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Hemispheric Specialization for Reading

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Behavioral laterality tasks with linguistic stimuli were used to assess the differential processing efficiencies of the cerebral hemispheres in right- and left-handed adults. Findings from a lateralized lexical decision task with concrete nouns supported Zaidel's (1983) ''direct access'' model of hemispheric functioning. A dual task consisting of oral and silent reading indicated that the right hand was significantly more disrupted than the left during unimanual finger tapping; however, some bilateral interference was observed. Taken together the findings suggest that although the left hemisphere was relatively more efficient, the right hemisphere was dynamically involved in the reading process. © 2000 Academic Press

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Although the human brain acts as an integrated whole, each of the two cerebral hemispheres is thought to have an advantage for the processing of certain types of information. For example, in at least 90% of the population, the left hemisphere is primarily responsible for speech expression and reception. Proficient reading also depends on a normally functioning left hemisphere; however, predominance does not imply exclusivity. As detailed below, there is now substantial evidence that the right hemisphere is also actively involved in the processing of certain aspects of written information. The purpose of the present study was to extend this research in order to evaluate right-hemispheric participation in lexical and narrative reading in an adult population of right- and left-handed individuals.

As first demonstrated in studies with commissurotomy patients, the right

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hemisphere has some linguistic competence. When processing written material, the right hemisphere is thought to access the meaning of words ‘‘directly’’ from orthography without intermediate phonological decoding (Bogen, 1985; Zaidel & Peters, 1981), whereas the left hemisphere is specialized for phonological and grammatical processing (see Zaidel, Clarke, & Suyenobu, 1990). As Chiarello, Senehi, and Nuding (1987) stressed, these findings do not challenge the view of left-hemisphere dominance for most linguistic functions, but rather suggest that ‘‘this superiority may be restricted to particular word classes or semantic operations’’ (p. 43). In this view, the right hemisphere typically supplements left-hemisphere language processing (Zaidel, 1985).

Despite the evidence from split-brain patients, the normal, nondisconnected right hemisphere’s ability to recognize a string of letters as a word is still a controversial issue (see Joanette, Goulet, & Hannequin, 1990). The more recent research supporting such competence comes from functional brain-imaging observations showing that normal adults experience equal bilateral activation in the temporal cortex during single-word reading (e.g., Gross-Glenn, Dunra, Yoshi, Barker, Chang, Apicella, Boothe, & Lubs, 1987; Hynd, Hynd, Sullivan, & Kingsbury, 1987; Posner, Petersen, Fox, & Raichle, 1988). Visual half-field studies have also shown that for normal right-handers, the right hemisphere is as competent as the left provided that words are relatively short (three- and four-letter) concrete nouns (Bruyer & Janlin, 1989; Bub & Lewine, 1988; Day, 1977, 1979; Eviatar, Menn, & Zaidel, 1990; Searleman, 1977; Zaidel, 1986).

In the current study, two behavioral laterality tasks with linguistic stimuli were used to assess the differential processing efficiencies of the two cerebral hemispheres. A *lateralized lexical decision task* (go/no-go paradigm with concrete nouns and two types of nonwords) was employed to compare two models of hemispheric processing (Zaidel, 1983; Zaidel, White, Sakurai, & Banks, 1988). The ‘‘direct access’’ model emphasizes relative hemispheric specialization for a task. This model assumes that each hemisphere is capable of processing the stimuli presented directly to it, although with unequal levels of efficiency. Alternatively, callosal connectivity is the focus of the ‘‘callosal relay’’ model (callosal transfer of the stimulus when projected to the nonspecialized hemisphere).

In order to distinguish between the two models, linguistic stimuli in each visual field are paired with each response hand (the contralateral advantage test, Fig. 1). If the left hemisphere is preferentially specialized for processing concrete nouns, the ‘‘callosal relay’’ model predicts faster responses with the right hand (for both visual fields) relative to responses with the left hand. However, if the right hemisphere processes its own sensory input, then the ‘‘direct access’’ model would predict a faster response time with a left visual field (LVF)–*left hand* pairing relative to a LVF–right hand pairing (Zaidel et al., 1988; see also Bertelson, 1982).

