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Shape-Set Dimensionality vs Structural-Distance Effects in a Patient with Category-Specific Visual Agnosia

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The shape identification performance of a patient with category-specific agnosia for biological objects (E.L.M.) was investigated. E.L.M.'s ability to remember the association between visual shapes and computer-screen locations was assessed. All shape sets comprised exemplars that differed along a single diagnostic dimension. Two shape sets shared values on nondiagnostic dimensions, whereas a third set had differences on a redundant second dimension. E.L.M. significantly benefited from information contained in the redundant second dimension indicating that he can extract object information concerning multiple visual dimensions. We propose that E.L.M.'s problem involves disambiguating exemplars that are closely located in multidimensional shape space.

Introduction

Brain damage can selectively impair the visual identification of certain categories of objects while sparing others. Some researchers have proposed that such category-specific deficits emerge because of differences in the visual similarity of exemplars comprising different object categories (e.g., Humphreys, 1996). Although we agree that visual similarity is an important constraint on what can be identified by patients with category-specific deficits, the exclusive use of line drawings to elucidate the role of visual similarity is problematic. The difficulty is that the primitives of the forms depicted by line drawings are unspecified. Because we cannot specify which shape primitives allow *normals* to distinguish between a drawing of a cat and that of a dog, it is impossible to say what mechanisms, if any, fail at the level of structural shape processing in patients who display category-specific deficits for such drawings.

Arguin, Bub, and Dudek (1996) rectified this problem by using simple computer-generated blobs with well-defined underlying shape dimensions (Fig. 16).

Single-dimension sets were generated by producing shapes with equally spaced values along a single visual dimension (e.g., different degrees of curvature or elongation). Conjunction sets were generated by combining two stimulus dimensions. For every shape in a conjunction set there is another

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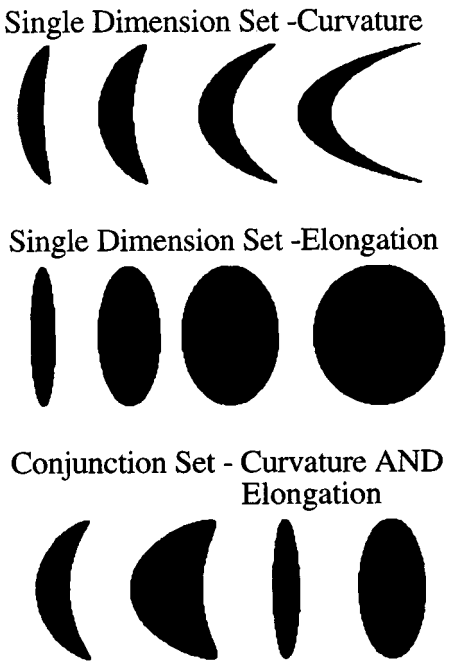

FIGURE 16

shape that has the same value on one dimension but differs on a second dimension. Thus, in order to disambiguate any given shape from the other three, values on *both* critical shape dimensions must be processed.

Dixon, Bub, and Arguin (1997) replicated Arguin et al. (1996) The patient E.L.M. was sequentially presented with exemplars from a single dimension or a conjunction set. On learning trials, each of four shapes were presented in different computer screen locations (top, bottom, left, right). On test trials, a single shape was presented center-screen and E.L.M. was asked to name its former location. E.L.M. made 4.7% errors on the single dimension set, but 41% errors on the conjunction set in Fig. 16.

E.L.M.'s vastly superior identification performance on single dimension sets can be accounted for in two ways. The first postulates that temporal lobe damage limits the amount of attention that can be devoted to extracting visual-dimension information. When E.L.M. can focus all of his limited capacity of attention on a single dimension and gate irrelevant dimensions (Kruschke, 1992) his performance is relatively good. When E.L.M. must divide this depleted capacity over multiple dimensions (as in conjunction set) his performance suffers dramatically. E.L.M. appears to inappropriately devote all of his attention to extracting information on only one of the two diagnostic dimensions.

Alternatively, E.L.M. could have normal attentional gating abilities, but

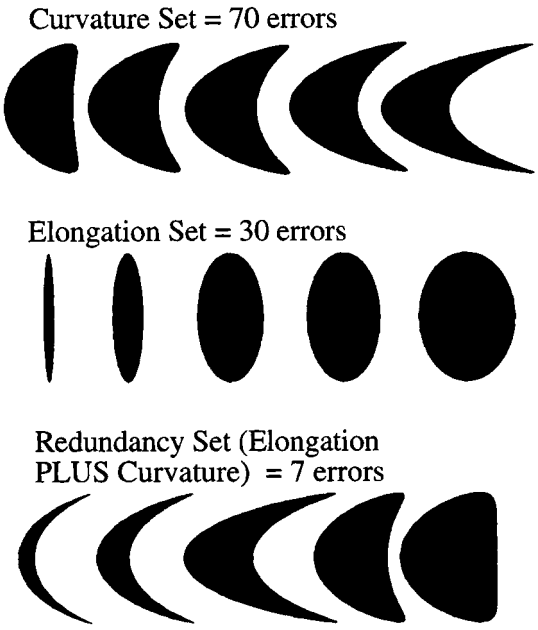

FIGURE 17

an abnormal propensity to confuse objects that are stored close together in a multidimensional shape space. For single-dimension sets, E.L.M. can compensate for this abnormality by appropriately gating irrelevant dimensions and focusing his attention on the appropriate dimension. However, when exemplars share values along multiple dimensions (i.e., conjunction sets), this attentional gating strategy is ineffective and his performance suffers because of the close proximity of objects sharing visual features.

A simple experiment was designed to distinguish between these alternatives. Three shape sets were produced in which exemplars differed along a single diagnostic dimension. Two shape sets shared values on nondiagnostic dimensions, while the third set had different values on a redundant second dimension (Fig. 17). If E.L.M. can only attend to a single dimension, the redundant information on the second dimension should not help him. If, E.L.M.'s errors are determined by visual distance, however, then the shapes in the redundant set will be easier to disambiguate because exemplars are spaced further apart in shape space than exemplars in sets sharing values on nondiagnostic dimensions.

Methods

Subject. E.L.M., born in 1928, suffered a stroke that caused bilateral damage in areas 21 and 37 of the temporal lobes and left him with category-specific recognition deficits. See Arguin et al., (1996) for a full description of this patient.

Stimuli. Curvature set: five shapes with unique values on curvature but common values on elongation. Elongation set: five shapes with unique values on elongation but common values on curvature. Redundancy set: five shapes that combined the values of the curvature and elongation sets (Fig. 17).

Procedure. On learning trials, shapes of each quintuplet were sequentially presented at preassigned locations for a duration of 2 s. On test trials, shapes were centrally presented, and E.L.M. was asked to point to that shape's learning-trial location; shapes remained on screen until E.L.M. responded. Ten learning trials (two of each shape) were followed by 10 test trials, with this pattern repeated until 120 test trials had been completed.

Results

The redundant set (7 errors) was significantly better identified than either the curvature set (70 errors) ($\chi^2 = 41.92$, $p < .001$) or the elongation set (30 errors) ($\chi^2 = 14.23$, $p < .001$).

Discussion

In the redundancy set, each of the five shapes could be disambiguated by attending to values on either curvature or elongation. Importantly, these exemplars are easier to disambiguate if one can integrate values on both dimensions. E.L.M.'s significantly superior performance on the redundancy set contradicts the notion that E.L.M. can only extract from memory knowledge concerning a single visual dimension. In contrast, it supports the notion that what gets confused in E.L.M.'s memory are shapes that share many visual features. In the two standard, single-dimension sets, shapes have different values on the diagnostic dimension but share values on other dimensions (e.g., all the elongation shapes are uncurved). In the redundancy set, shapes have different values along multiple visual dimensions. Thus, E.L.M.'s errors are constrained by visual similarity. In contrast to studies using line drawings of objects, by using computer-generated shapes with specifiable properties, we are in a position to operationalize visual similarity in terms of the number of shared values across multiple shape dimensions.

Searching for Targets in Left and Right Visual Fields

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We report two experiments investigating the hemispheric specialisation of mechanisms that search for visual stimuli. In the first experiment, participants search for an inverted T set among a homogeneous set of upright T's. In the second experiment,

the target was a domino block set among similar blocks which had been inverted. The results of both studies show that error rate was linearly related to display size in the left but not the right hemisphere. We suggest that the results are consistent with the lateralized extraction of target–distractor relationships.

Introduction

One factor known to affect the speed of visual search is the similarity between targets and distractors (Duncan & Humphreys, 1989). When a target can be readily discriminated from distractors it is searched at a rate which is independent of display size (in parallel) but when discrimination is difficult, reaction times increase linearly as more distractors are added (in serial). In the present study, we examined whether visual similarity between targets and distractors is computed equally across the cerebral hemispheres.

Previous research provides evidence for cerebral differences in the conduct of visual search. For example, the hemispheres differ in their abilities to inspect the global and local properties of displays (e.g., Martin, 1979), and in their sensitivity to targets of a particular spatial frequency (Sergent, 1982). In addition, reaction times and the probability of a correct detection of a target have been shown to vary as a consequence of position in the visual field (the detection gradient) with each hemisphere producing a different detection gradient (Efron & Yund, 1996).

In the present study, we report on two experiments (with a further two briefly reported in the Discussion). In all cases, the experiments involve the search for a target set among homogeneous distractors, maximizing both the grouping between nontargets and the differences between targets and distractors.

Method

Each experiment followed the same basic method, which we adapted from a standard visual search task. In a standard visual search task, RT is correlated with display size and displays are presented until a response is made. However, in the present series of studies, display duration was fixed at 200 ms and display size (distractors or distractors plus target) ranged from two to four. Given the difficulty of the task and the restricted exposure duration, we maximized error rates (rather than RTs). As error rates and RTs are correlated in standard visual search tasks (e.g., Efron & Yund, 1996), we assumed that a parallel search would be reflected in an error rate which remained unchanged across display size but that a serial search would lead to an increasing error rate as display size increased. Each subject performed 432 trials with the same number of present and absent trials, presented in equal numbers in the right and left visual fields as well as bilaterally. Six male and female participants performed in each experiment; all were strongly

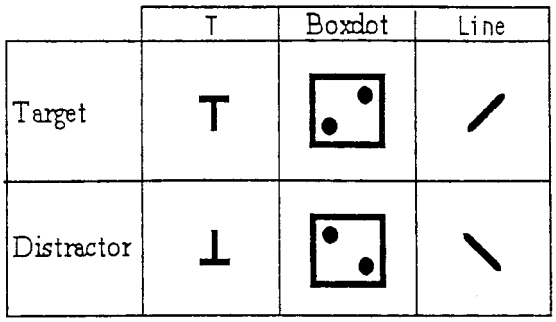

FIG. 18. Target and distractor for each stimulus type.

right-handed. The task was to respond by pressing one of two computer keys depending on whether a target had (''present'') or had not been (''absent'') presented. The pairs of targets and distractors used in each study are shown in Fig. 18. Stimuli appeared black with a luminance of 0.5 cd/m^2 on a white background of luminance 75 cd/m^2. The experiments were constructed using Superlab and run on a Macintosh 650.

Results

Mean error rates (with standard errors) for each experiment are presented in Figs. 19a and 19b. In all cases, the error rates we refer to are summed across present and absent trials. For the sake of simplicity, we present a combined analysis from both experiments as each experiment produced data which differed only in overall error rate, $F(1, 22) = 7.45, p < .05$, and the extent of the display size effect, $F(2, 44) = 4.25, p < .05$. The critical interaction was between display size, visual field, and simulus type, $F(2, 44) = 3.66, p < .05$. For both stimulus types there was evidence of a linear search strategy in the RVF–LH (100 and 85% of variance accounted for by linearity in the T and box-dot stimulus, respectively) but no evidence of any effect in the LVF–RH (0% of variance accounted for by linearity in both types of stimulus).

Discussion

The results demonstrate a consistent pattern of errors across stimulus types: error rates increased linearly with display size in the RVF–LH but not in the LVF–RH. These results are consistent with a serial search strategy being employed by the left hemisphere but not by the right. The nonlinear patterns of error is consistent with the idea that search is affected by the similarity relations between items operating in the right hemisphere.

The distinction between serial and parallel processing is notoriously difficult to make. It might be argued that displays of two items represent a special

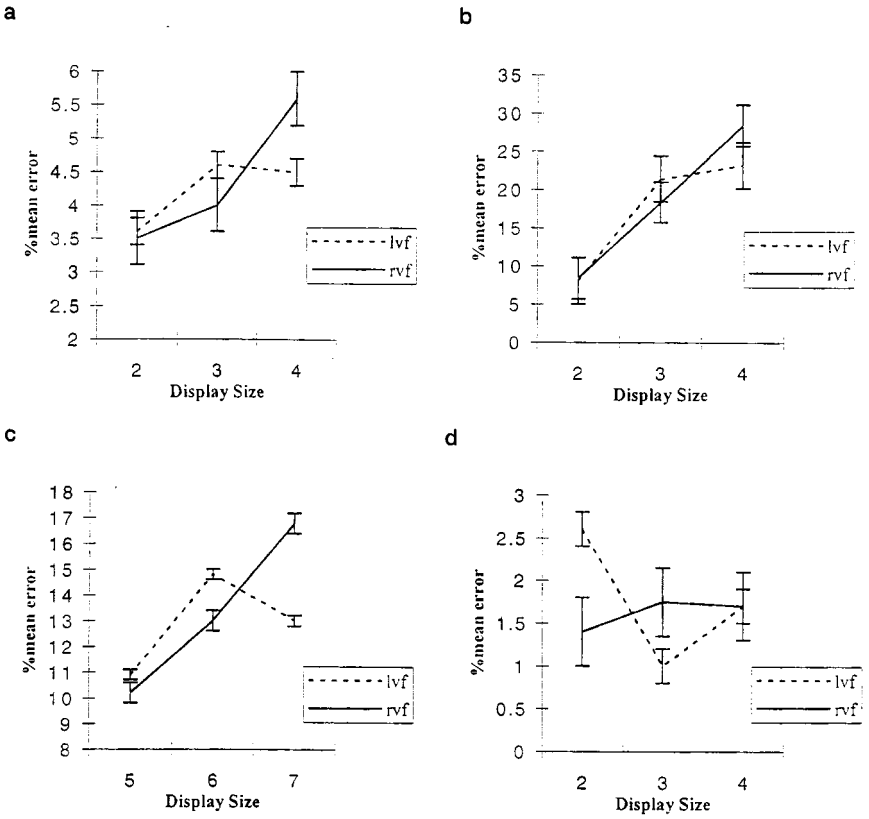

FIG. 19. Percent mean errors (with standard errors) for performance in each stimulus condition across Visual Field and Display Size: (a) T stimulus (2, 3, 4 items), (b) box dot stimulus, (c) T stimulus (5, 6, 7, items), and (d) line stimulus.

case in that the visual search task reduces to a same/different decision. Therefore, in a further experiment we showed a different group of participants displays of five, six and seven ''T'' items (in addition to a block which replicated our original experiment of 2, 3, and 4 items). In addition to replicating our basic hemispheric effect with displays of 2, 3, and 4 items, we also found a significant interaction with displays of 5, 6, and 7 items ($F(2,22) = 6.12, p < .01$). The interaction confirmed a nonlinear search function in the right hemisphere but a linear search function in the left hemipshere which accounted for 97% of the variance (see Fig. 19c).

In all of the experiments reported so far, the items were chosen so that they segmented from each other and would not readily organize to form an object at a larger spatial scale. When we used displays which maximized between item relations (e.g., left oriented oblique line distractors with a right

oriented oblique line target) we found no interaction between display size and visual field. We attribute the failure to find any differences in this condition to low-level perceptual processes creating emergent features which were easy to detect by both hemispheres (see Fig. 19d).

In conclusion, our results are consistent with different search processes in the left and right hemispheres. The left hemisphere uses a serial strategy to compare each item to stored memory. In contrast, the right hemisphere searches by computing similarity across all items in the visual field.

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Rhyme Judgments in a Case of Primary Progressive Aphasia: A Precurser to Phonological Alexia

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Many cognitive neuropsychological evaluations of fluent primary progressive aphasia (PPA) have been documented, but the nonfluent form of PPA has been underinvestigated. A cognitive neuropsychological investigation of a nonfluent patient (NL) was conducted. NL demonstrates intact spoken and written word–picture matching, lexical decision, semantic access, irregular word reading, and phonemic discrimination (assessed by minimal phoneme pairs). In contrast, nonword reading and rhyme-monitoring are impaired. NL's constellation of deficits suggested the beginnings of phonological alexia. We propose that in the early stages of PPA, rhyme-monitoring provides a more sensitive indicator of subtle phonological deficits than same–different judgments of minimal phoneme pairs.

