name these objects (see Fig. 1). To ensure that the line drawings were easily and consistently named, a pretest was run on 20 additional subjects. Each person was given a series of 150 line drawings and asked to supply the name of each object. Of this set, 40 line drawings which were identically named by at least 90% of pretest subjects were employed in the actual experiment.

The pictures were black ink line drawings on white stimulus cards. The near point of each line drawing was located 2°3' from center fixation. The line drawings subtended maximal horizontal and vertical visual angles of 2°43'. In addition, each line drawing was shown in a particular orientation in one visual field and in the mirror orientation in the opposite visual field to ensure that the same visual information appeared at equal distances from the fovea in each visual field. The words were aligned vertically and were typed in black capital letters (IBM Bookface) on white stimulus cards. Each word was located 1°22' from center fixation. The four-letter words subtended 2°23' and the five-letter words subtended 2°43' of vertical visual angle. For both word and picture stimuli, a random digit ranging from 2 to 9 appeared at the center of each stimulus card.

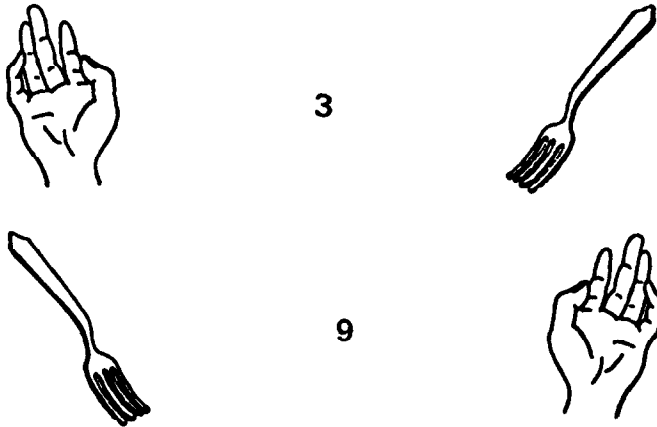


FIG 1. Two sample stimulus cards, showing mirror images of line drawings.

Procedure and design. Before each trial the subject fixated centrally on a black outline square. The experimenter said, "Ready," and 100 msec later the stimulus card appeared. The subject's task was first to report the center digit and then to name the two stimuli with no constraint on report order. To ensure central fixation, the data from any trial on which the center digit was not reported correctly were discarded and replaced with an additional trial at the end of the trial block.

Trials were blocked by stimulus type (words, pictures). Subjects were divided into two groups such that half were shown words before pictures and vice versa. In addition, the stimuli were randomly divided into two sets such that a particular subject viewed each stimulus as either a word or a line drawing, but not both. Further, visual field of presentation for each item was counterbalanced across subjects. Each subject was presented with 20 bilateral picture trials and 20 bilateral word trials.

Prior to each trial block, individual subjects were presented with 20 pretest trials in order to establish the exposure duration which would yield approximately 30% correct responding on test trials. This was done so that each task would be of sufficient difficulty to differentially engage the processing of the specialized hemisphere. It should be noted that all exposure durations determined by this method were 150 msec or less, well below eye movement latency. The average exposure duration for pictures was 23 msec and that for words was 79 msec.

RESULTS

The average numbers of words and line drawings recognized in the left and right visual fields is shown in Fig. 2. A repeated-measures analysis of variance was performed with Sex, Order (pictures first, words first), and Set (specific items shown as a word or a picture) as between-subject variables and Visual Field of Presentation and Stimulus Type as within-subject variables. The main effect of Stimulus Type was significant $F(1, 24) = 18.57, p < .001$, in favor of line drawings. The main effects of Visual Field, Sex, Set, and Order were not significant.

Importantly, the two-way interaction of Stimulus Type \times Visual Field

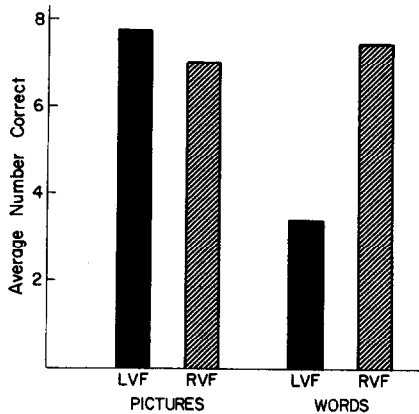


FIG. 2. The average numbers of words and line drawings (out of 18) recognized in the right and left visual fields by all subjects.

was found to be significant ($F(1, 24) = 22.82, p < .001$). Post hoc Tukey tests show that this interaction is attributable to a significant RVF advantage for word recognition ($p < .01$) and no visual field advantage for picture recognition ($p > .10$) (See Fig. 2.) There was also a three-way interaction of Stimulus Type \times Visual Field \times Order ($F(1, 24) = 9.42, p < .01$). Post hoc Tukey tests revealed a significant RVF advantage for words for the Words First Group ($p < .01$) but no asymmetry for words for the Pictures First Group. In contrast, there was no asymmetry for pictures for either the Words First Group or the Pictures First Group ($p > .10$).