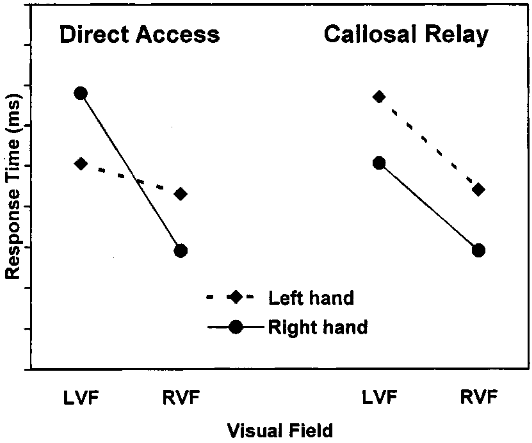

FIG. 1. Two patterns of behavioral laterality effects with linguistic stimuli that are indicative of either independent hemispheric processing (‘‘direct access model’’) or exclusive left-hemisphere specialization (‘‘callosal relay model’’) for a given task (modified from Zaidel et al., 1988).

One criticism of the visual half-field procedure is that it is artificial and of limited relevance to normal language functioning, i.e., the data do not refer directly to the issue of the right hemisphere’s participation in natural reading. Therefore, we also employed a more ‘‘ecologically valid’’ laterality task (*dual-task paradigm*) which required participants to read different passages of narrative text during speeded right and left index finger tapping.

Oral reading and speaking in general (Dalby, 1980; Hellige & Longstreth, 1981; Hiscock, Antoniuk, Prisciak, & von Hessert, 1985; Hiscock, Cheesman, Inch, Chipuer, & Graf, 1989; Singh, 1989) have been well established since the first experiments by Kinsbourne and Cook (1971) and Hicks (1975) as activities that interfere with the right hand more than the left. The left hemisphere typically controls speech production and distal movements of the right hand and the right hemisphere controls distal activity of the left hand. Because each hemisphere is thought to have limited processing capacity, the interference effect is typically explained as due to an overload of demands for processing resources in one hemisphere (Kahneman, 1973). Alternatively, Kinsbourne and Hiscock (1983) advanced the principle of functional cerebral distance to explain why two independent tasks interfere more with each other when both involve neural circuits in the same hemisphere (see Hammond, 1990).

In the dual task, the movement of the mouth while reading aloud may be a potential contaminating motor influence (Kosaka, Hiscock, Strauss, Wada, & Purves, 1993). Interference effects in oral reading tasks may also be due hemispheric specialization for *speech* rather than to the reading ‘‘per se’’ (Zaidel, 1983). In the present study it was possible to control for these influences by comparing dual-task interference while reading aloud *and* reading silently.

It is anticipated that our laterality findings will provide further support for the hypothesis that the ''normal'' right hemisphere participates in reading. It is predicted that the lateralized lexical decision task will reveal faster and more accurate performance on ipsilateral visual-field/response-hand pairings (''direct access'') relative to contralateral pairings. According to Zaidel (1983), and based on his work with split-brain and ''normal'' adults (Zaidel, 1985, 1986; Zaidel & Peters, 1981), this interaction demonstrates that both hemispheres can process concrete nouns, although not necessarily with equal competence.

In the dual task, it is predicted that for right-handers, reading aloud *and* silently will interfere with concurrent right-hand finger tapping more than left-hand performance. However, if the right hemisphere does process certain aspects of the narrative material, some left-hand tapping interference should also be observed, particularly in the silent reading condition. Furthermore, evidence suggests that left-handed individuals may show the opposite pattern, with concurrent speech disrupting left-hand performance more than the right hand (Orsini, Satz, Soper, & Light, 1985; Simon & Sussman, 1987; van Strein & Bouma, 1988). As such, if reading depends on the same hemisphere as speaking in certain left-handers, then left-greater-than-right-hand dual-task interference should be observed.

Method

Participants

Thirty-eight volunteer senior-level undergraduate and graduate students from the University of Calgary participated in this study. Males ($n = 19$, mean age = 28.9, right-handed = 14) and females ($n = 19$, mean age = 29.8, right-handed = 14) were matched on the basis of chronological age and hand preference. Participants were assessed for hand preference using a modification of Annett's (1970) performance tasks. They were asked to reach for and subsequently use 10 objects such as a comb and pen placed midline in front of the subject. All participants were native English speakers and had normal or corrected-to-normal vision. Each volunteer participated individually in one experimental session of approximately 40 min duration. The two laterality tasks were counterbalanced between participants. The stimuli and general procedure for both tasks in this study have been outlined previously in detail (see Waldie & Mosley, 2000).