Introduction

Primary Progressive Aphasia (PPA) refers to a degenerative neurological disease process characterized by progressive deterioration of language in the absence of generalized cognitive impairments. Patterns of language impair-

ments in PPA may vary. However, impaired word-retrieval is the hallmark feature (Mesulam, 1987).

The fluent form of PPA (i.e., semantic dementia; Hodges, Patterson, Oxbury, & Funnell, 1992) is characterized by fluent speech, impaired comprehension, and preserved repetition but an underlying degradation of semantic memory. THe nonfluent form is characterized by anomia, phonemic paraphasias, and impaired repetition, but preserved comprehension. Using a mixture of fluent and nonfluent patients, Westbury (1995) found a variety of impairments involving reading.

Two routes of word reading have been proposed. A lexico-semantic route accesses lexical items via semantics. A phonological route computes pronounciation directly from orthography. Damage to the semantic route forces patients to use the phonological route, resulting in surface dyslexia (e.g., pronouncing ''pint'' as though it rhymes with ''lint''). Damage to the phonological route spares irregular word reading, but impairs nonword reading.

Grossman et al. (1996) found evidence for impairments in phonological processing by having participants discriminate between same and different minimal phoneme pairs. Same–different judgments may pick up only gross deficits; detecting more subtle phonological impairments may require more sensitive tasks such as rhyme monitoring. In rhyming pairs, the initial phonemes of each word differ, while the latter phonemes are identical. Thus, unlike minimal pairs discrimination, rhyme-monitoring requires detection of shared phonology within words. Difficulties in rhyme-monitoring have been documented in patients with phonological dyslexia (Freidman & Kohn, 1990).

Our hypothesis was that early in the course of nonfluent PPA, subtle phonological processing deficits could be detected in the absence of semantic deficits.

Methods and Results

Participant. NL is a 74-year-old man diagnosed with nonfluent PPA. NL has experienced a slow deterioration in speech fluency and word retrieval abilities since June 1996 when he first noticed his speech becoming ''slow.'' An MRI (February 17, 1997) showed mild generalized cerebral atrophy while SPECT revealed bilateral hypoperfusion in the peri-sylvian region.

An Aphasia Quotient of 96.2 on the Western Aphasia Battery (Kertesz, 1982) was within normal range. Performance on the spontaneous speech, comprehension, repetition, naming, reading, writing, and praxis subtests were all normal. Impaired word-retrieval abilities were demonstrated on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983). No deficits in visuospatial ability, memory, or nonverbal reasoning were evident. NL presented with a nonfluent speech pattern due to a moderate dysarthria and apraxia of speech.

Cognitive neuropsychological testing using primarily the Psycholinguistic Assessments of Language Processing in Aphasia (Kay, Lesser, & Coltheart, 1992) was completed in October and December, 1997.

Spoken and written word–picture matching. NL correctly matched spoken words (40/40, 100%) and written words (39/40, 98%), to one of five black and white line drawings.

Semantic access. NL correctly formed 52/52 picture pairs (100%) in the 3 picture form of the Pyramids and Palm Trees Test (Howard & Patterson, 1992).

Lexical decision. NL was perfect in distinguishing 80 auditory real words from 80 nonwords (100%). For visual stimuli he made 4 false positives.

Phoneme discrimination. NL was perfect in make same–different judgments to 144 minimal phoneme pairs (e.g., lup–lup vs lip–nip or zud–zug) (100%).

Oral reading or irregular words. NL flawlessly read aloud 60 words with irregular sound to spelling correspondences (e.g., yacht, sew) (100%).

Oral reading of nonwords. NL was asked to pronounce 24 nonwords varying in length from 3 to 6 letters. NL correctly pronounced 17/24 words (71%).

Rhyming judgments. The *written* judgment task consisted of 116 pairs of written words (58 rhymes, 58 nonrhymes) from Kay et al. (1992) and Seidenberg and Tanenhaus (1979). Half of the pairs (29 rhymes, 29 nonrhymes) were orthographically similar (e.g., love/dove; mint/pint), half were orthographically different (dune–moon, foot–suit). NL correctly judged 35/58 pairs (60.34%). The majority (21/23, 91%) of his errors were false positives (saying that cost–boast rhymed). NL made significantly more errors when the pair was orthographically similar (e.g., pint/mint = 15 errors) than when the pair was orthographically different (e.g., toe–cow = 6 errors) ($\chi^2 = 3.86$, $p < .05$).

Auditory rhyme-monitoring consisted of the same word pairs. NL correctly judged 37/58 pairs correctly (63.78%). Again the majority (20/21, 95%) were false positives. NL made 12 and 8 errors for the orthographically similar, and dissimilar sets ($\chi^2 = .8$, ns). A summary of NL's performance on written and auditory rhyme monitoring is summarized in Fig. 20.

Conclusion

NL demonstrates intact spoken and written word–picture matching, lexical decision, semantic access, and irregular word reading. In contrast his nonword reading and his rhyme-monitoring are impaired. For reading, NL uses the lexico-semantic route to read irregular words flawlessly but has difficulty when he must read or use the phonological route to pronounce nonwords.

NL's other notable impairment is in rhyme monitoring. Although NL will

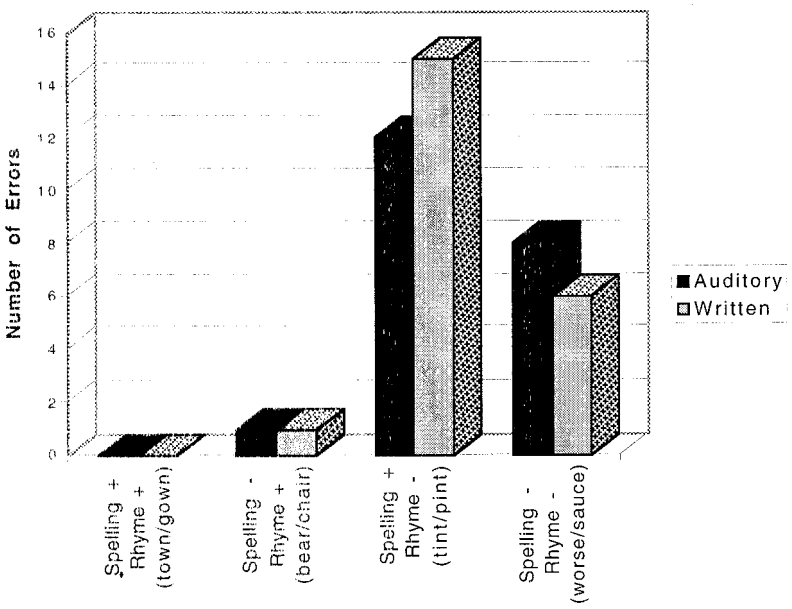

FIG. 20. Errors made on the rhyming task.

correctly judge pairs that rhyme (boat–coat, turn–learn) he makes a large number of false-positive errors (e.g., claim foot–toot rhyme). NL makes such errors both when judging auditory rhymes or when judging whether written word pairs rhyme. Despite problems in rhyme-monitoring, NL can flawlessly discriminate minimal phoneme pairs. We propose that in the early stages of nonfluent PPA, rhyme-monitoring difficulties are a more sensitive indicator of subtle phonological deficits than same-different judgments of minimal phoneme pairs. As such rhyme-monitoring difficulties may be a precursor to more severe deficits associated with phonological alexia. This study supports Grossman et al. (1996) in showing phonological processing deficits in nonfluent PPA.

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Complementarity of Cerebral Function among Individuals with Atypical Laterality Profiles

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Recent work has revealed that lateral preferences other than handedness are important correlates of the cerebral lateralization of higher functions. This paper investigates the nature of the complementarity of the processing of the verbal aspect of language and that of its prosodic dimension in individuals with unusual combinations of lateral preferences. We administered both linguistic and prosodic dichotic-listening tasks and laterality preference questionnaires to 47 individuals. Although most individuals exhibited the typical left-hemisphere-verbal and right-hemisphere-prosodic effects, footedness was the only preference that differentiated between different current models of complementarity. Correlations between scores on the prosodic and linguistic tasks were positive, and significantly higher for right-footed participants than for left-footed participants. Complementarity of cerebral function (the notion that each hemisphere subserves complementary functions) is the prototypical pattern of brain organization. The idea that the right hemisphere is specialized to perform nonverbal processing *because* the left-hemisphere preferentially deals with language processing is referred to as 'causal complementarity' (Bryden, Hécaen, & DeAgostini, 1983), and underlies some models of the development of cerebral laterality (see Corballis & Morgan, 1978; MacNeilage, 1991). Bryden articulated two alternative scenarios in addition to causal complementarity (Bryden, 1990; Bulman-Fleming & Bryden, 1998). His ''statistical-complementarity'' model is one in which the processes by which lateralization of various functions occur are independent of one other, and his ''bias'' model posits underlying anatomical

asymmetries as heavily influencing behavioral asymmetries. Each of these models predicts a different correlation between tasks tapping right-and left-hemisphere functions. The causal model predicts a negative correlation, the statistical model predicts a lack of correlation, and the bias model predicts a positive correlation. We report here the testing of 47 individuals selectively recruited because of their atypical laterality phenotypes, because recent work has suggested the importance of preferences other than writing hand to patterns of hemispheric specialization (Elias & Bryden, 1998; Elias, Bryden, & Bulman-Fleming, 1998).

Method

A screening questionnaire was administered to approximately 3500 undergraduates asking which hand they preferred for writing and for throwing and which foot they preferred for kicking. For this study, we attempted to include individuals with every possible combination of these three factors, though for the rarer combinations this was not possible (see Table 10).

All participants completed a handedness and a footedness questionnaire (see Elias, Bryden, & Bulman-Fleming, 1998). The eyedness of each participant was also assessed using a simple sighting task. Linguistic lateralization was assessed using the Fused Dichotic Words Test (FDWT) test described by Wexler and Halwes (1983), which has been validated with sodium amytal testing (Zatorre, 1989). Prosodic lateralization was assessed using the Emotional Words Test (EWT) described by Bryden and MacRae (1988). Every participant was given all tests in one session.

Participants' laterality data were dichotomized for each of the laterality measures, based on composite scores on the preference questionnaires. Dichotic-listening data were scored using the lambda index described by Bryden and Sprott (1981).

Results

As expected, most participants (39/47 = 83%) exhibited right-ear advantages (REA's) on the linguistic dichotic task, and left-ear advantages (LEA's) (38/47 = 81%) on the prosodic dichotic task. Two participants did not exhibit any ear advantage on the EWT (for subsequent analyses, one of these

TABLE 10
Classification of Participants by Writing Hand, Throwing Hand, and Foot Preference

	Left-writers		Right-writers	
	Throwing Hand			
Foot Preference	Left	Right	Left	Right
Left	13	0	2	5
Right	6	9	3	9

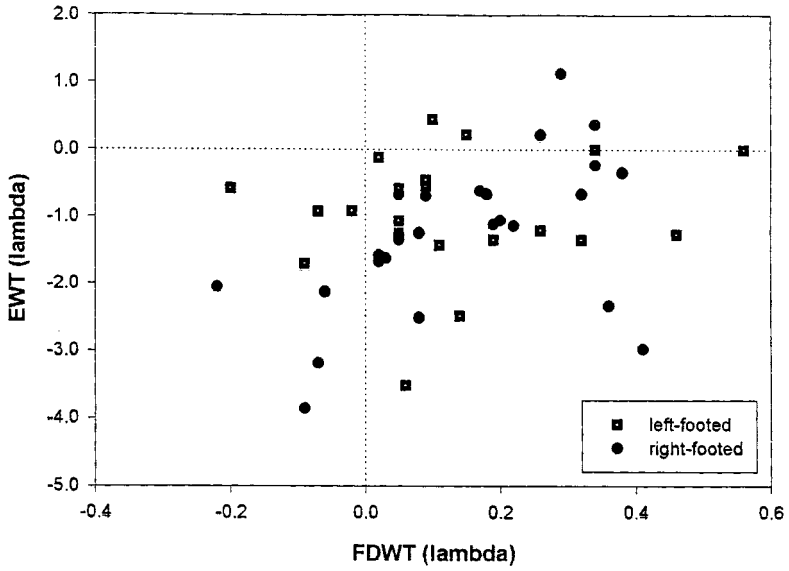

FIG. 21. Individuals' lambda scores on the linguistic dichotic-listening task (FDWT) versus lambda scores on the prosodic task (EWT). Positive values are indicative of REA's.

subjects was added to the REA group and one was added to the LEA group). There was a significant positive correlation between lambda scores on the FDWT and the EWT ($r = .308$, $p = .033$) (see Fig. 21). Most subjects (33/47 = 70%) exhibited the typical pattern of left-hemispheric linguistic dominance and right-hemispheric prosodic dominance, but none of the subjects exhibited the reverse pattern of hemispheric dominance. Instead, 9/47 (19%) of the subjects exhibited right-hemisphere dominance for both tasks, whereas 5/47 (11%) exhibited left-hemisphere dominance for both tasks.

To investigate whether an individual's pattern of linguistic and prosodic lateralization was related to his or her lateral preferences or sex, we compared the correlations between the FDWT and EWT lambdas for each sex, handedness (writing and throwing), footedness, and eyedness group. The correlations were generally very similar between the respective groups (ranging between $r = .246$ and $r = .327$), except for the two footedness groups. Lambda scores correlated strongly for right-footed participants, $r = .517$, $p = .008$, but not for left-footed participants, $r = .133$, $p = .564$, and the difference between the two correlations was highly significant by the Fisher r to z transformation ($z = 4.29$, $p < .001$).

Discussion

In the present experiment there was a significant positive correlation between laterality scores on the linguistic and the prosodic dichotic-listening

tasks. The majority of the participants exhibited the ''normal'' cerebral dominance pattern (left-hemispheric linguistic dominance and right-hemispheric prosodic dominance), but no participants exhibited the opposite pattern of cerebral dominance. Instead, subjects with ''atypical'' patterns of cerebral dominance appeared to exhibit a bias to process both types of information in either one hemisphere or the other.

The positive association between lateralization of linguistic and prosodic perception varied with the lateral preferences of the subjects. Right-footed participants exhibited a significant positive correlation between the dichotic tasks and left-footed participants did not. The finding that preferred foot may be a factor that differentiates patterns of cerebral lateralization is compatible with other recent studies that have shown footedness to be a better predictor of both the lateralization of linguistic and of affective aspects of language processing (Elias & Bryden, 1998; Elias, Bryden, & Bulman-Fleming, 1998).

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Case Alternation and Orthographic Neighborhood Size Effects in the Left and Right Cerebral Hemispheres

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Effects of cAsE aLtErNaTiOn and orthographic neighborhood size were studied in a lateralized visual lexical decision task with normal readers. A cost for high neighborhood size was observed on error rates. A case alternation cost occurred for response times and error rates, but only with right-hemifield stimuli. On error rates, the case alternation cost for right-hemifield stimuli was observed only with words but not with nonwords. We propose that case alternation disrupts a familiarity discrimination mechanism, which is either more effective in the left hemisphere or less affected by stimulation of the right hemisphere's more efficient visual processes.

Introduction

CaSe aLtErNaTiOn has long been known to disrupt visual word recognition relative to conditions where stimuli are presented in single (upper or lower) case (Mason, 1978; Smith, 1969). In the present experiment, we compared the effect of case alternation in a lexical decision task with right- and left-hemifield stimulations. The purpose was to test the hypothesis of an abstract orthographic representation system operating more effectively in the left hemisphere and of a form-specific system operating more effectively in the right hemisphere (Marsolek, 1995; Marsolek et al., 1992). This hypothesis predicts a greater cost for case alternation with left than right hemifield stimuli.

Another goal of this experiment was to examine the effect of orthographic neighborhood size (i.e., number of words of the same length as the target and that differ from it by just one letter) in conjunction with those of case alternation and visual field. With stimuli presented in central vision, the reading performance of normal readers is facilitated for words with many orthographic neighbors. Whether this result is affected by case alternation or whether it remains true for stimulation of either hemisphere has yet to be determined.

Method

Participants. Participants were 14 male or female graduate or undergraduate students. All were right-handed francophones.

Stimuli. Stimuli were 96 French words and 96 nonwords, all five letters in length. Half of the words had five or more orthographic neighbors (HN words) and the other half had only one (LN words). Word sets were matched

on lexical and bigram frequencies. Nonwords were pronounceable and were created by changing one letter of a real word.

Procedure. The experiment was conducted in two blocks within which each stimulus appeared once. In one block, items were printed in lowercase letters and in the other they were printed in CaSe aLtErNaTiOn. Block order was counterbalanced across subjects.

Targets were lateralized to the left (LVF) or right visual field (RVF) and were aligned 1.5 cm away from a central fixation appearing 750 ms before the target. Subjects indicated whether the target was a word or a nonword by pressing response keys assigned to each hand. Response key assignments were counterbalanced across subjects.

Results

Correct response times (RTs) and error rates were analysed as a function of stimulus case (lowercase vs case alternation), target type (HN, LN, nonwords), and hemifield (RVF, LVF).