A separate analysis of variance collapsed over subjects rather than items (with pictures and words treated as random variables) revealed main effects of Visual Field ($F(1, 83) = 23.02, p < .0001$), in favor of the RVF, and Stimulus Type ($F(1, 83) = 12.57, p < .0001$), in favor of pictures. Moreover, there was a significant Visual Field \times Stimulus Type interaction ($F(1, 83) = 34.00, p < .0001$), indicating that this interaction was present across items as well as subjects. This interaction should hold across a new set of subjects and items since the *min F'* value (Clark, 1973) was found to be significant ($\text{min } F'(1, 54) = 8.25, p < .01$).

On inspection of the data, it was noted that 10 of the 32 subjects tested displayed a LVF advantage for words. This finding is unexpected since Wada test results suggest that approximately 95% of right-handed subjects with dextral relatives have left hemisphere specialization for speech (Milner, 1974). A separate analysis of variance on the data from these 10 subjects revealed a highly significant main effect of Visual Field ($F(1, 8) = 32.42, p < .001$), in favor of the LVF, and no Visual Field \times

Stimulus Type interaction. Post hoc Tukey tests show significant LVF advantages that are equivalent in magnitude for words as well as pictures ($p < .05$). For reasons which will be discussed later in this section, we believe that the pattern of results shown by these 10 subjects is attributable to a left-to-right directional scanning bias. Thus, these 10 subjects are referred to as Scanners, and the remaining 22 subjects as Nonscanners (See Fig. 3.)

An analysis of variance on the scores of these remaining 22 subjects showed significant main effects of Visual Field ($F(1, 20) = 42.33, p < .0001$), in favor of the RVF, and Stimulus Type ($F(1, 20) = 10.44, p < .001$), in favor of pictures. In addition, the Visual Field \times Stimulus Type interaction was significant ($F(1, 20) = 32.11, p < .0001$). Similar to the group as a whole, post hoc Tukey Tests show that this interaction is attributable to a significant RVF advantage for words ($p < .01$) and no visual field advantage for pictures ($p > .10$) (see Fig. 3). There is no evidence that the absence of a visual field asymmetry for pictures among these subjects is attributable to a bimodal distribution of visual field asymmetries. An F test for the equality of variance of visual field asymmetries for pictures shows no significant difference between Scanners and Nonscanners ($p > .10$). Rather the majority of the Nonscanners exhibited a near zero visual field asymmetry for picture naming.

We attempted to determine whether any subject characteristics differentiated the 10 Scanners from the remaining 22 Nonscanners. χ^2 tests

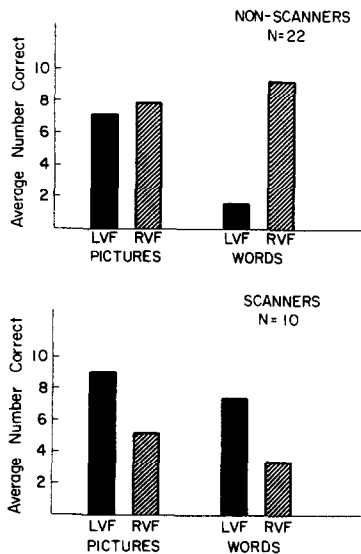


FIG. 3. The average numbers of words and line drawings (out of 18) recognized in the right and left visual fields by Scanners and Nonscanners.

showed that the distribution of sex, eyedness, and familial handedness history did not differ between the two groups. However, a χ^2 analysis did reveal that Scanners were significantly more likely to be in the group that saw pictures first than the group that saw words first (8/16 vs. 2/16, $p < .025$).

Two possible explanations for the unexpected results of these 10 subjects were considered. First, it could be argued that the LVF advantage for words is attributable to priming of the right hemisphere by prior picture presentation. Priming of the right hemisphere for word recognition has been reported when presentation of face stimuli precedes word stimuli (Klein et al., 1976). However, while a right hemisphere advantage is consistently reported for recognition of faces (e.g., Klein et al., 1976; Leehey & Cahn, 1979; Young & Bion, 1980) we found no asymmetry for pictures, even when they were presented first. It seems unlikely that the nonlateralized picture task could result in significant priming of the right hemisphere for word recognition.