Stimuli and Procedure

Lateralized lexical decision task. In brief, the stimulus items were a series of 60 four-letter capitalized concrete frequent nouns (Brown, 1984; Spreen & Schulz, 1966) and 60 four-letter capitalized nonwords. Each of the 60 concrete nouns generated either 30 pronounceable orthographically regular nonwords (e.g., DEKS for ''DESK'') *or* 30 nonwords that were orthographically irregular and visually similar to the concrete nouns (e.g., GAOT for ''GOAT''). All stimuli were black on a light-gray background and were 1 cm in height and 4 cm in length.

Participants were instructed to look at a central fixation dot (3000 ms) which would be followed by a single, horizontally presented word/nonword (116 ms) displaced 3° (inside edge) from central fixation to the right visual field (RVF) or left visual field (LVF). The participants were told that concentrating on the central fixation point increases accuracy. The adults were instructed to press the middle of the keyboard spacebar with their index finger as quickly and as accurately as possible if the stimulus was a word but to refrain from responding if it was not a word. Each participant responded with one index finger on one block of trials (30 words and 30 nonwords) and responded with the index finger of the opposite hand on the other block of trials (different 30 words and 30 nonwords). The starting response-hand was counterbalanced between participants.

Dual-task paradigm. The dual-task procedure consisted of speeded right and left finger tapping alone (two unimanual single-task baseline conditions), during the oral reading of different narrative passages (two dual tapping–oral-reading conditions), and during the silent reading of different narrative passages (two dual tapping–silent-reading conditions). Standardized comprehension questions also followed each of the silent reading conditions in order to monitor task engagement. As suggested by Hiscock et al. (1989), the requirement to recall textual content increases the cognitive demands of the reading task and enhances the amount of interference generated. The narrative passages and comprehension questions were taken from the Classroom Reading Inventory (Level 9; Silvaroli, 1982). Each participant performed the six conditions in a different predetermined random order.

The computer mouse, placed midline in front of the participant, was employed as the tapping apparatus. The participants were instructed to tap with an index finger quickly and steadily (McFarland & Ashton, 1978) and were required to keep their forearm in contact with the tabletop in order to prevent whole-arm movements. Software was designed to collect finger-tapping rate (number of taps/second) and tapping variability (mean of the standard deviations of the intertap interval: release time + depression time associated with each individual tap). The variability of intertap intervals is thought to reflect the consistency of an internal time-keeping mechanism (Sergent, Hellige, & Cherry, 1993).

Oral-reading performance (number of words read during the 14 s of each reading condition) was scored from audio tape recordings. For the two silent-reading conditions, the participant was asked to point to the last word read immediately following the condition and prior to the comprehension questions. The paragraphs were long enough so that a subject could not finish them before the end of the 14-s reading period.

RESULTS

The Statistical Package for the Social Sciences (SPSS) software was utilized for all analyses of variance (ANOVAs). Tests of simple effects involving within-subjects factors were conducted using the appropriate error term for repeated measures. An alpha level of $p < .05$ was used for all tests of statistical significance. Pairwise comparisons were analyzed with *t*-tests for paired samples with a Bonferroni adjustment to the alpha level. Unless otherwise stated, only statistically significant findings are reported.

Lateralized Lexical Decision Task

Response times for correct responses to words. Median correct reaction times (in milliseconds) were subjected to a Sex (Male, Female) × Hand Preference (Left-handed, Right-handed) × Visual Field (LVF, RVF) × Response-Hand (Left, Right) ANOVA, with Visual Field and Response-Hand as repeated measures. The analysis revealed a Visual Field main effect [*F*(1,

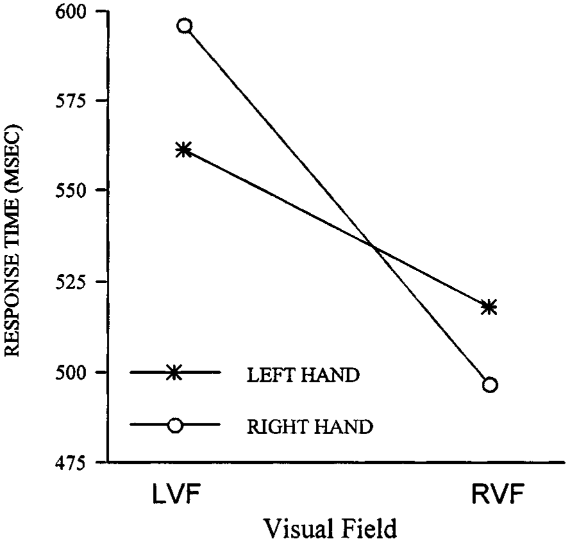

FIG. 2. The average of the median reaction times of the Right and Left Response-Hands as a function of Visual Field.