Response times. Analysis revealed main effects of target type [$F(2, 24) = 28.07, p < .001$] and visual field [$F(1, 12) = 6.53, p < .05$]; RTs were shorter with words (HN or LN) than nonwords and with RVF than LVF stimuli. A case $\times$ hemifield interaction was also observed [$F(1, 12) = 12.84, p < .003$], with a significant cost of case alternation occurring only with RVF stimuli [$F(1, 12) = 5.31, p < .05$].

Error rates. Results showed a main effect of target type [$F(2, 24) = 12.38, p < .001$], with more errors for HN words than for LN words or nonwords. A case $\times$ target type $\times$ hemifield interaction was also found [$F(2, 24) = 4.25, p < .05$]. No effect of case occurred with LVF stimuli. However, case alternation increased error rates to HN and LN words displayed to the RVF. There was no effect of case alternation with RVF nonwords.

Discussion

The main result of the present experiment is that a case alternation cost is found on lexical decision performance only with RVF stimuli. This result is incongruent with the hypothesis of a left-hemisphere superiority in abstract orthographic processing and of a right-hemisphere superiority in shape-specific word representation. This hypothesis predicts that disruption of the visual form of written stimuli would have a greater effect on the right than the left hemisphere. The present observations are directly opposed to this prediction.

In previous investigations, Besner (1983) found that the effect of case alternation on lexical decision performance was greater for words than for nonwords. From this result, he proposed that lexical decision recruits a familiarity discrimination mechanism that operates on the visual shape of the stimulus. Because subjects already have a stable representation for words, case

alternation disrupts their processing more than for nonwords. This familiarity decision mechanism seems to be largely responsible for the case alternation effects in the present experiment. Thus, case alternation affected error rates for words but not for nonwords. In addition, a cost of case alternation was found only for the left hemisphere, which may be assumed as the main responsible for lexical representation.

The absence of a case alternation cost in the right hemisphere may be explained in either of two ways. One possibility is that, because of the right hemisphere's relatively poor capacity for lexical representation, its familiarity discrimination mechanism is less effective than that of the left hemisphere. Alternatively, the right hemisphere's superior visuo-spatial capacity may protect it against stimulus manipulations which alter its shape. In line with this latter interpretation, Bryden and Allard (1976) have found that letter recognition is less affected by font alteration with LVF than RVF displays.

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Temporal Control of Voicing in Parkinson's Disease and Tardive Dyskinesia Speech

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Basal ganglia disorders are associated with a set of clinical syndromes characterized by various motor disabilities. The hypocinetic syndromes, of which Parkinson's disease (PD) is the prototype, are mainly marked by a paucity and a slowing down of motor function, while the hypercinetic disorders, and among them tardive dyskinesia (TD), are mainly distinguished by involuntary and abnormal movements. The abnormal speech motor control is part of the parkinsonian semiology, but little is known about the specific speech alterations in TD. In the present acoustic study, the motor

control capabilities of PD and TD subjects were compared in a sentence production task. Three temporal measures were used: sentence duration, total number of pauses, and ratio of total pause duration to total sentence duration. Analyses of data revealed a significant decrease of voiceless speech periods in the two clinical groups, relative to controls, but most markedly in TD subjects. These data indicate that TD is not only characterized by involuntary movements but also by a disturbance of voluntary motor control. The results also revealed that, in spite of their clinical and neurophysiological differences, PD and TD also share similar patterns of deficits.

Introduction

Parkinson's disease is the outward sign of a neurovegetative disorder affecting the substantia nigra and is also associated with a depletion of nigrostriatal dopamine. This hypocinetic disorder is characterized by numerous motor symptoms affecting not only limb movements and posture but also verbal motor function. Hypocinetic dysarthria associated with PD is revealed by disturbances affecting various components of speech production such as articulation and prosody. Besides these abnormalities, some studies have also shown a phonation control deficit characterized by the presence of continuous voicing and by the reduction of the normal duration of pauses within speech segments (Cohen et al., 1993; Fraïle et al., 1994; Kent & Rosenbek, 1982).

PD remains the most studied syndrome among the wide range of motor syndromes related to a dysfunction of the basal ganglia. Tardive dyskinesias are a type of hypercinetic motor syndrome related to the effects of chronic neuroleptisation on the basal ganglia. These pathologies are known to be associated with involuntary movements in the orofacial area, but few studies have dealt with voluntary movements, and in particular with the motor control of speech. To our knowledge, no research has been conducted to compare the patterns of pathological desintegration of the speech in PD and TD, with the exception of a study that showed that PD and TD patients exhibited similar patterns of prosodic deficits (Fraïle et al., 1996).

The purpose of the present research was to evaluate whether the disturbances in phonation control previously documented in PD patients were also present in PD patients. The investigation of possibly similar speech abnormalities in these two clinical populations would add greater precision not only to the semiology of TD but also concerning the role of subcortical structures in the control and the organization of voluntary movement.

Methods

Subjects. Three groups of Canadian French-speaking subjects participated in this study. The Parkinsonian group was composed of 21 nondemented and nondepressed patients with no other neurological disorder than idiopathic Parkinson's disease (mean age = 67.1 ± 6.06 years). A group of 6 psychiat-

ric patients with iatrogenic Tardive Dyskinesia also participated in the present study (mean age = 68 ± 3.69 years). The control group was composed of 11 normal subjects with no neurological or psychiatric illness (mean age = 67.4 ± 4.78 years).

Apparatus and procedure. Subjects were tested individually in a quiet room and their productions were recorded on a SONY TCD5M tape recorder with a Realistic PZM microphone placed 12 cm from the mouth. For the TD group, speech samples were first digitized on a MacIntosh IIci with an Audiomedia card and then transformed into a SIGNALYZE format (Keller, 1991). For the two other groups, speech samples were filtered, amplified, and then digitized on a MacIntosh IIci via a MacAdios speech A/D converter, using SIGNALYZE software. Random comparisons showed that digitization mode had no effect on the extracted acoustic values.

Subjects were asked to reproduce verbally three different neutral sentences presented under three linguistic modes, i.e., interrogative, imperative, and declarative intonation. Stimulus sentences were prerecorded and presented auditorily one at a time and in random order.

Results

Digitized productions were analyzed in order to evaluate timing aspects of speech. For each sentence, three temporal measures were computed: total sentence duration, total number of pauses, and ratio of total pause duration to total sentence duration. Pauses were defined as voiceless segments and absence of voicing was confirmed, when necessary, by a wideband spectrogram.

Data obtained for the three stimulus sentences were averaged and separate ANOVAs were then conducted for each measure using a Group (3) × Mode (3) design with repeated measure on the last factor. Analysis for sentence duration (Fig. 22) revealed only a main effect of Mode ($p < .001$). Other analyses, conducted on transformed data (Figs. 23 and 24), only showed a main effect of Group for number of pauses ($p < .001$) and for ratios ($p = .003$). For both measures, post hoc analyses indicated that all groups differed from one another (all p's $< .05$). These observations suggest that the mean number of pauses and their relative duration are lower for TD than for PD subjects. The speech of PD subjects, in turn, is also characterized by a lower number of pauses and shorter relative duration of pauses than controls.

Discussion

The results of this study showed that TD subjects exhibit a significant disturbance in the control of pauses and voicing in an evaluation setting closely approximating a natural language situation. This disturbance, characterized by a significant reduction of voiceless periods in speech, resembles that observed with PD subjects but is, however, more pronounced. In these

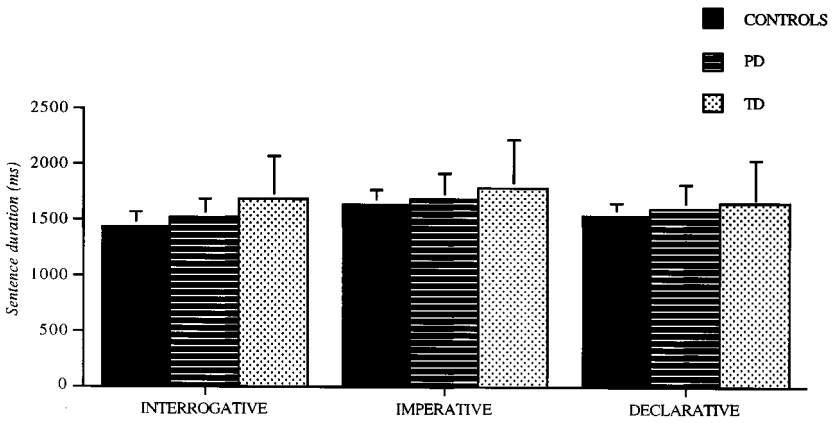

FIG. 22. Sentence duration for each linguistic mode (means and *SD*).

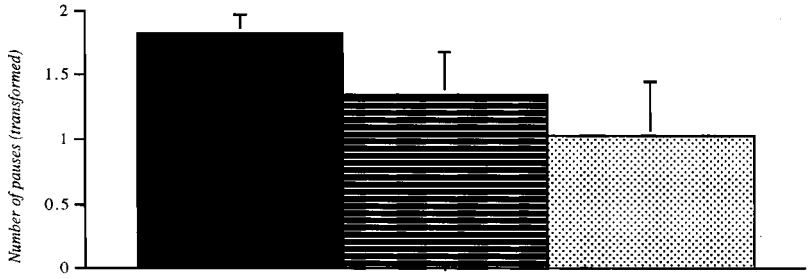

FIG. 23. Number of pauses—all linguistic modes combined (means and *SD*).

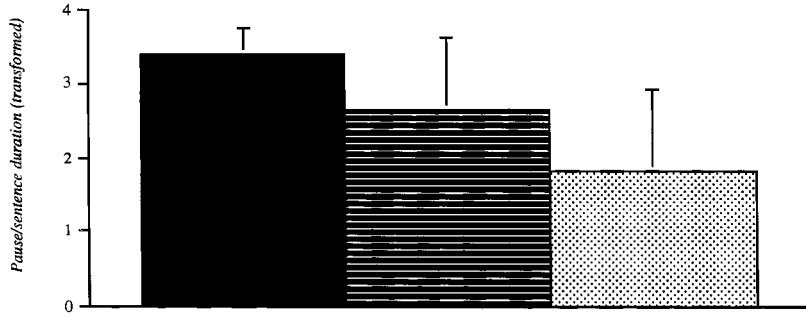

FIG. 24. Ratio of total pause duration to total sentence duration—all linguistic modes.

two clinical groups, this disturbance appears in the absence of abnormality at the global speed level as reflected by the total duration of the sentences that were produced.

The data suggest that in a speech production condition requiring complex and continuous sequences of varied movements, PD and TD subjects have difficulties with the temporal organization of these movements. These documented disturbances of motor control capabilities could reflect a disorder affecting the inhibition of laryngeal activity. It is also possible that the decrease in transitions between phonemes and words is ultimately a way to bypass a problem in movement initiation, with more or less continuous upholding of activation to avoid reinitiation. More generally, the similarities of patterns in PD and TD subjects suggest that the affected basal ganglia, by perturbing the dynamic interactions within the neural networks, result in motor deficits that could reflect the deterioration of common central mechanisms.

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Right Hemifield Superiority in Reading and Attentional Factors

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An attentional bias toward the right side could play a role in the right hemifield superiority over left hemifield in reading tasks. We tested this hypothesis with the cueing paradigm in normals. Our results showed that a letter string (word or nonword) presented in the left hemifield is better identified following a spatial cue in the same side, compared to a condition where the cue is in the right side. No difference was obtained when the letter string was presented in the right visual hemifield. This result is in favor of maximal attentional ressources allocated in the right hemifield in reading.

Introduction

Letter strings are better identified when they are presented in the right visual hemifield (RVH) than in the left visual hemifield (LVH). This right hemifield superiority is very robust, specifically for words (Beaumont, 1982). Among the explanations of the phenomenon, there are the direct access from RVH to the left language-dominant hemisphere or an attentional preference toward RVH because of the reading direction (Bryden & Mondor, 1994).

We tested the attentional hypothesis in normals using the spatial cueing paradigm (McCann, Folk, & Johnston, 1992; Posner, 1980; Sieroff & Posner, 1988). In the present experiment, a spatial cue was presented in one hemifield followed by a letter string (word or nonword) in the same hemifield (valid condition) or in the opposite hemifield (invalid condition). The letter string was tachistoscopically presented and had to be identified; accuracy of report was measured. The attentional bias hypothesis means that less attentional ressources are allocated to the left hemifield. This lower level in the attentional gradient should be easy to modulate by a spatial cue, which can increase the attentional level (valid) or decrease it (invalid). If maximal resources are systematically allocated to the right hemifield in reading, the spatial cue should have a smaller effect on this side. Also, we used different types of cues because they may have a differential effect according to the stimulus type. Some experiments show that, although word letter strings are better identified with a cue indicating the size of the whole letter string than with a cue indicating the size of each individual letter, cueing effect could be different with nonwords (Sieroff, Auclair, & Gatheron).

Method

Twenty four right-handed students (of mean age 21) participated to the experiment.

Letter strings were 160 familiar five-letter words and 160 five-letter illegal nonwords, composed of the same letters as words but in a scrambled order. They were printed in 18 font Courier in lower case.

The spatial cue was made of two horizontal bars (plain or five-dashed), one above and one below the letter string and of same length (2° visual angle). The distance between the fixation item and the nearest extremity of the cue was of 0.7° (see Fig. 25).

The experiment was run on a Macintosh 7100/66, using Psylab (Bub & Gum, 1988). Each trial began with a fixation cross for 500 ms, immediately followed by the spatial cue for 80 ms. Then, a letter string was presented for 40 ms for words and 80 ms for nonwords, immediately followed by a patterned mask. Valid trials (same side for cue and letter string) appeared 50% of the time. All factors were counterbalanced.

After fixating the cross, subjects were asked not to move the eyes. The

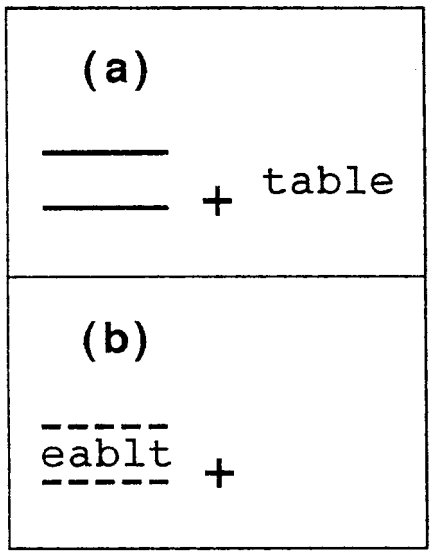

FIG. 25. Examples of conditions used in the experiment: (a) invalid trial, with word in the RVH and plain cue; (b) valid trial, with nonword in the LVH and 5-dashed cue.

task was to read aloud the letter string. A practice with 32 trials using other letter strings preceded the experiment.

Results and Discussion

The percentage of correctly identified letters in a letter string was calculated for each subject. We conducted a four-way ANOVA with Stimulus type (words, nonwords), Stimulus position (left, right), Cue position (left, right), and Cue type (plain, five-dashed) as within factors.

There was an effect of Stimulus position with best performance in RVH [$F(1, 23) = 63.5$; $p < .01$]. Although we used different duration times for words and nonwords in order to reduce the difference in accuracy of report, there was an effect of Stimulus type [$F(1, 23) = 18.6$; $p < .01$] with words better identified than nonwords (63.5%/57.1%). There was an interaction Stimulus position $\times$ Stimulus type [$F(1, 23) = 31.7$; $p < .01$]: the word superiority over nonword was significant only in the RVH [$F(1, 23) = 54.3$; $p < .01$] (see Table 11, part a). Cue type was also significant [$F(1, 23) = 4.3$; $p < .05$], showing that letter strings are better identified with plain cues than with five-dashed cues (60.9%/59.7%), for words as well as for nonwords. This result shows that indicating the letter size does not improve, in this condition, nonword identification.

Most importantly, cue position was significant [$F(1, 23) = 21.8$; $p < .01$]: accuracy of report was better with a left cue than with a right cue (61.6%/

TABLE 11
Percentage of Correctly Identified Letters, with Stimulus in the Left Visual Hemifield (LVF) or in the Right Visual Hemifield (RVF)

		LVF	RVF
(a)	words (40 ms)	49.2	77.9
	nonwords (80 ms)	49.0	65.1
(b)	left cue	*valid*	*invalid*
		51.1	72.1
	right cue	*invalid*	*valid*
		47.1	70.9

Note. (a) Performance for words and nonwords; (b) performance for all stimulus according to the side of the cue.

59.0%). Also, there was an interaction Stimulus position × Cue position [$F(1, 23) = 5.3$; $p < .05$]: Cue position was significant only with stimuli in the LVH [$F(1, 23) = 20.0$; $p < .01$]. Stimuli in the LVH were better identified with a cue in the LVH than with a cue in the RVH (see Table 11, part b). Cue position had no effect when the stimulus was presented in the RVH [$F(1, 23) = 2.8$; $p = .11$]. This factor did not interact with Stimulus type [$F(1, 23) < 1$; ns].