Another explanation, which we consider more likely, is that the unexpected LVF advantage for words is attributable to a left-to-right directional scanning bias. This possibility is supported by the finding that the 10 subjects with a LVF advantage for word recognition also showed a LVF advantage for pictures. Moreover, the LVF advantages for pictures and words were equivalent in magnitude. The fact that the magnitude of this LVF advantage was independent of stimulus type is consistent with the hypothesis of a directional scanning preference.

Further, analysis of order of report on trials on which subjects reported two stimuli revealed that these 10 subjects reported from left to right on 80% of the picture trials and on 82% of the word trials. In contrast, subjects who displayed a RVF advantage for words reported from left to right on only 61% of the picture trials and 45% of the word trials. Thus, the 10 subjects with the LVF advantage for words had a stronger left-to-right order of report bias for both pictures and words than the other 22 subjects.

The prevalence of the left-to-right scanning bias among subjects who were shown pictures first is most likely attributable to the fact that the hemispheres are equally involved in the picture task, and hence subjects' natural left-to-right scanning bias is not disrupted (MacKavey et al., 1975). On the other hand, since there is a right visual field-left hemisphere advantage for word recognition, the left-to-right scanning bias was most likely disrupted in the words first condition. In addition, words were oriented vertically rather than horizontally, which also may have discouraged left-to-right scanning in the Words First condition. We believe the greater scanning bias in the Pictures First than the Words First condition underlies the Visual Field \times Stimulus Type \times Order interaction.

DISCUSSION

As predicted, pictures and the words that name them do not show identical visual field advantages. While words show a significant RVF-left hemisphere advantage, pictures show no visual field difference. Although left hemisphere involvement in the naming of pictures and words appears to be similar, as shown by equal RVF scores, the right hemisphere appears to be more involved in the naming of pictures than of words, as shown by a significantly greater LVF score for pictures.

Our results contrast with the majority of previous studies that report greater left hemisphere involvement in the naming of line drawings (Young et al., 1980; McKeever & Jackson, 1979; Bryden & Rainey, 1963; Wyke & Ettlinger, 1961). It is possible that left-to-right scanning biases in some of the previous studies may account for this discrepancy. Bryden and Rainey (1963) report a LVF advantage for naming bilaterally presented pictures, analogous to our scanning group, and a RVF advantage for naming of unilaterally presented pictures. The opposite visual field advantages obtained for bilaterally and unilaterally presented pictures can most easily be explained by directional scanning preferences (White, 1969). Since Bryden and Rainey did not control for central fixation, this explanation seems likely.

McKeever and Jackson (1979) report a RVF advantage for the naming of pictures but their measure, unlike ours, was vocal RT. It is certainly possible that normal subjects might name pictures presented in the two visual fields equally well, but might be able to name them faster when they are presented in the RVF, because the left hemisphere is specialized for the production of speech (Gazzaniga & Sperry, 1967). In addition, McKeever and Jackson used a smaller set of five pictures repeated over 140 trials, in contrast to the present study in which 40 different picture stimuli were presented, each only once. Recently, using letter stimuli, Miller and Butler (1980) have reported a RVF advantage with a small set size of four items that were presented repeatedly, but no visual field advantage with larger set sizes. Thus, the small set size used by McKeever and Jackson might also have contributed to their finding of a RVF reaction time advantage for the naming of pictures.

Similarly, Wyke and Ettlinger (1961) report a RVF advantage in subjects' accuracy for naming both unilaterally and bilaterally presented pictures, employing a procedure in which subjects were repeatedly shown each stimulus until that stimulus was recognized. This repetition method may be equivalent in effect to using a small set size. In addition, there was no positive control over fixation. Either of these procedural differences may account for the discrepancy with our results.