34) = 26.06, $p < .001$], with faster correct responses to words presented to the RVF (left hemisphere) (M = 507.27 ± 111.88) than the LVF (right hemisphere) (M = 578.62 ± 137.28).

The Visual Field × Response-Hand interaction was also significant, [$F(1,34) = 7.98$, $p = .008$]. As shown in Fig. 2, faster response times occurred for Left Response-Hand/RVF words (M = 518.02 ± 129.83) compared to Left Response-Hand/LVF words (M = 561.06 ± 150.56), [$F(1, 37) = 8.48$, $p = .006$]. Simple effects tests further showed that during Right-hand responses, response times were faster when words were presented to the RVF (M = 496.52 ± 118.75) than to the LVF (M = 596.18 ± 173.36) [$F(1, 37) = 18.36$, $p < .001$].

Sensitivity analysis. Nonparametric signal detection analysis (A') (an index of sensitivity; Grier, 1971) was used to obtain estimates of subjects' ability to discriminate words from nonwords in each visual field. The following formula was used:

$$A' = .5 + [(y - x)(1 + y - x)/4y(1 - x)],$$

where x is the probability of a false positive and y is the probability of a hit (responding to a word). Values for A' range from 0 to 1, where 1 is perfect performance.

Participants were able to discriminate between words and nonwords significantly better when the stimuli were presented to the RVF (M = 0.78 ± 0.09) rather than to the LVF (M = 0.73 ± 0.06), $F(1, 37) = 6.07$, $p = .024$].

These results, which are consistent with reaction-time data, show that the latency effects cannot be attributed to a speed–accuracy trade-off.

Percent error responses to nonwords. In order to examine response bias, the types of errors made in each Visual Field/Response-Hand combination were analyzed. Errors were classified as False Negative (failing to respond to a word), False Positive I (incorrectly responding to an orthographically regular nonword), or False Positive II (incorrectly responding to an orthographically irregular nonword). The percentage error data were subjected to a Sex × Hand Preference × Error Type by Visual Field × Response-Hand repeated-measures ANOVA.

The analysis revealed a significant Error Type main effect [$F(2, 66) = 60.06$, $p < .001$] as well as a significant Error Type × Visual Field interaction (Fig. 3), [$F(2, 66) = 13.41$, $p < .001$]. Failing to respond to a word (False Negative error) occurred significantly more often in the LVF ($M = 32.71\% \pm 10.4$) than in the RVF ($M = 19.52\% \pm 13.84$), [$F(1, 36) = 44.03$, $p < .001$].

Furthermore, simple effects tests by each visual field showed that when stimuli were presented to the *LVF* [$F(2, 72) = 51.42$, $p < .001$], significantly more False Positive II errors were made ($M = 49.9\% \pm 16.62$) compared to False Negative ($M = 32.71\% \pm 10.4$) [$t(36) = 4.63$, $p < .001$] and False Positive I errors ($M = 18.75\% \pm 10.23$), [$t(36) = 10.65$, $p < .001$]. As

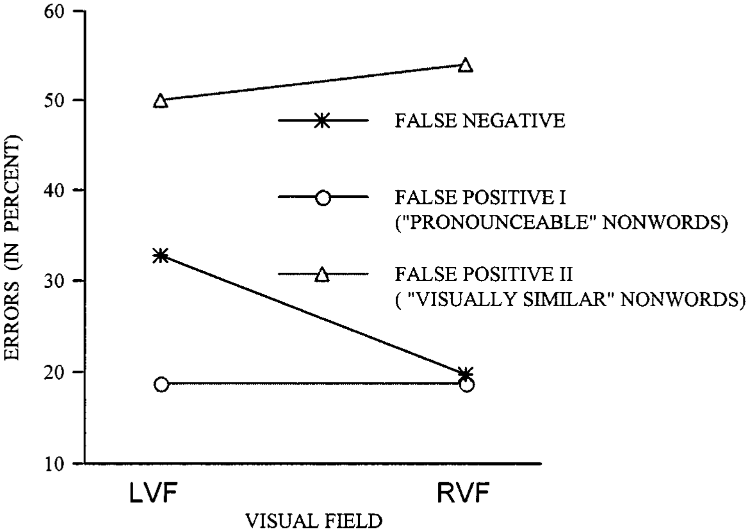

FIG. 3. The mean percentage of errors corresponding to the rejection of Words (False Negative errors), responding to ‘‘Pronounceable’’ Nonwords (False Positive I errors), and responding to ‘‘Visually Similar’’ Nonwords (False Positive II errors) as a function of Visual Field.