We obtained a stronger cueing effect in the LVH in reading. This effect could result from a normal gradient in the allocation of attentional resources in reading. A possibility is that the reader maximizes his attentional resources in the RVF; then, a spatial cue has a smaller effect on this side. Consequently, attentional factors may participate to the RVH superiority effect in reading. Finally, this right-sided attentional bias occurs for word as well as for nonword, thus it cannot explain the stronger word superiority effect in the right hemifield (direct access to the left hemisphere?).

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Implicit and Explicit Memory for Music in Old and Young Adults

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The effect of aging on implicit and explicit memory was studied with familiar and unfamiliar melodies. After a study phase, implicit memory was assessed with an affect task in which subjects rated their liking of each melody. Explicit memory was assessed with a recognition task. In the affect task, both old and young adults exhibited higher preference for studied than nonstudied unfamiliar melodies, whereas they equally liked familiar melodies. In the recognition task, familiar melodies were best recognized, with the elderly performing significantly worse than the young adults. The results support the notion that the aging process spares implicit memory but impairs explicit memory, extending the dissociation to the auditory nonverbal domain.

Introduction

Explicit memory, which refers to conscious recollection of past episodes, appears to be impaired by the aging process. In contrast, implicit memory, which is defined as a facilitation in performance attributable to the prior presentation of an episode, seems to be spared in the elderly. This dissociation has been established for visually presented verbal material; However, little is known about auditory memory processes and even less about nonverbal ones. In order to address this issue, we developed an experimental paradigm that allows one to compare explicit and implicit memory for melodies (Peretz, Gaudreau, & Bonnel, in press).

To assess implicit memory, we exploited the mere exposure effect (e.g., Zajonc, 1968l), which refers to the increase in liking of melodies as a result of a prior exposure. In a previous study including young university students (Peretz et al., in press), we found that a single prior exposure to unfamiliar melodies increased preference for these melodies, whereas familiar melodies were equally liked, irrespective of prior study. Conversely, with the recognition task, we found that the familiar melodies were best recognized. Thus, affect and recognition judgments were differently influenced by subjects' familiarity with the material, suggesting the operation of distinct implicit and explicit memory processes. In the present study, we exploited the same paradigm to investigate the effects of aging on implicit and explicit memory for music.

Method

Participants. Forty elderly (mean age 70.4) and 40 young adults (mean age 22.8) matched for sex and years of education participated. All participants were nonmusicians and raised in a French-speaking culture to ensure

a shared knowledge of popular music. Twenty elderly and young adults performed the affect task while the remainder (20 others in each age group) performed the recognition task.

Material and procedure. Eighty melodic lines taken from the popular repertoire served as stimuli. Two sets (A and B) were constructed so that each contained 20 familiar and 20 unfamiliar melodies. During the study phase, subjects heard 40 melodies—for example Set A—and indicated their familiarity for each excerpt. In the test phase, subjects heard the 40 studied melodies (for example, Set A) mixed with 40 nonstudied melodies (Set B). In the affect task, subjects rated their liking of each melody using a 10-point scale in which 1 meant ''I don't like it'' and 10, ''I like it a lot.'' In the recognition task, subjects had to identify the melodies which were heard in the study phase, using a 10-point scale in which 1 meant ''no, I certainly have not heard their excerpt in the prior test'' and 10, ''yes, I certainly have heard this excerpt in the prior test.''

Results

Affect task. An ANOVA with Group (young vs old) as the between-subjects factor, Presentation (studied vs nonstudied), and Familiarity (familiar vs unfamiliar melodies) as within-subjects factors was performed on the individual mean ratings obtained in the affect task. The analysis yielded a significant Group effect, $F(1, 19) = 5.4$, $p < .05$, indicating that the rating of elderly were higher for all melodies. The Group variable, however, did not enter into any significant interaction (all $F < 1$). Overall, familiar melodies were generally preferred, as revealed by the main effect of Familiarity, with $F(1, 19) = 76.92$, $p < .001$. More importantly, a significant Familiarity $\times$ Presentation interaction, with $F(1, 19) = 8.7$, $p < .005$, was obtained. Prior study increases liking of unfamiliar melodies, with $t(19) = 3.937$, $p = .001$, but it does not influence affect rating for familiar melodies ($t(19) = 0.84$). Thus, old and young adults displayed the same pattern of results in the affect task. (See Table 12.)

TABLE 12
Mean Ratings of Old and Young Adults in the Affect and Recognition Tasks as a Function of Prior Exposure and Familiarity with the Melodies

	Familiar melodies		Unfamiliar melodies	
	Presented	Nonpresented	Presented	Nonpresented
Affect				
Old	7.0	7.0	5.4	5.0
Young	6.4	6.4	4.7	4.1
Recognition				
Old	7.5	4.0	3.9	2.9
Young	7.8	3.2	5.8	3.3

Recognition task. The same ANOVA as the one computed on the affect data was performed on the recognition ratings. It yielded several interactions. There was a significant interaction between Familiarity and Presentation, with $F(1, 19) = 80.1, p < .001$, showing that recognition is better for familiar than unfamiliar melodies. The Group by Familiarity interaction also reached significance, with $F(1, 19) = 11.17, p < .01$, indicating that young adults gave generally higher scores than the elderly for unfamiliar melodies. Finally, as expected, there was an interaction between Group and Presentation, with $F(1, 19) = 11.17, p < .01$, revealing that young adults were generally more accurate than the elderly in discriminating the studied melodies from the nonstudied ones.

Conclusion

The results provide further evidence for preserved implicit memory in the presence of impaired explicit memory in the elderly. The originality of the present study lies in the use of an affect task to assess implicit memory in the elderly and in the use of melodies to assess memory.

The affect task has been shown to reflect the contribution of implicit as opposed to explicit memory in the visual domain (Seamon et al., 1995) as well as in the auditory musical domain (Peretz et al., in press). To demonstrate the link between the affect task and the use of implicit memory, manipulation of various factors, such as prior familiarity with the material, has been studied. Here we replicate the differential role played by familiarity on liking and recognition judgments in both young and old subjects. We add, however, a new dissociation variable that is related to the aging process. In doing so, we suggest that the domain of memorization is irrelevant. Aging appears to spare implicit memory and to impair explicit memory in the visual and auditory modality similarly, be it verbal or nonverbal material. This rather general finding is compatible with the notion that explicit memory is more effortfull than implicit memory, hence being more vulnerable to a resource limitation in the elderly.

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Callosal Function in Developmental Dyslexia: Evidence of Intact Hemispheric Sharing

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It has been suggested that developmental dyslexia may be associated with a deficit in interhemispheric relations (i.e., corpus callosum). We compared normal and dyslexic children on a visual hemispheric sharing task involving the detection of within-field and across-field letter matches. We predicted that while normal children would show a bilateral field advantage (BFA) (i.e., across-field advantage) in letter-matching, dyslexics would show a reduced or absent BFA, reflective of deficient interhemispheric functioning. Both groups, however, exhibited highly significant BFA's, the dyslexic BFA being no smaller than the control BFA. These results suggest that certain interhemispheric functions involved in hemispheric sharing are preserved in developmental dyslexics.

Introduction

Hemispheric sharing refers to the stimultaneous execution or management of different cognitive processes in the two cerebral hemispheres. Several studies using hemispheric sharing tasks in the visual modality have shown that, in certain situations, the division of perceptual information to be processed *across* the hemispheres can facilitate performance relative to when a single hemisphere must process the information. This facilitation is known as the Bilateral Field Advantage (BFA). To the extent that hemispheric sharing is managed by the corpus callosum, the BFA may be used as a means of assessing callosal function.

In the present study, we compared normal and developmental dyslexic children on a visual hemispheric sharing task previously shown to yield a BFA in normal adult subjects (Belger & Banich, 1992). Several studies using sensori-motor transfer or bihemispheric motor coordination tasks have suggested that developmental reading impairments are associated with callosal deficits (Fletcher et al., 1982; Moore et al., 1995). Since learning to read probably involves bihemispheric processes, we predicted that dyslexic children would show smaller BFA's than would normal children.

Methods

Subjects. Fifteen normal readers (9–11 years) and sixteen developmental dyslexics (9–14 years) participated in the study. All children were right-handed, native-French speakers. Both males and females were included, although both populations were predominantly male. All children had normal or corrected-to-normal vision and none had any known history of neurological injury or disease.

Procedure. Stimulus arrays of five letters positioned around a central fixation point were presented for 200 ms, one after another, on a computer screen placed 30 cm away from the subject. One letter appeared below the point in either left visual field (LVF) or right visual field (RVF), while four appeared above, two in each field. The bottom letter presented in a single field was presented 6.09° lateral from midline and 2.48° below fixation. The top two letters of the other four were presented 12.04° lateral from midline and 8.72° above fixation, while the bottom two were 12.04° lateral from midline and 4.19° above fixation. Each letter subtended a maximum of 2.86° horizontally and vertically.

All five letters differed, except in half of the trials, where the bottom letter was physically identical to one of the four above. Of these trials, half were matches contained within a single field (WITHIN condition), while half were matches in which one letter was presented in one field and the other in the other (ACROSS condition). The subject's task was to respond by using a key press after each stimulus array whether or not he or she detected a match.

Results

The number of omission errors were entered into a four-way analysis of variance (ANOVA) with Group and Age as between-subject factors and Field of bottom letter (LVF, RVF) and MatchType (across-field, within-field) as within-subjects factors.

The main effect of MatchType proved significant, $F(1, 27) = 8.186$, $p < .01$, reflecting an overall across-field advantage (see Fig. 26).

Contrary to expected, however, controls and dyslexics did not differ with respect to their across-field advantages. Nor was MatchType influenced differentially according to Age or Group and Age combined.

The main effect of Field also reached significance, $F(1, 27) = 6.398$, $p < .05$, revealing that, overall, error rate differed according to the field of presentation of the bottom letter (irrespective of MatchType). More matches were undetected when the bottom letter was presented in the LVF, suggesting a general RVF-advantage in letter-matching by physical identity. This advantage was not influenced by Group, Age, or the two combined.

A significant Field $\times$ MatchType interaction was also observed, $F(1, 27) = 7.254$, $p < .05$. More errors were committed when the bottom letter and its match were both contained within LVF (LVF WITHIN) than when they

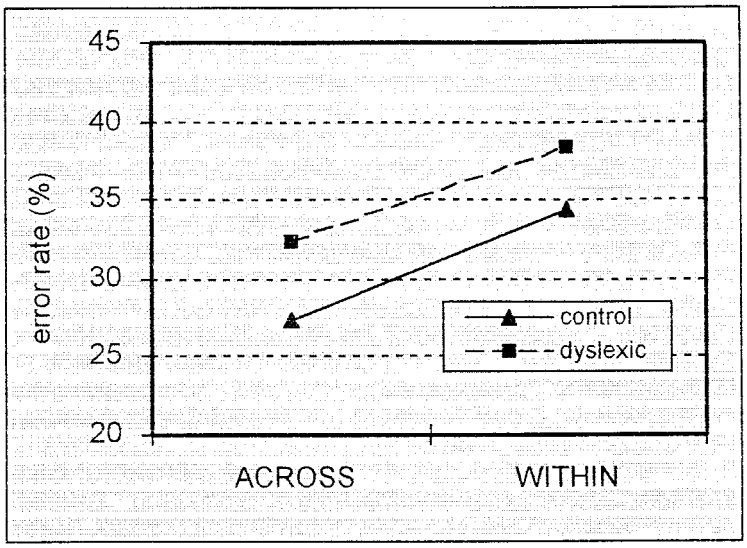

FIG. 26. Mean percent errors for controls and dyslexics in across-field and within-field letter-match trials. Both groups make less errors overall when the bottom letter and its match are spread across hemifields.

were both contained in RVF (Tukey *HSD,* $p < .05$), or when the match was spread across fields with the bottom letter in LVF (Tukey *HSD,* $p < .01$) or in RVF (Tukey *HSD,* $p < .05$). This interaction was not influenced by Group, Age, or the two combined.

Discussion

Like the normal adults in the previous study using a similar version of the same task (see Belger & Banich, 1992), both normal and dyslexic children showed robust BFA's, as evidenced in the across-field advantages in error rate. These BFA's furthermore did not differ between the two child populations, suggesting that dyslexic children are as capable of managing different simultaneous bihemispheric perceptual processes as are normal children. Such a capacity is likely made possible by the corpus callosum.

The one other study to our knowledge (Markee et al., 1996) using a hemispheric sharing task with (adult) developmental dyslexics also failed to find behavioral evidence of a deficit, but did find longer evoked potential interhemispheric transfer times for the same dyslexics on the same task. This finding, like ours, suggests that while certain interhemispheric functions may be deficient, certain other functions (i.e., those involved in hemispheric sharing) are preserved in developmental dyslexia. The sparsity of the literature on hemispheric sharing capacities in reading disorders, however, does not

permit us to rule out other possible explanations (i.e., the BFA may be a less sensitive indicator of the integrity of interhemispheric relations). Future studies investigating hemispheric sharing capacities would provide valuable insight to our understanding of callosal deficits and their implication in developmental reading disorders.

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Progressive Decline of Numerical Skills in Alzheimer-Type Dementia: A Case Study

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In the present study we report the progressive dissolution of numerical skills in EP, a former teacher of mathematics, suffering from an Alzheimer's-type dementia. The longitudinal examination revealed a pattern of decline different from previous reported cases. An initial impairment in arithmetical procedures was followed by an insidious decay in more basic numerical tasks with a selective preservation of arithmetical facts. The present investigation confirms the functional independence of facts and procedures within the calculation system. Moreover, these findings suggest that in the context of a general cognitive decline, specific numerical skills are more resistant to deterioration.

Introduction

The multicomponential structure of numerical skills has been established by numerous neuropsychological studies. Models of number processing and calculation postulate functionally independent mechanisms mediating numeral comprehension and production as well as distinct components devoted to calculation itself (for reviews see Dehaene & Cohen, 1995; McCloskey, 1992). The investigation of patients with degenerative brain diseases has greatly contributed to elucidating the functional independence of distinct cognitive functions. Furthermore, the orderly dissolution of numerical abili-

ties may reveal the underlying organization, i.e., degree of automaticity and level of representation, of different numerical competencies. So far, only two follow-up studies were described. Grafman et al. (Grafman, Kampen, Rosenberg, Salazar, & Boller, 1989) described a demented patient whose initial impairment was limited to facts and procedures in multiplication and division; the longitudinal examination showed a decline of both number processing and calculation skills. A second follow-up study of an Alzheimer's patient was reported by Diesfeldt (1993). In this case, number processing and procedural knowledge were spared despite a progressive impairment of arithmetical facts. In this study we described the progressive dissolution of numerical skills in EP, a former teacher of mathematics, suffering from dementia.

Case History

EP is a right-handed, 74-year-old woman with a degree in mathematics. She taught mathematics in high schools until retirement. In January 1995 she was referred to the Geriatric day-hospital in Milan for progressive spatial disorientation. A CT scan revealed an atrophy of the right temporal pole; the final clinical diagnosis was Alzheimer's-type dementia with focal onset.

Spontaneous speech was normal as was her performance in the Italian version of the Aachen Aphasia Test. EP performed in the average in the MMSE (25/30). Her verbal memory was relatively intact but, within visuospatial memory, she showed a selective deficit in processing spatial information. EP was tested over a period of 22 months (March 1995 to January 1997) during which her memory and intelligence progressively deteriorated; comprehension and speech production difficulties emerged only from May 1996.

Method

EP's numerical skills were assessed through the administration of a battery of tests. The first part of the battery included the following tasks: enumeration of pattern of dots, counting, odd/even judgment, number comparison. The second part evaluated transcoding abilities: i.e., repetition of number-words, reading and writing Arabic numerals and number-words, transcoding written number-words into Arabic and viceversa. The third part assessed calculation skills: i.e., recognition of arithmetical signs, alignment of multidigit operations, arithmetical facts retrieval, written and mental calculation, approximate calculation, number reasoning (composition of numbers by tokens of different value). Knowledge of cardinal facts (e.g., How many days in a week?) and numerical estimates (e.g., number of passengers in a bus) were assessed.

TABLE 13
EP's Percentage of Correct Response in Transcoding and Calculation Tasks over the Testing Sessions

TASK	T1	T2	T3
Transcoding			
Arabic[a]	100	100	91.5
Numberwords[a]	100	100	100
1 — one	80	80	80
one — 1	87	80	73
Arithmetical facts			
Addition	100	95	70
Subtraction	100	100	85
Multiplication	100	93	92
Division	100	97	50
Written calculation			
Addition	100	75	25
Subtraction	75	43.7	31.2
Multiplication	37.5	0	0
Division	83.3	33.3	16.6
Approximate calculation	100	62.5	25

[a] Reading and writing scores collapsed.