Finally, Young et al. (1980) used a method similar to the present experiment with the following modification: in both the word and picture

conditions subjects were required to report the LVF stimulus first on half the trials and the RVF stimulus on the other half. For words, a RVF advantage was found on both the first and second report items. For pictures, items reported first showed no visual field difference, while those reported second showed a RVF advantage, yielding a significant overall RVF advantage. On the basis of their findings, Young et al. suggest that the left hemisphere is differentially involved in the recognition of words as well as pictures. There is, however, an alternative explanation for their results. Examining their picture data in terms of trials on which subjects were required to report the stimuli in a left-to-right order versus a right-to-left order, there is apparently no visual field asymmetry for left-to-right order of report but a RVF advantage for right-to-left order of report. A similar magnification of the RVF advantage was obtained for picturable nouns and CVCs when subjects were required to report from right to left vs. left to right. Since our data and those of others (e.g. MacKavey et al., 1975) suggest that subjects typically show a left-to-right scanning preference, requiring subjects to report from right to left may selectively interfere with their ability to report the second item, i.e., the LVF item. These considerations suggest that the Young et al. finding of a RVF advantage for pictures may not reflect underlying hemispheric asymmetry but rather may be an artifact of forced directional scanning. Although a natural left-to-right scanning preference may have some effect on the results of studies in which report order is not controlled, its influence seems to be relatively minor. This is suggested by numerous studies employing bilateral presentation in which order of report is unconstrained, and opposite visual field asymmetries for words and visuospatial stimuli are found (e.g., Young & Bion, 1980; Leehey & Cahn, 1979; MacKavey, et al., 1975).

In addition to these methodological considerations, studies reporting a RVF advantage for picture naming appear to be less compatible with the picture recognition and naming abilities of brain-damaged patients than our results. It has been clearly demonstrated that certain groups of patients, notably alexics without agraphia, have profound deficits in reading words but often maintain the ability to name objects and pictures (Stachowiak & Poeck, 1976; Benson & Geschwind, 1969; Ajax, 1967; Geschwind & Fusillo, 1964). Although this dissociation does not necessarily imply different patterns of hemispheric involvement in the naming of pictures versus words, it is certainly consistent with our finding of differential left hemisphere involvement in word naming and bilateral involvement in picture naming.

Several investigators have proposed that there are two distinct steps in the naming of visually presented objects or pictures, the first involving visual recognition and the second accessing the appropriate verbal label (Jonidas, 1977; Bryden & Allard, 1976; Rochford, 1971; De Renzi, Scotti,

& Spinnler, 1969). This notion seems to be consistent with the literature on deficits in brain-damaged individuals. In general, deficits in visual recognition of objects and pictures have been associated with bilateral damage and deficits in attaching a verbal label to an already recognized visual object have been associated with left hemisphere damage. Newcombe, Oldfield, Ratcliff, and Wingfield (1971) report that left brain-damaged and bilaterally brain-damaged patients are impaired in their ability to name line drawings of objects, while right brain-damaged patients are not. However, the errors of left brain-damaged patients suggest that they can visually recognize the objects but have anomia, i.e., difficulty in attaching appropriate verbal labels to objects (e.g., syringe = "a thing for pushing medicine . . . an injector"), while the naming errors of bilaterally brain-damaged patients suggest that they have deficits in visual recognition and are therefore unable to appropriately name objects (e.g., microscope = "drill"). The finding of no impairment in right brain-damaged patients is most likely attributable to the ability of the intact left hemisphere to both recognize and name the line drawings.

In agreement with the finding that deficits in visual recognition of objects and line drawings are associated with bilateral damage, studies of commissurotomy patients also indicate that both hemispheres can recognize pictures, but only the left hemisphere can name them (Levy & Trevarthen, 1976; Levy, Trevarthen, & Sperry, 1972; Gazzaniga & Sperry, 1967). Further, remediation efforts with left brain-damaged global aphasics, who have marked deficits in both verbal comprehension and production, suggest that they can successfully be taught a pictorial communication system (Gardner, Zurif, Berry, & Baker, 1976). Their success is most likely attributable to the ability of the intact right hemisphere to recognize pictures.

In view of the findings with brain-damaged adults, our finding of no visual field asymmetry for pictures suggests that our task is tapping the visual recognition step rather than the name accessing step of picture naming. This is not surprising since tachistoscopic presentation limits the time available for visual recognition, but given successful recognition, the subject then has unlimited time to retrieve the appropriate name of the object. In agreement with the present findings, using tachistoscopic presentation of line drawings with normal adults, Kimura and Durnford (1974) and Kimura (personal communication) report no visual field asymmetry in tasks involving either recognition or naming of line drawings. It is possible that if reaction time, rather than accuracy in naming line drawings was measured, a RVF (left hemisphere) advantage would be obtained, as was reported by McKeever and Jackson (1979).

In summary, the present study clearly shows different laterality patterns for the naming of words versus pictures in normal adults. A left hemisphere advantage was found for the naming of words and no asym-

metry was found for the naming of pictures. These findings are consistent with reports in the neurological literature that picture- and word-naming deficits are dissociable, and that the visual recognition step in picture naming tasks is disrupted by bilateral lesions.

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