well, more False Negative errors were made than False Positive I errors [$t(37) = 5.85$, $p < .001$].

Similarly, when stimuli were directed to the *RVF* [$F(2, 72) = 79.31$, $p < .001$], significantly more False Positive II errors ($M = 53.96 \pm 17.03$) were made relative to both False Negative ($M = 19.52\% \pm 13.84$) [$t(36) = 8.83$, $p < .001$] and False Positive I ($M = 18.72\% \pm 9.6$) errors [$t(36) = 13.42$, $p < .001$].

Dual Task

Baseline finger-tapping rate. Baseline tapping data were subjected to a Sex × Hand Preference × Tapping Finger (Right, Left) ANOVA with Tapping Finger as the repeated measure. As expected, the Tapping Finger main effect was significant [$F(1, 34) = 39.59$, $p < .001$], with all participants tapping more quickly with the right index finger ($M = 5.5$ taps/s $\pm$ 0.78) than the left ($M = 4.8$ taps/s $\pm$ 0.83).

Interference. Interference is expressed as a proportional change score. An interference index was computed using the formula

$$Y = 100(\mathrm{ST} - \mathrm{DT})/\mathrm{DT},$$

where ST represents tapping performance in the single-task (baseline tapping) condition and DT represents dual-task (concurrent reading) tapping performance. A positive score indicates a decrement in tapping rate, whereas a negative score indicates an increment in tapping rate (in percentages). Interference means (standard deviations) are shown in Table 1.

The interference data were subjected to a Sex × Hand Preference × Tapping Finger × Task (Oral, Silent) ANOVA, with Tapping Finger and Task as repeated measures. The analysis showed a significant Tapping Finger main effect [$F(1, 34) = 9.64$, $p = .004$], with slower tapping with the Right finger ($M = 9.40\% \pm 6.58$) during concurrent reading than the Left finger ($M = 3.74\% \pm 6.60$). No other main or interaction effects were significant.

TABLE 1

Mean Interference (Percentage Decrease in Right- and Left-Finger-Tapping Rate); Standard Deviation and Mean Variability in Seconds (Standard Deviation of the Intertap Interval) of Each Tapping Finger as a Function of Dual-Task Condition

	Right finger		Left finger	
	Silent reading	Oral reading	Silent reading	Oral reading
Mean interference	08.78% (8.1)	10.02% (7.2)	03.89% (7.0)	03.60% (7.6)
Mean variability	47.84	30.06	45.87	56.99

Finger-tapping variability. Finger tapping variability (i.e., timed depression and release periods associated with each individual tap) was assessed to determine whether right and/or left finger tapping becomes more variable (less consistent) during concurrent reading.

A Sex × Hand Preference × Tapping Finger × Task (Baseline, Oral, Silent) repeated-measures ANOVA was performed on the variability data. Although there were no significant main or interaction effects, Table 1 shows some noteworthy trends. Silent reading increased Right finger tapping variability *slightly* more than Left tapping, which is consistent with the direction of asymmetry shown in the rate interference data. In contrast, concurrent Oral reading increased *Left* finger-tapping variability substantially more than Right finger tapping.

Reading performance analysis. The mean number of words read was subjected to a Sex × Hand Preference × Tapping Finger × Task ANOVA with Tapping Finger and Task as repeated measures. The analysis revealed no significant main or interaction effects. Earlier research (reviewed in Kinsbourne & Hiscock, 1983) has similarly found that the performance outcome of verbal tasks is not a sensitive indicator of lateralized interference.