Results

Testing 1 (March 1995). EP's counting and number processing skills were preserved. Few errors occurred in written transcoding when syntactic processing was more demanding (e.g., 6010 — seicentodieci [six hundred and ten]). Her performance in arithmetical facts was fast and accurate (see Table 13). Mental calculation was in the normal range; in written calculation she solved correctly all addition but some difficulties emerged in subtraction. Performance in multidigit multiplication was severely compromised by a failure in applying the correct algorithm. No other problems emerged.

Testing 2 (March 1996). Verbal counting was preserved but EP failed occasionally in enumerating quantities. Number processing was intact except for some syntactic errors in written transcoding. Simple arithmetic scores were within the normal range. In mental calculation, EP showed difficulties with addition and subtraction with two-digit numerals while multiplication of two-digit numerals was better mastered. Her performance in written calculation indicated increasing difficulties in the execution of procedures: some additions were only partially solved, borrowing was often omitted, and she consistently applied the addition algorithm in multiplication. In the number reasoning task she had major difficulties in all trials requiring 4 tokens or more. All errors consisted in partial omission (e.g., 76 — 50 + 10 + 5 + 1). Her ability in numerical estimates was also impaired.

Testing 3 (October 1996). EP's counting skills were constrained to the most automatic sequences. Transcoding was relatively preserved even if her difficulty in the syntactic processing emerged also in reading Arabic numerals. Within arithmetical facts as well as mental calculation, multiplication was well preserved compared to all other operations. In written calculation, she could solve only problems where carrying or borrowing was not required. In all other cases she failed to execute the appropriate procedure or omitted parts of it. At this stage, she answered only few of the easiest trials in the number reasoning task. Her numerical estimates were highly implausible.

In January 97 her clinical conditions did not allow any reliable testing and impeded any further investigation.

Discussion

In this study we report the progressive dissolution of numerical skills in a patient with a remarkable premorbid mathematical knowledge. The first evaluation outlined a selective impairment of arithmetical procedures limited to multiplication and complex subtraction in the context of well preserved general cognitive abilities, number processing and simple arithmetic, and in absence of any verbal deficit. Albeit her severe spatial memory impairment, EP's difficulties in written calculation were not secondary to spatial problems but genuinely due to a failure in the execution of the appropriate algorithm (e.g., misapplication of carry procedure). These data support the functional dissociation between procedural and facts knowledge within the same operation. Longitudinal examination indicated increasing difficulties in written calculation as well as in less automatized tasks requiring the manipulation of numerical quantities (e.g., number reasoning, approximate calculation). Interestingly, retrieval of arithmetical facts was spared until the final examination, multiplication being the easiest operation. This finding supports the hypothesis according to which tables are likely to be stored as verbal associations thus being more automatized compared to other operation (Dehaene & Cohen, 1995). Moreover, within numerical semantics, she presented an unusual pattern of preserved magnitude and parity knowledge and impaired declarative knowledge and estimation ability. The present investigation, along with other evidence from demented patients, seems to suggest that numerical abilities may be differentially vulnerable to degenerative deterioration.

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Processing Time and Space Components of Semantic Memory: A Study of Frontal-Lobe-Related Impairments

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Eleven patients with frontal-lobe damage and 12 control subjects were tested on temporal and spatial script-generation tasks and on two tests that required organization of semantic knowledge in the appropriate spatial or temporal order. Patients displayed typical perseverative errors in temporal scripts, but produced sequence errors regardless of the nature of the information. Moreover, the semantic structure of the patient's scripts was largely composed of idiosyncrasies and a low frequency of major actions for the spatial scripts. Results are discussed within Shallice's and Grafman's theoretical frameworks.

Shallice (1982, 1988) and Grafman (1989) have proposed that the frontal lobes are involved in organizing the representation of large-scale conceptual units, called scripts (Schank, 1975). Scripts refer to rehearsed sequences of events that have a typical temporal and semantic structure (e.g., going to a restaurant). Godbout and Doyon (1995) tested patients with frontal-, temporal-, or parietal-lobe damage on different scripts. Actions were generated in a forward (routine) and backward (nonroutine) sequence. Results showed that the frontal lobes, together with the parietal cortex, play a special role in establishing the spatio-temporal sequence of events within a script. Because the script-generation tasks used by Godbout and Doyon (1995) required the mental manipulation of actions in both time and space, they could not determine if patients' impairment was attributed specifically to the temporal or spatial nature of the information, or both.

It is well documented that the parietal lobes are involved in processing spatial information (De Renzi, 1982). Therefore, parietal lobes may also be required in generating scripts. A recent study (Coutier & Godbout, 1997) revealed that the deficits of patients with parietal-lobe lesions are more prominent when spatial scripts have to be mentally manipulated. However, it is still unknown whether the impairment associated with frontal insults in a script-generation task is caused by the inherent temporal nature of the task, or because the frontal lobes are systematically requested to generate scripts, regardless of their nature.

The purpose of this study was to determine if the deficits due to frontal lesions are restricted to the temporal structure of a script or if they are generalized to both temporal and spatial information. We also examined whether script generation deficits of frontal-lobe patients vary according to the difficulty of the task (routine and nonroutine) as proposed by Shallice (1982). Finally, the semantic structure of the scripts generated by the two groups was compared in regard to the proportion of central, contextual, or idiosyncratic actions.

Method

Participants. Eleven patients with circumscribed frontal-lobe lesions and 12 normal control subjects took part in the present study. All patients underwent surgery for removal of an indolent brain tumor and showed radiographic evidence of a circumscribed lesion. None of the control subjects showed any indication that suggests a neurological or psychiatrical antecedents.

Materials and procedure. Subjects were tested under four conditions: routine and nonroutine script-generation task with high spatial content and high temporal content. They were asked to enumerate a list of 10 to 20 actions describing what people generally do over the course of an activity and to place the actions in the appropriate chronological (routine) or reverse (nonroutine) order. They were also told not to include idiosyncratic actions.

Moreover, they were asked to answer a series of questions that was comprised in two tests that required organization of semantic knowledge (geographical locations, historical events) in the appropriate spatial or temporal order.

Scoring. Subjects' responses were evaluated following the same semantic and structural criteria as those used in our previous work (Cloutier & Godbout, 1997; Godbout & Doyon, 1995). Among the various measures, two types of errors were very important for the purpose of this study: (a) sequence

TABLE 14
Number of Subjects Who Produced Sequence Errors in the Four Script-Generation Tasks

	Group				
	Frontal (n = 11)		Control (n = 12)		
Condition	0 error	>1 error	0 error	>1 error	Fisher's p
Spatial/forward	8	3	11	1	ns
Spatial/backward	3	8	10	2	.01
Temporal/forward	8	3	11	1	ns
Temporal/backward	4	7	11	1	.008

TABLE 15
Number of Subjects Who Produced Perseverative Errors in the Four Script-Generation Tasks

	Group				
	Frontal (n = 11)		Control (n = 12)		
Condition	0 error	>1 error	0 error	>1 error	Fisher's p
Spatial/forward	11	0	12	0	ns
Spatial/backward	8	3	12	0	ns
Temporal/forward	7	4	12	0	.03
Temporal/backward	7	4	12	0	.03

errors consist in a displacement in the natural sequence of actions within a script; (b) perseverative errors consist in repeating an action more than once within a script.

Results

Because sequence or perseverative errors have a low probability of occurrence, Fisher exact probability tests were computed to compare the number of patients and control subjects who produced these errors. In the script-generation task, patients demonstrated greater difficulty to order actions in a backward sequence, regardless of the spatial or temporal nature of the scripts (see Table 14). By contrast, perseverative errors occurred only when patients had to order informations in time, in both forward and backward sequences (see Table 15).

Interestingly, similar results were obtained from the statistical analyses of the semantic memory test scores. t tests revealed that the average performance of frontal-lobe patients was significantly lower than control subjects on the spatial [$t(21) = 2.49, p < .05$] and the temporal [$t(21) = 2.49, p < .05$] versions of the test (see Table 16).

The analysis of the semantic structure indicates that patients with frontal lesions produced significantly more intrusions in both spatial [$F(1, 63) = 30.59, p < .0001$] and temporal [$F(1, 63) = 8.22, p < .01$] script-generation

TABLE 16
Average Score (%) of Patients and Control Subjects on the Two Semantic-Memory Tests

	Spatial test		Temporal test	
Group	Mean	*SD*	Mean	*SD*
Frontal	78.09	8.20	74.64	19.48
Control	87.50	9.79	90.00	6.55

tasks. Nevertheless, they generated significantly less major actions [$F(1, 63) = 10.65, p < .001$] in spatial scripts.

Conclusion

Overall, the present findings reveal that frontal lobes are involved in organizing spatial and temporal semantic information, especially in nonroutine activities. Because the structure of the scripts was preserved in the routine condition, our results are in agreement with Shallice's (1982) model. Nevertheless, a higher number of perseverative errors in temporal scripts indicates that the frontal lobes also have a specific function in processing temporal information. These errors can be explained within Grafman's (1989) structural theory, which postulates that to initiate the forthcoming action in a script, the current action must be inhibited. We suspect that this inhibition process was deficient in our patients and caused the repetition of a number of actions. Finally, the analysis of the semantic structure revealed that patients produced a wide set of idiosyncrasies and a low frequency of major actions in the spatial scripts. Both results demonstrate the difficulty that patients with frontal-lobe lesions experienced when required to manipulate abstract concepts without relating them to their own personal experiences. We speculate that spatial scripts, in comparison to temporal scripts, do not provide a frame of reference within which actions are strongly tied to each other. Similar observations were made by Sirigu, Zalla, Pillon, Grafman, Dubois, and Agid (1995).

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Planning and Drawing Abilities in Normal Aging

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In order to verify the hypothesis that planning decline is responsible for the drawing difficulties in normal aging, two groups of subjects ($n = 17$, ranging in age from 65 to 78 years, $n = 13$, from 24 to 40 years) were asked to copy tridimensional superposed figures, tridimensional geometrical nonsuperposed ones, and bidimensional concrete and geometrical figures. The planning ability was measured by means of the copying of superposed figures, which requires a front-to-back strategy. Analysis of data indicates that when compared with the performance of young adults, the ability to copy and plan superposed and nonsuperposed figures is impaired in the old group. However, the ability to plan did not predict the drawing performances in elderly. Spatial and exploration abilities in aging could be two other factors of variation in copying.

Introduction

It is well known that performances in visuospatial tests, such as in the copy of some bidimensional and tridimensional figures, are impaired in normal aging (Ardila & Rosselli, 1989; Moore & Wyke, 1984; Ska, 1986; Ska et al., 1987; Troyer et al., 1994). A decline in executive functions is one explanation to this phenomenon since visuospatial tasks require problem solving (Libon et al., 1994). Considering that contingent planning, which is akin to problem solving, is one of the components underlying drawing abilities (van Sommers, 1989), the goal of the present study is to verify that, comparatively to young adults, elderly have more difficulties to copy figures because of problems in the planning of drawings.

Method

Subjects. Seventeen subjects aged 65–78 (mean age = 71.5; mean education = 12.1) formed the elderly group (4 men and 13 women). They were recruited from the list of subjects of the Centre de recherche, Institut universitaire de gériatrie de Montréal. They were all submited on a neuropsychological examination (Protocole d'Évaluation Neuropsychologique Optimal). Subjects who showed mnesic deficits were excluded.

Thirteen subjects aged 24–40 (mean age = 31; mean education = 14) formed the young adult group (7 men and 6 women). They were recruited from the personnel of the Centre hospitalier Côte-des-Neiges and from advertisements posted in different public centers in Montreal. They had not been studying for at least two years. All subjects were all in healthy condition.

Tasks

Planning in drawing. Subjects were asked to copy seven concrete tridimensional superposed figures which had one part occluded (i.e., a circle in front of the cube, a plank in front of a wall) (van Sommers, 1984). In order to plan these drawings, they had to use a front-to-back strategy. One point for each drawing for a total of seven points was allocated when the front-to-back strategy was used.

Copy of figures. Subjects were asked to copy seven geometrical tridimensional figures, seen either in transparency or not (e.g., a cube), and nine concrete or geometrical bidimensional figures (e.g., a star). Because all parts of the tridimensional figures were complete and not occluded, they were considered to be nonsuperposed figures.

The quality of the copy of all figures was scored by two judges on a 0 to 4 point scale. The score four was given when the drawing was identical to the model and zero was given when the drawing was unrecognizable.

Results

A single-factor ANOVA on the variable age indicated a significant between-group difference for the planning tasks ($F(1, 30) = 10.87, p = .003 < .05$). The elderly subjects used a front-to-back strategy significatively less often than young adults. Furthermore, a single-factor ANOVA on the variable age analyzing the quality of the copies of tridimensional superposed figures indicated a significant between-group difference ($F(1, 30) = 4.77, p = .037 < .05$). The elderly subjects copied worse tridimensional superposed figures than the young adults. A single-factor ANOVA on the variable age indicated also a significant between-group difference in the copy of bidimensional and tridimensional nonsuperposed figures ($F(1, 30) = 9{,}591, p = .004 < 0.5$). The elderly subjects copied worse nonsuperposed figures than the young adults. The level of education is correlated to the ability to copy nonsuperposed figures in aging ($r = .741$). However, the correlation between the ability to plan and the quality of the copy of superposed figures and nonsuperposed figures is not high (respectively, $r = .556$ and .350).

Conclusion

As expected, a significant effect of age was obtained for the planning task. As well, the copy of tridimensional superposed and nonsuperposed figures is sensitive to age. However, the correlation between the ability to use a front-to-back strategy and the quality of the drawings in the elderly group was not high. The ability of the elderly to plan did not predict their drawing performances. In this view, some subjects could have a better ability to copy than to plan and some others could have a better ability to plan than to copy. This result can be explained by the fact that exploration and spatial abilities

are also required in drawing (Guérin, Ska, & Belleville, submitted). One of these abilities could also decline with age and affect drawing. An explanation of the fact that some subjects should be better in copying than in planning is that some drawings could be familiar and routine for certain subjects with a high level of education, and could be produced following well-known schemes in semantic and procedural memories, without contingent planning (Guérin, Ska, & Belleville, submitted). Moreover, a competent drawer can use his perceptual abilities for anticipating the points of intersection of figures' lines and the front part of superposed figures (van Sommers, 1984; 1989). These explanations are plausible considering the cognitive heterogeneity in aging (Albert, Duffy, & Naeser, 1987; Valdois & Joanette, 1991; Valdois, Joanette, Poissant, Ska, & Dehaut, 1990).

However, subjects with good perceptual abilities would compensate less for their lack of planning in copying nonsuperposed figures than in copying superposed figures. Superposed figures are more correlated to planning than nonsuperposed figures. A common planning error observed in the elderly is to draw the rear part of the superposed figures first without anticipating the front part. For example, in the superposed figure representing a plank in front of a wall, some aged subjects drew the line representing the wall first, but did not leave a gap to anticipate the drawing of the plank. In this case, a part of the wall was not occluded and the tridimensional effect of superposition was not reproduced. This kind of planning error cannot happen in the copy of nonsuperposed figures because occluded parts do not have to be considered. In summary, contingent planning and drawing abilities are sensitive to age. However, drawing performance in aging cannot rely on planning abilities. Taking into account the cognitive heterogeneity in aging, we can predict that spatial or exploration abilities of certain subjects should also be affected. In contrast, some subjects could use their perceptual abilities to compensate for their lack of planning, but not with tridimensional superposed figures, which require a greater ability to anticipate. In order to validate this conclusion, the perceptual abilities of the elderly in drawing must be evaluated in future multiple case studies.

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Training Dyslexics with Acoustically Modified Speech: Evidence of Improved Phonological Performance

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Twelve 10- to 12-year-old children with a diagnosis of pure phonological dyslexia underwent intensive daily training using phonological awareness exercises (45 min/day, over a 5-week period). Six of the children received exercises consisting of normal, unmodified speech, whereas the other 6 received exactly the same exercises modified with systematic enhancement of duration and amplitude of the short transitional speech elements. Improvement in phonological abilities was significantly greater in the group receiving modified speech, this effect persisting 1 month after the end of the training period. Intensive ''temporal'' auditory training, previously shown to be effective in language learning impaired children, may also be beneficial to developmental dyslexics.

In spite of normal intelligence and adequate education, 8 to 10% of school-age children experience severe difficulties learning to read and spell, a condition referred to as developmental dyslexia (DD). Although its mechanisms and etiologies are not completely elucidated, DD is commonly related to a specific defect in voluntarily segmenting and manipulating speech sounds (Liberman, 1982), so-called ''phonological awareness'' (PA), presumably due to abnormal development of cortico-subcortical brain circuits involved in auditory speech processing (Galaburda, Menard, & Rosen, 1994).