DISCUSSION

The purpose of this study was to examine hemispheric specialization for reading in right- and left-handed adults as reflected by their performance on tasks requiring the processing of visually presented single nouns and nonwords (*lateralized lexical decision task*) and the processing of narrative material (*dual-task procedure*). Both paradigms take advantage of the fact that finger movements are controlled by the contralateral cerebral hemisphere. Kinsbourne and Hiscock (1983) classified the visual half-field procedure as an ‘‘input interference measure’’ in that the greatest competition between stimuli occurs at the perceptual stage of information processing and the dual-task paradigm as an ‘‘output interference measure.’’ It was therefore of interest to compare the findings from the two tasks to determine if they would yield similar laterality patterns in the same experimental sample.

Lateralized Lexical Decision Task

As noted previously, we tested two contrasting models of laterality. According to the ‘‘callosal relay’’ model, the left hemisphere is exclusively specialized for the processing of linguistic stimuli. For example, when a stimulus is presented to the LVF (right hemisphere) the information would need to be relayed transcallosally (right to left) before processing could begin. The response time would then be greater if the left hand rather than the right was required to respond because of transcallosal (left-to-right) relay of the motor command. This model therefore requires a significant RVF- *and* right hand-advantage. In contrast, according to the ‘‘direct access’’ model the right hemisphere is capable of processing the stimuli presented directly to it. Thus when a letter string is directed to the right hemisphere, left-hand responses would be quicker than right-hand responses because relay of the motor command would not be necessary (Measso & Zaidel, 1990).

In the current study, the presence of a significant Visual Field × Response-Hand interaction (superimposed on a RVF advantage) is consistent with the ‘‘direct access’’ model. For all participants, the left hand responded more quickly than the right following LVF word presentation, indicating that the right hemisphere was involved in the lexical decision making, albeit more slowly than the left hemisphere.

We examined the latency data further to determine Crossed–Uncrossed Differentials (CUD; Bashore, 1981). The data showed a significant negative left-hand CUD. That is, left-hand responses were generally faster for RVF word presentation (‘‘crossed’’ condition) than for LVF presentation (‘‘uncrossed’’ condition). Right-hand responses were similarly faster for RVF word presentation (‘‘uncrossed’’ condition) relative to the LVF (‘‘crossed’’ condition), resulting in a significant positive right-hand CUD. This pattern of findings has been proposed to reflect the right hemisphere’s use of a ‘‘slow’’ callosal channel and the left hemisphere’s use of a ‘‘fast’’ callosal channel (Braun, Sapin-Leduc, Picard, Bonnenfant, Achim, & Daigneault, 1994). It also suggests at least some transcallosal relay of linguistic information from the right to the left hemisphere prior to processing. Taken together, the latency findings are compatible with current ‘‘interhemispheric cooperation’’ theories of reading, whereby the left hemisphere is still ‘‘dominant’’ but the right hemisphere is dynamically involved (Mohr, Pulvermuller, & Zaidel, 1994).

With regard to the error data, our findings showed that participants were significantly more likely to withhold a response to a word (false negative) when the right rather than the left hemisphere received the stimulus. Chiarello, Nuding, and Pollock (1988) interpreted their similar finding as probable support for the ‘‘direct access’’ model, with the right hemisphere being a conservative lexical decision-maker. Each cerebral hemisphere is generally thought to have access to an independent lexicon (a hypothetical dictionarylike store that contains acquired lexical knowledge) based on evidence that the disconnected right hemisphere can comprehend written material. Therefore, if the right hemisphere is processing the stimuli presented to it (and assuming that the right hemisphere has a smaller lexicon than the left hemisphere), many real words which are not represented in the lexicon would be incorrectly categorized as nonwords (Eviatar et al., 1990).

In contrast to the asymmetry observed in the false negative data, false *positive* errors were made equally across visual fields (i.e., no significant visual field advantage). This was expected for pronounceable nonwords based on previous findings (Bradley & Garrett, 1983; Chiarello & Nuding, 1987; Mohr et al., 1994). However, we modified the typical lexical decision paradigm by also including orthographically irregular nonwords (visually close to half of the concrete nouns, e.g., BAOT–BOAT, PAER–PEAR) to assess whether visual field differences would occur with this type of nonword. We found that although there were more errors overall with these stimuli, they occurred relatively equally across visual fields.

Dual-Task Findings

Of particular interest in this study was whether the dual-task findings would correspond with those from the lateralized lexical decision task. Despite the advantages of the visual half-field technique (in terms of being noninvasive and easily interpretable), the procedure has limited relevance to normal reading in that it can only assess the role of the right and the left hemispheres in processing single words. As we have confirmed, processing single concrete nouns appears to be within the capacity of the right hemisphere but earlier research indicated that it is poor with abstract nouns (Day, 1977), function words (Chiarello & Nuding, 1987), and words requiring phonetic processing (Zaidel & Peters, 1981). As such, reading relatively long narrative passages would be expected to result in greater right-hand than left-hand disruption in tapping rate, indicating left-hemisphere predominance in processing written material. Some left-hand tapping interference was also expected due to the right hemisphere's involvement in the spatial (Hecaen & Albert, 1978) and semantic-thematic (Zaidel & Schweiger, 1984) aspects of reading.

As predicted, the right tapping finger was significantly slower than the left during both concurrent oral *and* silent reading. Furthermore, silent reading resulted in greater left-handed tapping interference than during oral reading, suggesting more right hemisphere involvement when the task did not require overt motor articulation. The involvement of the right hemisphere may be particularly important when reading silently, whereby word patterns are ‘‘recognized at a glance, gestalt fashion, without being further analyzed‘‘ (Zaidel & Schweiger, 1984).

The analysis of finger tapping variability during concurrent reading revealed a noteworthy (but not significant) trend toward asymmetrical interference in tapping consistency. As expected, the right finger tapped less consistently during silent reading. In contrast, disruption during oral reading occurred only when participants tapped with their *left* finger. This was contrary to expectation (see Kee, Morris, Bathurst, & Hellige, 1986; Todor & Kyprie, 1980) and suggests that the right hemisphere may be involved in the temporal regulation of speech. That is, increased variability during dual-task performance may be ascribed to disruption in the timing of neural processes that control the integration of speech and motor activity (Kelso, Tuller, & Harris, 1983). Further evidence for a possible role of the right hemisphere in the timing of linguistic expression can be observed following damage to the right hemisphere in regions equivalent to Broca's area (see Ardila, 1984). Expressive language deficits (e.g., problems with articulation, intonation, and prosody) are common in these patients and many do not show significant functional recovery. Alternatively, increased left-hand tapping variability during oral reading may result from limited access to a noncortical (possibly cerebellar) time-keeping mechanism (Sergent et al., 1993).

CONCLUSIONS

Taken together, the findings from the two tasks are consistent. The lateralized lexical decision task data indicate that the right hemisphere does contribute to at least the perceptual identification of concrete nouns as well as different nonword forms. The interference observed while tapping with the left hand while reading silently suggests that some right-hemisphere activity was also involved in the output stage of information processing.

There is controversy, however, as to whether interference effects in reading are due to motor involvement (as measured by hand preference) rather than language dominance (Simon & Sussman, 1987; van Strein & Bouma, 1989). It has been argued that less interference is observed in the nonpreferred tapping hand because of poorer baseline tapping performance. In the present study, however, the left tapping hand was significantly slower than the right during baseline tapping, regardless of hand preference. Furthermore, in a study by Kosaka et al. (1993), right-handed patients who had their speech dominance determined by carotid Amytal testing were evaluated with a dual-task procedure similar to the present paradigm. Patients with left-hemisphere speech showed greater inference effects in the right hand while reading, whereas patients with right-hemisphere speech showed greater interference in the left hand. Because all participants in their study were right-handed, it was concluded that interference effects are more closely related to language rather than to motor dominance.

In the present study we included both right- and left-handed male and female adults and tested for possible differences in hand preference and sex. Analyses revealed no significant effects of either variable. A few studies have found greater left-than-right interference in left-handers during current speech (Orsini et al., 1985; Simon & Sussman, 1987; van Strein & Bouma, 1988) and, in general, left-handers tend to show more symmetrical representation of language processing than right-handers (Hecaen & Ajuriaguerra, 1964; Herron, 1980). It is possible that handedness effects may have been observed in the present study had our sample size of left-handers ($n = 10$) been larger. On the other hand, because only about 30% of normal left-handers have speech represented bilaterally or in the right hemisphere (Satz, 1979), the present findings are not unexpected.

In sum, our combined findings further our understanding of the ''normal'' profile of right- hemisphere reading, using relatively straightforward, noninvasive tasks. The findings also have important implications for research with certain populations (e.g., dyslexia, dysphasia, mental retardation, and Down's Syndrome) where hemispheric specialization is presumed to be atypical.

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