Recently, a great deal of excitement has arisen following the suggestion

that a training method aimed at improving temporal processing in the brain may be beneficial to dyslexic children. The rationale for this method was based on the assumption that phonological deficits reflect a fundamental incapacity of these children's brains to process the rapidly changing features of human speech (Tallal, 1980). In two influential reports (Tallal et al., 1996; Merzenich et al., 1996), a subgroup of dyslexic children with oral language impairments received a series of exercises made with acoustically modified speech, in which both duration and amplitude of the short transitional speech elements were artificially and systematically enhanced. However, although this method significantly improved receptive verbal performances (such as verbal comprehension, which is usually unimpaired in dyslexics), its efficacy on PA abilities remains speculative. Therefore, claims that this method may be useful as a treatment for dyslexia have been disputed. Moreover, the temporal processing theory of dyslexia, which is a subject of brisk debate in the recent literature (Mody, Studdert-Kennedy, & Brady, 1997), may be enlightened by directly testing the effect of temporal training on phonological abilities in dyslexics.

The purpose of the present study is to specifically evaluate the relevance of such training method applied to PA exercises in pure phonological dyslexics with no previous impairment in oral language acquisition.

Methods

Twelve French-speaking dyslexic children, aged 10–12, with a typical profile of phonological dyslexia were carefully selected from a special boarding school and rehabilitation clinic in France. During period of 5 consecutive weeks, all children received a 1-hour training session, 5 days a week, mainly composed of PA exercises recorded on audio-CD. Six children (EXP for ''experimental'') received a special regimen, whereby exercises were acoustically modified. The spectral instability in critical bands feature (SIF) was computed on each speech item. A gain function was constructed from this SIF, by smoothing linear transformation and clipping (to avoid too high energy level).

The other 6 children (PLAC for ''placebo'') received exactly the same training, except that speech composing the PA exercises was left unmodified. The two subgroups were strictly matched in educational and cognitive levels as well as for their PA abilities, which were assessed just before, just after, and one month after training. A special algorithm was implemented to automatically transform natural speech elements. The speech signal was amplified in its unstable portions, especially on consonant–vowel transitions, and then slowed by a constant factor (up to 2). The modification was maximal at week 1 and was gradually reduced during the training period, reaching normal speech rate at week 5.

Phonological awareness assessment and training program. Both training exercises and pre- and posttraining tests were created with words and nonwords according to difficulties inherent to the French language (voiced vs unvoiced consonants, constricted vs stop-consonants, presence of simple or double consonants in initial or intervocalic position). The materials consisted of series of 3 or 4 words or nonwords all but one sharing a common consonantic sound (as in ''pin,'' ''win,'' ''sit,'' ''fin''), and among which children were instructed to find out the ''odd one,'' i.e., that differing by one phonological characteristic (''sit''). Due to specific phonology in French, several series included double consonants, some of them only differing in temporal order (''scorpion, masque, action''). The same battery was used for pre- and posttraining evaluations, whereas training exercises used on each day of the 5-week training period were constructed on the same structure but with different items. The assessment battery was normalized on a group of 80 age-matched normal reading children.

Results

Before training, EXP and PLAC did not differ ($p = .8845$, Wilcoxon rank-sum test), whereas after training PLAC performance did not vary ($p = .8438$, paired test) but EXP significantly improved ($p = .0032$, paired test). Only EXP children on posttraining testing reached the level of normal reading controls. One month after the end of the training period, the between-group difference was still significant. A repeated measure ANOVA performed on each child's day to day performance also disclosed significantly larger improvement in EXP than in PLAC children ($F = 3.336$; $p = .0001$). (See Fig. 27.)

Discussion

These results show the utility of applying a speech modification algorithm to PA exercises administered under intensive training to children with phonological dyslexia. Modifying the speech signal may have helped children decode and manipulate verbal information within the consonant–vowel transitions. The persistence of this effect one month after the end of the treatment period suggests that the neural substrate of the improved function has been the site of some kind of reorganization.

Our results also lend strong support to the view that brain structures specialized in language processing are sensitive to the temporal features of the acoustic signal and that, contrary to recent claims (Mody et al., 1997), the basic dysfunction in the dyslexic brain may reside, at least in part, in prelinguistic, low-level auditory processes.

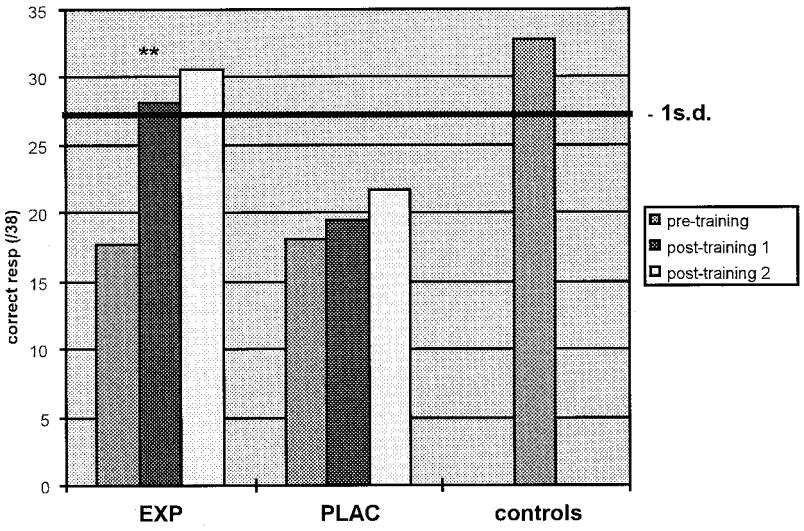

FIG. 27. Phonological awareness performance of 6 dyslexic children trained with modified speech (EXP) compared to 6 matched dyslexics receiving the same exercises with unmodified speech (PLAC) before and after a 5 week training period and to 80 normal reading controls (horizontal line: 1 SD below average performance of controls). Only the EXP group reached the normal range of performance on posttraining evaluation (posttraining 1). This effect was still present at a one-month retest (posttraining 2).

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Performance of the Manual and Oral–Motor Systems Using the Dual-Task Paradigm[5]

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A single experiment was conducted to examine interference in the oral-motor and manual output systems when using the dual-task paradigm. The manual task involved a repetitive and sequential finger tapping condition, right and left hand. A concurrent verbal task involving a series of bilabial syllables enabled the experimenters to quantify the patterns of oral–motor output during different finger tapping conditions. The results indicated a unidirectional pattern of asymmetry, involving only the oral–motor system when the manual task was performed sequentially or with the right hand. These data provide support for a lateralized ''praxis'' system in the left hemisphere.

Traditionally, the study of dual-task paradigms has focused on disruptions to manual output. Generally, this research supports the contention that a right-hand decrement occurs when performed with a concurrent verbal task, while left-hand performance is not similarly affected (i.e., Lomas & Kimura, 1976). This phenomenon has been attributed to a combination of factors including lateralization of the left hemisphere (LH) for language and speech production, LH contralateral control of the right hand, and the limited capacity of the LH to control both tasks simultaneously (Kinsbourne & Hicks, 1978). Although a plethora of research has demonstrated this asymmetrical manual performance during the dual-task, the effects of concurrent performance on speech production has yet to be examined. While right-hand performance is diminished more than left-hand performance during concurrent speech production, the key question is whether speech production is itself similarly affected when performing a concurrent manual task with the right and left hand. Previous research (Heath, 1997) has indicated that the pattern of performance seen in the oral–motor system is differentially affected by the nature and complexity of speech. Thus, the purpose of the present study was to manipulate task complexity and LH capacity demands using the dual-task paradigm in order to determine if the normal patterns of speech production are disrupted by a concurrent reptitive or sequential manual task.

Method

Participants. Eight male graduate students from McMaster University were recruited to participate in this study. Participants were right handed and reported no history of facial or neurological impairments.

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Apparatus and design. The finger-tapping device consisted of three momentary contact switches mounted side by side and connected to a microcomputer (500 Hz). In one condition (Repetitive) participants were instructed to use their index finger to depress the middle switch as rapidly as possible. Another condition (Sequential) involved a sequential tapping pattern with the index, middle, and ring finger.

The speech task involved the production of four bilabial syllables (/ma/ /ba/ /pi/ /bi/). Light-emitting diodes placed on the outer right and left edges of the lower lip were used to quantify performance of the oral–motor system. Two markers were used to examine speech patterns on the right and left sides of the mouth (Side). An Optotrak 3020 motion analysis system sampling at 200 Hz was used to track movement of the diodes. Each trial consisted of a preparatory period, followed by 5 s of data acquisition. A total of nine experimental conditions were employed: four involved concurrent production (2 Repetitive and 2 Sequential) of the right and left hand while the remaining five conditions involved baseline data for each tapping condition and the speech production task.

Data analysis. Data for the speech production task (y axis) were filtered at 6 Hz (Butterworth) and differentiated using a two-point central finite difference algorithm to obtain instantaneous velocity. Movement duration and peak velocity of the syllable /pi/ was used in data analysis.

Finger tapping was examined using 2 (Left Hand, Right Hand) $\times$ 2 (Concurrent, Non-Concurrent) $\times$ 2 (Repetitive, Sequential) repeated measures ANOVA to analyze mean number of key depressions. Speech production data were examined using two analyses. In analysis one, the performance of baseline speech trials was compared to the concurrent trials of the right and left hand. The second analysis involved comparing baseline speech trials with speech performance during repetitive and sequential tapping contexts. In each case a 2 $\times$ 3 repeated measures ANOVA was employed.

Results. The overall tapping rate was significantly faster in the right hand, $F(1, 7) = 27.51, p < .001$, and during the repetitive trials, $F(1, 7) = 33.99$, $p < .001$. Surprisingly, the concurrent verbal task did not reduce the tapping frequency of either the right or left hand.

The speech production data indicated that the overall duration of the verbal task was significantly lengthened when performed in conjunction with the sequential tapping condition, $F(2, 14) = 9.87, p < .01$ (Fig. 28), and when the secondary task involved right hand performance, $F(2, 14) = 8.36, p < .01$.

Discussion

The results indicated a unidirectional pattern of interference in the concurrent trials. Specifically, finger tapping interfered with the speech production task while the speech production task did not result in manual interference.

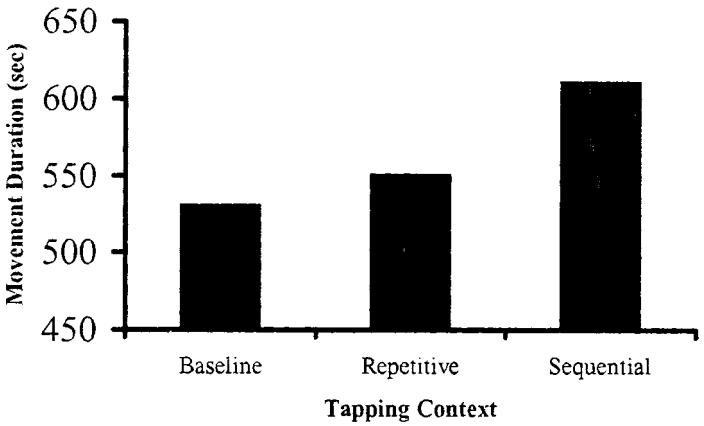

FIG. 28. Mean movement duration (s) for the syllable ''pi'' during baseline trials and concurrent repetitive and sequential tapping contexts.

The pattern of interference associated with speech production centered on two components. Interference occurred when tapping in the sequential but not repetitive conditions, as well, greater interference to speech production resulted when the right hand was used during the concurrent verbal task. This pattern of interference is consistent with the notion of a LH system responsible for ''praxis'' control of speech and limb movements since the tasks which relied on greater praxis control (i.e., sequential tapping with the right hand) produced interference in the oral-motor system (Square, Martin, & Roy, 1997). If such as system exists then why was a similar pattern of manual performance not elucidated? This unidirectional pattern of interference may have occurred because participants were instructed to insure 100% accuracy of the sequential tapping pattern and to maintain a consistent but rapid tapping rate during the repetitive trials. Thus, participants may have adopted a strategy of devoting more attentional resources to the manual task making it less susceptible to interference from the concurrent verbal task. Such a strategy would then limit the capacity of the praxis system to consistently control the secondary verbal task.

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A Study of the Interaction between Lexical and Sublexical Reading Routes

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According to dual-route models of reading, there exist two fundamental and distinct processes in reading. The lexical process, on the one hand, allows words to be read in their ''global'' form, while the sublexical reading process proceeds by way of grapheme-to-phoneme conversion rules. Recent forms of these models assume that, despite their potential functional independence, the two routes share some degree of interaction in the reading process. In this experiment, results demonstrated that nonwords which contained bigrams carrying two possible pronunciations, one corresponding to a regular sublexical conversion rule and the other corresponding to an irregular lexical word, were not read significantly slower than nonwords which contained bigrams carrying only one possible pronunciation. These results suggest that there was no interference effect between the pronunciations generated by the conventional sublexical rules and those generated by the irregular lexical items. In the context of this experiment, there is no evidence for an interaction between the lexical and sublexical routes. Yet, the results support the functional independence of the sublexical processing route.

Introduction

There has been much debate in recent years in the domain of cognitive neuropsychology concerning the existence of the processes which underlie reading. Dual-route models of reading generally assume that there exist two fundamental and distinct processes in reading (Ellis, 1984). On the one hand, a lexical route allows words to be read in their global form. The reader assumes a visual recognition of the whole word and then translates it in its corresponding global phonological form. On the other hand, sublexical reading allows for a segmentation of a word into its basic sublexical graphemic units (i.e., graphemes). These units are then converted, by way of specific conversion rules, into their corresonding phonemes, and the latter are then assembled so as to pronounce the whole phonological form of the word. The lexical route is used to read regular and irregular words, while the sublexical route is used to read novel regular words (or of low frequency) and nonwords. At the other end of the continuum, analogy models and more recently connectionist models assume that reading is subserved by a unique underly-

ing process. According to analogy models (Glushko, 1979) for example, nonwords and novel words are read by analogy to known lexical items.

More recent versions of dual-route models (Lecours, 1996) presume that despite the potential functional independence of the lexical and sublexical routes, there is a strong interaction between the two processing routes. Whole-word phonological forms, for example, can help in the pronunciation of low-frequency words which are read by means of graphophonemic conversion (e.g., HIPPOPOTAMUS).

Furthermore, the sublexical route holds its origin in the lexical route: Conventional graphophonemic conversion rules are originally derived from regular words. Thus, a graphemic unit which holds only one phonological form will be read following a specific conversion rule. However, certain graphemic units have more than one pronunciation. The most regular pronunciation will become a rule (i.e., [ʃ] in ''CHOCOLAT'' in French), while words which hold the irregular pronunciation will become irregular words (i.e., CHORALE).

If there is in fact an interaction between the two reading routes, it can be assumed that nonwords (read by sublexical means) which contain bigrams holding more than one pronunciation should be prone to an interference effect between the activation of the ''regular'' sublexical rule (i.e., [ʃ] in ''ch'') and the activation of the irregular lexical item (i.e., ''CHORALE''), as opposed to nonwords whose graphemic units contain only one possible pronunciation. This interference effect should result in longer reaction times.

Methods

Thirty French-speaking undergraduate students served as subjects. All of them were right-handed, with no personal or family history of dyslexia.

The stimuli consisted of 40 bisyllabic six-letter legal and pronounceable nonwords in French. The nonwords were presented for reading aloud singly in pseudo-randomized order. The 20 nonwords of List 1 were composed of graphemes which had only one possible pronunciation (i.e., TORBAL), and the stimuli of List 2 included, in the second syllable, a bigram which contained two possible pronunciations (i.e., TARLIS, where IS can be pronounced [i] and [is] as in avis and vis). Forty distractor nonwords were added in the randomization in order to conceal the nature of the experiment.

The stimuli of each list were matched pairwise in terms of their sublexical bigram frequencies and their onset characteristics. A grapheme was defined as being the equivalent written form of a phoneme. The average sublexical bigram frequency was 690.66 in List 1 and 681.5 in List 2. Initial, middle, and final bigram frequencies were taken from the Content and Radeau (1988) frequency tables for the French language. Also, considering that there are no existing data on phoneme frequencies, we assumed there was a close match between sublexical graphemic and phonemic frequencies.

Results

The results of a one-tailed *t* test for paired samples indicate that reaction times were not significantly higher ($t = -.634$, $p < 0.27$ (29 *d.f.*)) for nonwords containing bigrams which had two possible pronunciations than for nonwords whose graphemes only had one pronunciation. The difference in mean reaction times between stimuli of List 1 and List 2 was 8.841 ms.

Discussion

Nonwords containing bigrams which had two possible pronunciations were not read significantly faster than nonwords containing single-pronunciation bigrams. These results go against the notion of a potential interference effect resulting from the confrontation between the activation of regular sublexical conversion rules and that of known irregular lexical items. The absence of such an interference effect has several implications.

First, in the context of this experiment, the results do not support the idea of an interreliance of the lexical and sublexical routes. In the specific instance of reading nonwords which contained two possible pronunciations, the lexicon appeared to be neither activated nor involved in the sublexical reading process. Nonetheless, the fact that irregularly spelled words were not activated in this type of sublexical processing does not exclude the possibility that there are interactions between the two reading routes in other types of processing. On the other hand, the fact that the sublexical route can operate independent of the lexical route supports its potential functional independence. Therefore, the results obtained in this study still argue in favor of traditional dual-route models of reading.

Considering that nonwords carrying two pronunciations (including the pronunciation of an irregular word) are not read significantly slower than nonwords carrying only one pronunciation, it is likely that normal readers favor the use of a selective strategy in reading nonwords, one which is based exclusively on sublexical conversion rules and which does not activate known lexical irregular items. This notion stands against the fundamental assumption of lexical-analogy models. However, it does not seem to challenge recently developed connectionist models. It can be argued that if, in a connectionist model, the units representing the most frequent phonological form of the heterophone bigrams imbedded in the nonwords are activated more often, they will bear more weight and thus will be selected before their irregular phonological counterparts (which carry less weight). Therefore, the results can also be interpreted in the optic of connectionism, with some reserves, however, with regard to its reductionist nature.

In conclusion, we underline the importance of normal group studies in the development of cognitive models of reading, and to consider that they are an important complement to the contribution of pathological case studies.

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Effects of Prenatal Androgen Exposure on Cerebral Lateralization in Patients with Congenital Adrenal Hyperplasia (CAH)

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A battery of tests was administered to 6 males and 7 females with congenital adrenal hyperplasia (CAH) and a group of normal controls to investigate the effects of prenatal androgen exposure on cerebral lateralization and cognitive functioning. CAH is a disorder which exposes sufferers to elevated adrenal androgen levels *in utero*. CAH individuals were compared on measures of hand preference and verbal and performance IQ with 13 matched controls. A higher incidence of left-handedness was found among CAH participants. CAH individuals exhibited higher performance as opposed to verbal IQs as measured by the Weschler Intelligence Scales. These results suggest a pattern of right hemisphere dominance in patients with CAH.

Introduction

Over the past two decades, several theorists have proposed that sex steroid hormones such as testosterone act on the fetal brain during a critical period of development to influence cerebral lateralization (Geschwind & Galaburda, 1987; Hines & Shipley, 1984; Witelson, 1991). Since then, literature has both supported and refuted the above claim, and the effects of prenatal testosterone exposure on cerebral lateralization are still being debated (see Bryden, McManus, & Bulman-Fleming, 1994). The two hemispheres of the brain appear to be specialized for different kinds of cognitive processing. In the majority of the population, the *standard* pattern of dominance is a left hemi-

sphere specialization for verbal and mathematical processing and control of the right hand. The right hemisphere dominates visuospatial and motor processing, emotional expression and artistic ability (Springer & Deutsch, 1993). In contrast, a pattern of *anomalous* dominance results in an increased prevalence of sinistrality (left-handedness) and a shift in lateralization toward the right hemisphere. This pattern of lateralization is usually stronger in males than females, and it has been suggested that this sex difference in lateralization is related to differences in prenatal hormone levels (Hines, 1982). This study aims to explore the effects of androgens on cerebral lateralization using people who have inherited the condition of congenital adrenal hyperplasia (CAH). Individuals with CAH are exposed to increased levels of the sex steroid hormone testosterone *in utero*. Cerebral lateralization was measured through self-reported hand preference and verbal and performance IQ measures. If testosterone exposure produces anomalous dominance, there should be a higher incidence of left-handedness in the CAH group. In addition, the CAH group should have higher performance IQs compared to verbal IQs because of an increased reliance on the right hemisphere.

Method

Participants. Thirteen patients with CAH (6 male, 7 female) and 13 matched controls were employed in the study. CAH status was confirmed by the presence of diagnostic levels of 17-hydroxy progesterone. Controls were matched for age, sex, and socioeconomic status. Participants' ages ranged between 10 and 23 years (mean = 16 years).

Apparatus. The Edinburgh Handedness Inventory (Oldfield, 1971) was used to confirm and to provide a measure of handedness. To assess cognitive style, subscales of the Weschler Adult Intelligence Scale (WAIS) and the Weschler Intelligence Scale for Children Revised (WISC-R) were used. The subscales of vocabulary and arithmetic were used to measure verbal ability, while performance was measured using block design and picture completion.

Procedure. Two test batteries were administered to each participant. The first battery administered was the Oldfield Handedness Inventory. The inventory consists of 10 questions which seek to determine which hand is used for a variety of common tasks. The second battery assessed cognitive style. Sections of the WISC-R and WAIS were administered to measure the performance of both the left (verbal) and right (performance) hemisphere.

Results

Hand preference. A general factorial ANOVA was used to determine whether differences exist between the CAH and control population in measures of hand preference. Participants with CAH displayed significantly lower laterality quotients, indicating a left-hand bias as compared with their matched controls $F(1, 24) = 4.75$, $p < 0.05$. The mean laterality quotient

for CAH participants was +28.10, while the mean laterality quotient for controls was +73.78. Out of the 13 participants with CAH, three (23%) were left-handed and one was ambidextrous (8%) as compared with one left-hander in the control group (8%).

Cognitive style. To determine the effects of prenatal androgen exposure on cognitive style, a mixed between–within participants ANOVA was performed. Scores for the verbal and performance subscales of the WISC-R and WAIS were used as within participants factors, whereas sex and group (CAH, control) were used as between participants factors. There was no difference in IQ scores between participants with CAH and matched controls $F(1, 22) = 0.05, p > 0.05$, or between the sexes $F(1, 22) = 1.35, p > 0.05$. Scores were higher for the performance scale than the verbal scale $F(1, 22) = 6.82, p < 0.05$. A significant interaction was found between group and test type $F(1, 22) = 30.54, p < 0.001$. Participants with CAH had significantly higher performance IQ scores compared with controls, whereas controls displayed significantly higher verbal IQ scores than participants with CAH. There were no significant interaction between sex and test type, $F(1, 22) = 0.01, p > 0.05$, indicating no differences between the sexes in scores of verbal and performance IQ.

Discussion

The results of the present investigation support the hypothesis that elevated prenatal androgen exposure in individuals with CAH does influence later patterns of cognitive development and hand preference. Both male and female CAH patients were found to display a significant shift away from strong right-handedness toward weak right-handedness, or sinistrality, as compared with controls. Marked differences in cognitive style between CAH and control participants indicate that early androgenizing influences are important in the development of perceptual organization and spatial ability. CAH individuals displayed significantly higher performance IQ's as compared with verbal IQ's. A similar Verbal-Performance IQ discrepancy has been reported by Helleday, Bartfai, Ritzen, and Forsman (1994). However, in contrast to the findings of Helleday et al. (1994), there was no evidence of a general decline in intelligence for patients with CAH.

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Effects of Morphological Complexity on Phonological Output Deficits

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The single-word repetition of four aphasics (2 fluent and 2 nonfluent) was examined to explore the effects of derivational and inflectional affixes on phonological output disorders. While the performance of three of the four subjects declined with affixed (i.e., morphologically complex) targets, all four subjects showed similar effects of affix type on accuracy (e.g., inflectional morphology presented greater difficulty than derivational morphology). The error data, on the other hand, revealed differences between the fluent and nonfluent aphasics. For example, affix omissions were common errors for the nonfluent subjects, while affix substitutions were common for the fluent subjects. The implications for models of language processing, and the characterization of aphasic deficits, will be discussed.

Difficulty producing affixes is an important feature for classifying certain types of sentence production deficits (e.g., agrammatic and paragrammatic speech) and oral reading deficits (e.g., phonological and deep dyslexia) following neurological damage. The role that morphological complexity plays in specific word-production deficits is less clear (see Miceli and Caramazza, 1988). This study investigated the effect of morphological complexity on phonological output disorders in aphasia (Badecker and Caramazza, 1991). The single-word repetition of words with and without affixes was examined in four aphasic subjects who produced phonological errors when repeating morphologically simple words (e.g., *cafeteria* > /*tæfiər*/; *sincere* > /*ʌnsir*/; *bell* > /*vɛl*/). Data analysis focused both on correct performance and error types. We addressed the following questions: (1) Does morphological complexity further stress a phonological output deficit? (2) Do different types of affixes differentially affect performance (e.g., prefixes vs suffixes, inflec-

tional vs derivational affixes)? (3) Are there distinct patterns of affix errors among aphasic subjects (e.g., morpheme omissions vs substitutions vs additions)?

Methods

All subjects were right-handed, had suffered left-sided neurological damage (three due to stroke, one due to gunshot), and had essentially preserved hearing and single-word auditory comprehension. For all subjects, phonological errors in speech were common, while semantic errors were rare. Two subjects were nonfluent, agrammatic aphasics, with a dense right hemiplegia and minimal dysarthria. The other two subjects were fluent aphasics, who spoke in well-articulated and grammatically complete utterances.

Subjects were asked to repeat 459 words, which varied in morphological complexity, number of syllables, syllable complexity (e.g., presence or absence of consonant clusters), and location of main stress. Stimuli were presented on audiotape by a female speaker, with two successive presentations of each item. All performance was audiotaped and transcribed by two listeners. Disagreements were resolved through a third listener, which led to a high level of agreement (between .92 and .99).

Results

Repetition performance with the morphologically simple words ($n = 212$) was highly comparable for all four subjects. They repeated between 80 and 83% of the targets correctly and produced errors reflecting mild-to-moderate breakdown within the phonological output system. The vast majority of errors consisted of phonemic paraphasias, formal paraphasias, and fragments. Semantic paraphasias and neologisms were rare. Three of the four subjects repeated substantially fewer affixed targets correctly ($n = 197$): BD = .80 vs .59; JW = .81 vs .44; RD = .82 vs .56. ED alone showed no substantial difference in performance on unaffixed and affixed forms: .82 vs .83. The fact that the repetition accuracy of ED (a fluent aphasic) did not decline suggests that the two sets of words were roughly matched for phonological difficulty.

In examining the repetition accuracy of morphologically complex targets according to the type of affix they contain, the four subjects showed identical patterns of performance (apart from some ceiling level performance). Our findings comparing words matched for frequency and length are summarized as follows: (1) Performance on words comprised of a root and a derivational suffix was better than on words comprised of a root and an inflectional suffix (e.g., *blender* vs *blended*). (2) Repetition of words ending in the derivational suffix *-er* was worse than for words ending in a nonmorphological, but homophonous sequence *-er* (e.g., *blender* vs *panther*). (3) Regular nonprefixed past tense verbs were repeated more accurately than regular prefixed past

tense verbs (e.g., *dusted* vs *unzipped*). (4) Irregular inflected words were repeated more accurately than regular inflected words (e.g., *women* vs *tables*).

When focusing on patterns of affix errors (i.e., full morpheme omissions, additions, substitutions), all subjects displayed little difficulty with derivational endings, but substantial difficulty with inflections. Two errors patterns emerged: Two subjects tended to omit inflections; while the other two subjects substituted, omitted, and added inflections, with the latter errors sometimes leading to nonlegal forms (e.g., *mischose* > **mischosed; manx* > **manxed*). Moreover, only the subjects who omitted inflections also displayed difficulty with prefixes, due again, to omission. We confirmed that the prefix omissions were triggered by the morphological status of the prefix, rather than its phonological properties: These subjects rarely omitted weakly stressed or nonstressed word-initial syllables in morphologically simple words (e.g., *pursuit* > /*sirsut*/ vs *misplace* > *place*). Note that their affix difficulty conformed neither to the prefix–suffix distinction, nor to the inflection–derivation distinction: They omitted derivational prefixes and inflectional suffixes, while preserving derivational suffixes. Note further, that these subjects were both nonfluent speakers. By contrast, the remaining, fluent aphasics produced errors that were primarily confined to inflectional endings, involving a variety of error types.

Summary and Conclusions

In examining the single-word repetition of aphasic subjects with phonological output deficits, we found that the accuracy of only three of the four subjects declined with morphologically complex versus simple targets. This finding suggests that the production of words with affixes may stress some, but not necessarily all, stages of the phonological output system (e.g., phonemic planning vs lexical–phonological access; Kohn & Smith, 1995).

When focusing on the morphologically complex targets, the pattern of repetition accuracy and distribution of errors according to affix type revealed that all subjects were sensitive to the morphological composition of words. Their performance exhibited the following order among different types of affixes according to the degree to which they disrupted performance ('<' means ''had less effect''): derivational suffixes < derivational prefixes < inflections. This order likely reflects the structure of lexical–phonological representations in the mental lexicon. Derivational morphology may be more closely associated with word stems, while inflections may be added at a later, postactivation stage of processing (see Miceli & Caramazza, 1988).

Finally, when focusing on the type of affix error, we observed two distinct patterns: (1) omission of prefixes and inflections; and (2) a variety of errors restricted to inflectional endings, which led to some nonlegal forms. While the affix errors were elicited during single-word production, the error pattern for the nonfluent subjects (i.e., prefix/inflectional omissions) is similar to the

affix errors associated with the agrammatic speech of nonfluent aphasics, while the error pattern for our fluent subjects is similar to the affix errors associated with the paragrammatic speech of fluent aphasics (i.e., inflectional additions, substitutions, and omissions). Thus, examining single-word production in aphasic speakers may provide insight into their sentence production difficulties.

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Reversed Effects of Familiarity and Novelty in Visual and Auditory Working Memory for Words

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Already young children can differentiate written words as they map local word structure. The effect of familiarity and novelty of word structure in visual and auditory working memory was investigated. Accuracy for spoken words increased with novelty of word structure, novelty causing a perceptual saliency effect triggering allocation of more attention. Written words were remembered best when familiar. It is concluded that for working memory, the effect of familiarity of word structure, also known as lexicality effect, is limited to written words. Familiarity and novelty effects were reversed in visual and auditory memory for words.

Introduction

Henderson (1982) and Rack (Rack, Hulme, Snowling, & Wightman, 1994) showed that already young children can differentiate written words as they map local structure of words. The present study investigates the effect of familiarity and novelty of word structure in visual and auditory working memory in children between five and nine years, systematically comparing mapping ''by ear'' and ''by eye.'' Because young children are more experienced in perceiving and mapping words in the auditory domain (Jusczyk, 1997), it was expected that familiarity should have a differential effect in modality-specific working memory performance and development.

Previous research on the development of working memory showed that

visual memory is normally the more efficient working memory subsystem in young children when picture names compared to spoken words are tested (Hitch & Halliday, 1983). However, when not pictures but written words are memorized, this could be different, because familiarity with written words is only beginning to get established in young children, while familiarization with spoken words started in infancy. This means that although young children's visual word recognition is functional, auditory memory might be better developed, and familiarity is expected to play a more important role in visual than in auditory memory for words.

Method

Participants. Sample size was $N = 92$ children, 33 five to six year-olds $M = 5;5$ years ($SD = 0;5$ years, range 57 to 78 months), 34 seven year olds $M = 7;7$ years ($SD = 0;3$ years, range 84 to 95 months), and 25 eight year olds $M = 8;3$ years ($SD = 0;3$ years, range 96 to 111 months). All children were from urban middle-class backgrounds, but of different ethnicity (German-speaking, English-speaking).

Material. Number words from one to ten were used as young children master these on a verbal level. First, proper number words were the most familiar. Second, rhymed words were less familiar than the proper number words. Word onset letters were added or exchanged, but except in the words ''one'' and ''two,'' where spelling/pronunciation rules varied, the rest of the rhymed words consisted of the same letters in the same sequence as in the proper number words, thus sharing some local word structure. Third, twisted words were the least familiar and most novel words in this experiment. The same letters as in the proper number words were used, i.e., all letters were conserved, but in a randomly twisted sequence, so that common local word structure with the proper number words was eliminated, but words were still pronouncable.

A reaction time/accuracy paradigm was used. Auditory stimuli were read by native speakers, digitized, and played back from the computer hard disk. Item sequence in presentation and test trials was randomized. Each word type was tested twice. Five to six year olds were tested for 4 memory items plus 4 distractors, the two older age groups for 5 items plus 4 distractors. In the visual condition, presentation time was 3000 ms and ISI 1000 ms. In the auditory condition, spoken word duration was shorter than 3000 ms, thus ISI was increased to match the visual condition. In the memory delay a red fixation star appeared for 2000 ms.

Procedure. Participants were tested individually in a separate room. Sequence of visual and auditory modality was counterbalanced.

Results

Preliminary analyses showed no modality sequence effect and no performance difference between English- and German-speaking children. A 3 (age)

by 3 (word type) by 2 (modality) MANOVA of reaction times in milliseconds was performed with repeated measures on the second and third factor. A significant effect of age was found ($F\,(2, 92) = 12.20, p = .000$). Contrasts (simple) showed that children showed reduced latencies at 7 years (5–6 versus 7 years $t = 3.92, p = .000$, 7 versus 8 years $t = -.20$, ns).

The same MANOVA model for accuracy in percent showed a significant effect of age ($F\,(2, 92) = 24.13, p = .000$), contrasts (simple) demonstrating increased accuracy at age 7 (5–6 versus 7 years $t = -5.44$, $p = .000$, 7 versus 8 years $t = .43$, ns). A significant interaction of age by modality ($F\,(2, 92) = 6.79$, $p = .002$) demonstrated that memory for spoken words was better in young children and improved little (age 5–6 $M = 70.6$, age 7 $M = 79.8$, age 8 $M = 77.7$), while memory for written words was worse in young children, but improved more (age 5–6 $M = 60.1$, age 7 $M = 84.5$, age 8 $M = 84.1$). Further, a significant two-way interaction of word type and modality ($F\,(2, 92) = 5.85$, $p = .003$) showed that spoken words were remembered the better, the more novel (proper $M = 72.3$, rhymed $M = 76.8$, twisted $M = 78.6$), while written words were remembered best when familiar (proper $M = 77.5$, rhymed $M = 74.2$, twisted $M = 75.2$).

Discussion

In the present memory task, both latencies and accuracy improved at 7 years, i.e., at the same time as engaged attention, reflected by dominance of alpha (alert) EEG activity (Cole & Cole, 1996, p. 483). As expected, visual memory was less accurate, but improved more dramatically. However, what triggered attention in a memory task for words varied according to input modality independently of age. In auditory memory, accuracy increased with novelty of word structure. Presumably, novelty of spoken words caused a perceptual saliency effect, triggering allocation of more attention and thus more accurate auditory memory performance. The reversed effect was found in visual memory, written words were remembered best when familiar, confirming the experimental hypothesis. The familiarity effect in written word recognition is also known as lexicality or word superiority effect (Henderson, 1982). However, for working memory, it must be concluded that this effect is limited to written words, as familiarity and novelty showed reversed effects in visual and auditory memory for words.

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Loss of Global Visual and Auditory Processing Following Right Temporal Lobe Lesion

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Theories of perception emphasize the difference in efficiency with which ''wholes'' and ''parts'' are processed by each hemisphere, the right hemisphere being associated with global processing and the left with local processing. Evidence in favor of this dissociation stems from studies of visual perception, although recent work suggests that it may also apply to auditory processing. We report the first case study that indicates a crucial role of the right temporal lobe in this global–local dichotomy for both visual and auditory processing. The patient, a child with a right-temporal lobe lesion, showed a loss of global perceptual processing that interfered with her recognition of hierarchical visual stimuli as well as with her discrimination of melodies.

Introduction

Theories of perception emphasize the difference in efficiency with which ''wholes'' and ''parts'' are processed by each hemisphere. Typically, the right hemipshere is associated with global processing and the left, with local processing (Bradshaw and Nettleton, 1981). This neurological dissociation stems mostly from studies of visual perception (Lamb et al., 1990) but recent work suggests that it may also apply to auditory perception (Peretz, 1990). Although studies with brain-damaged subjects have implicated the temporal lobe in the processing of both visual and auditory stimuli, there are as yet no accounts of a combined loss of visual and auditory processing following a temporal lobe lesion. The present study reports the first such case.

Material and Methods

Subjects. Case description. AR was 9 years old when she contracted herpes encephalitis. Premorbidly, she was a bright student who had successfully completed third grade. Following her illness, she appeared to have become

functionally blind in spite of having normal basic visual functions (visual acuity: 20/25 for both eyes) and average intelligence (Verbal IQ: 101). Typically, in the attempt to visually identify objects, AR used feature-by-feature descriptions. For instance, a box of matches would be described as ''a box with sticks inside, therefore, a pencil case.'' Similarly, her image reproductions relied on local segments and her visual matching depended solely upon recognition of discrete local features. For example, two different light bulbs would be correctly matched on the basis of their contact-sockets but erroneously identified as flowers ''because of their stems.'' At the time of testing (age 13), her object perception had improved but she still had problems identifying faces, animals, and fruits/vegetables without using stimulus-specific characteristics.

A neuroradiological examination showed severe loss of brain parenchyma of the right temporal lobe associated with the enlargement of the right temporal horn. On the coronal images, severe atrophy of the right hippocampal and amygdaloid formations was identified. Faint, ill-defined areas of increased signal in the deep white matter of both temporal lobes, at the temporo-occipital junctions, were also observed (see Schiavetto et al., 1997). For control, AR's performance was compared to that of 6 neurologically intact control subjects matched on the basis of age, gender, and IQ.

Visual Task

Visual hierarchical processing was assessed (Fig. 29A) by using a paradigm that dissociated local and global visual processing (Lamb et al., 1990). The task consisted of detecting two target letters (H and S) by pressing a left or right key when an H or S appeared, respectively. There were a total of 280 trials, each involving a target at either the global or local level. Each of the two targets was presented with a distractor (A or E) morphologically similar (congruent stimuli: S and E; H and A) or dissimilar (incongruent stimuli: S and A; H and E) to it (see Fig. 29A). The size of the global stimulus was 3° and stimulus duration was 200 ms.

Auditory Tasks

Task 1—Global/Local. The processing of local intervals and global contours in melodies (Fig. 30) was used as an auditory analog of the visual local–global distinction (Peretz, 1990). Two types of manipulation were applied to melodies generated by an IBM-compatible computer-controlled Yamaha TX81Z synthesizer. The analog output, preset to a MIDI-timbre, simulated the sound of a piano and was recorded on a digital tape. In each trial, a standard sequence (Fig. 30A) preceded a comparison sequence with a 2-s silence interval. One manipulation consisted of creating a contour-violated alternate melody by modifying the pitch of one tone (marked by an asterisk,

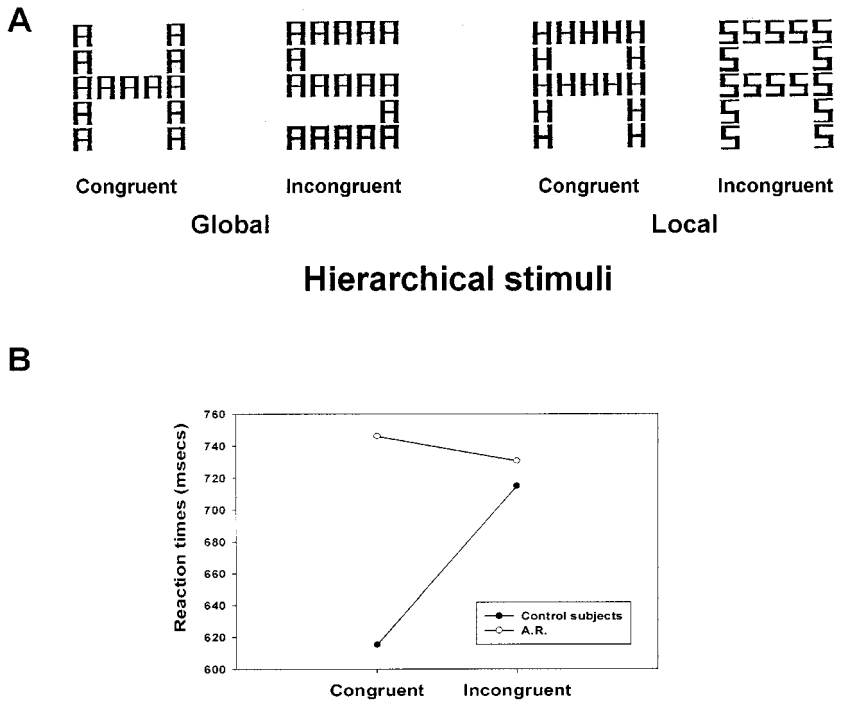

FIG. 29. (A) Hierarchical stimuli made of small or ''local'' letters embedded in large or ''global'' letters. For the purpose of clarity, the various conditions involving the target letters are presented with only one distractor, the letter ''A''. (B) Unlike controls, whose detection of local targets was slowed down when these stimuli were embedded in incongruent letters, AR did not show any difference in her response times between the congruent and incongruent conditions, thereby indicating that the global feature had no influence on her perception of the local targets.

Fig. 30C) so that it changed the pitch direction of the surrounding intervals while respecting the original key. A second manipulation consisted of creating a contour-preserved alternate melody by modifying the same critical pitch (also marked by an asterisk, Fig. 30B) to an equal extent (in terms of semitone distance) but conserving the original contour and scale. Each type of manipulation occurred in 30 blocked trials, with an equal number of SAME and DIFFERENT comparisons.

Task 2—Identification of melodies. AR was presented with musical excerpts of 30 highly familiar tunes, well-known by the time school children enter the first grade (Peretz et al., 1995). Each excerpt was presented without lyrics. The musical phrases presented were carefully selected to avoid the title (e.g. ''Morning bells are ringing'' rather than ''Brother John''). The

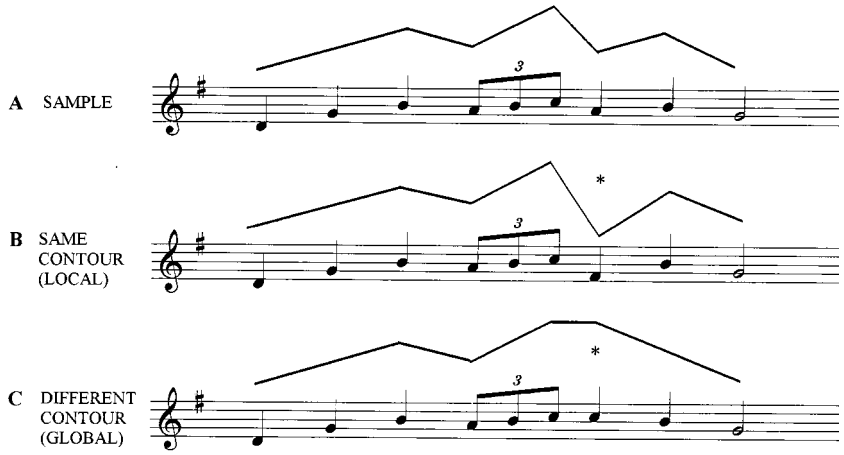

FIG. 30. Examples of melodies that were used for the auditory local/global task: (A) sample melody, (B) local transformation, and (C) global transformation (see text for details).

task consisted of naming the title of the song from which the excerpts had been extracted.

Results

Visual Task Although AR detected local stimuli as successfully as controls (AR: 137/140; mean RT: 747 ms; Controls: 138/140, mean RT: 771.5 ms), she was unable to detect any global stimuli (AR: 0/140; Controls 138/140). In order to verify whether the perception of the global stimulus interfered with that of the local one (Bihrle et al., 1980), an analysis was carried out on the local discrimination data (Fig. 29B). When the local target and global distractor were physically similar or congruent, normal controls gave faster reaction times than when the letters were dissimilar or incongruent ($p < .0001$). By contrast, AR's performance was almost identical for both congruent (746 ms) and incongruent (730.5 ms) letters. The absence of global interference on local processing indicates that she did not process, even unknowingly, the global letters.

Auditory Tasks

Task 1—Global–Local task. In melodies, contour (or pitch directions) is extracted earlier than interval sizes, thereby conferring an advantage in discriminating melodies that differ in contour (global condition, see Fig. 30C) over sequences that differ solely by their arrangement of local intervals (local condition, see Fig. 30B) (Peretz, 1990; Peretz and Morais, 1988). The superiority of contour as a discriminative cue was found in normal controls whose

performance in the global condition was often perfect and always exceeded 83%, with a systematically lower performance in the local condition (range: 73–96%). By contrast, AR performed as controls in the local condition, albeit in the low-normal range (73%), but was deficient in the global contour condition (73%). In both conditions, she based her judgments on the single change in pitch, exhibiting no sensitivity to the presence of the global factor as a discrimination aid. Thus, her lesion interfered with the representation and/or retrieval of global structure in the auditory modality.

Task 2—Identification of melodies. AR could only name 7 out of 30 highly familiar tunes (Controls: 29), all of which are typically known by age 6 (Peretz et al., 1995). Interestingly, when she recognized a melody, she only reported the lyrics corresponding to the musical segment heard (e.g., ''Morning Bells are ringing'' rather than ''Brother John'').

Discussion

Our findings indicates that a supramodal visual and auditory deficit may develop after a temporal lobe lesion and that this deficit can interfere with a number of functions, including the recognition of objects, faces, and music. In fact, our study shows for the first time a multimodal deficit in a disorder that had been primarily thought to be visuo-perceptual in nature. The loss of global auditory and visual processing following a right temporal lobe lesion not only indicates that the temporal lobe acts as a higher level multisensory integrating system, but also strengthens the notion of a hemispheric specialization in the cognitive processing of sensory information.

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Toward a Functional Explanation of the Locus of the Stroop Interference: A Psychophysiological Study

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The Event-Related Potentials (ERPs) of 15 subjects were recorded with 30 electrodes while they performed an analog version of the Stroop Color Word Test (SCWT). The task was divided in three parts: word, color naming, and Color/Word (CW). In the color/word block, subjects were asked to name the color printing in a different color. Results shows that P100 and P300 was not affected by the interference, but the succeeding SW was significantly delayed in latency and was larger in amplitude during the C/W experimental block. These results demonstrate that Stroop interference appears probably at a postevaluation level of information processing.

Introduction

The SCWT has been widely used in various forms and applications since its creation more than 60 years ago (Stroop, 1935). In the standard form, the subject is asked to name the color of a word printed in a conflicting color. Reaction times are normally slower in the conflicting situation, reflecting a typical Stroop interference. For many years, the Stroop interference has been associated with frontal-lobe functions (Golden, 1976), but several studies have indicated that the interference effect may best be explained by invoking a cognitive explanation (MacLeod, 1991). Indeed, the performance observed is generally dependent on the relative speed of processing each of the attributes contained in the stimulus (color and word). This speed difference is seen as critical when two potential responses compete for the actual response (Posner & Snyder, 1975). In the past decade, much effort has been made to integrate these localization and cognitive interpretations through the use of ERPs. These measures are derived from Electroencephalography (EEG) and represent the time-lock averaged EEG epochs related to the cognitive demands associated with a given stimulus. The present investigation aims at further studying the locus of the Stroop effect using ERPs and investigates the nature of the components that could be influenced by the Stroop manipulation.

Methods

Subjects. Fifteen neurologically intact women (mean age 22) with no history of pharmacological treatment participated in this study.

Experimental procedure. The stimuli were presented onto a computer screen and reaction times (RT) were recorded using a voice trigger. In the first condition, the subjects had to name the word of a color and then they

had to name the color of rectangles in the second. In the third, subjects had to name the color of the word that was printed in a different color. Each stimulus was presented on a white background for 100 ms and the intertrial interval varied randomly (2000–2200 ms).

EEG recordings and extraction of ERP data. EEG was recorded from 30 tin electrodes mounted in an electro-cap. The electrodes were placed according to the guidelines for standard electrode position by the American EEG Society at Fp1, Fp2, AF3, AF4, F7, F3, Fz, F4, F8, FC3, FC4, T7, C3, C1, Cz, C2, C4, T8, TP7, CP3, CP4, TP8, P7, P3, Pz, P4, P8, O1, Oz, and O2. The Electro-Oculogram (EOG) was recorded using 4 tin electrodes. The EEG signals were amplified by a bioelectric amplifier model ISS3-32BA (SA Instrumentation — InstEP-TALO). The early positivity (P100) was defined as the most positive peak between 80 and 120 ms and the succeeding P300 component was defined as the most positive deflection between 250 and 400 ms. Finally, the Slow Wave (SW) was defined as the most negative deflection between 400 and 900 ms poststimulus.

Results

The analysis of the P100 component revealed a more occipital maximum. However, the P100 showed no sensitivity to the interference effect, having similar amplitudes and latencies for the three conditions (word–color–color/word; 140 ms). The P300 component was maximal over the central region at 314 ms but failed to show any significant condition effect both for latency and amplitude measurements. The SW showed a similar latency and amplitude for the word (635 ms) and color (647 ms) conditions. However, the latency was significantly slower for the C/W condition (854 ms) and this effect was most marked over the parietal regions. The reaction times followed the same pattern as the SW with similar RTs for words (397 ms) and colors (453 ms) and a significantly longer latency in the color/word condition (707 ms). (See Fig. 31).

Discussion

Although the amplitude of the P100 component is thought to be related to early stages of selective attention (Mangun & Hillyard, 1990), our results concerning this component demonstrate that early cognitive processes are not affected by the Stroop interference effect. Concerning the subsequent P300, many studies have indicated that the latency of this component was related to stimulus evaluation and its larger amplitude to memory updating (Donchin, 1988). In the present study, the Stroop manipulation did not influence this component. Two possible explanations can be proposed to explain this absence of effect. The most obvious one is that cognitive processes related to memory updating and stimulus evaluation are not affected by the Stroop interference. A second explanation is linked to the nature of the task.

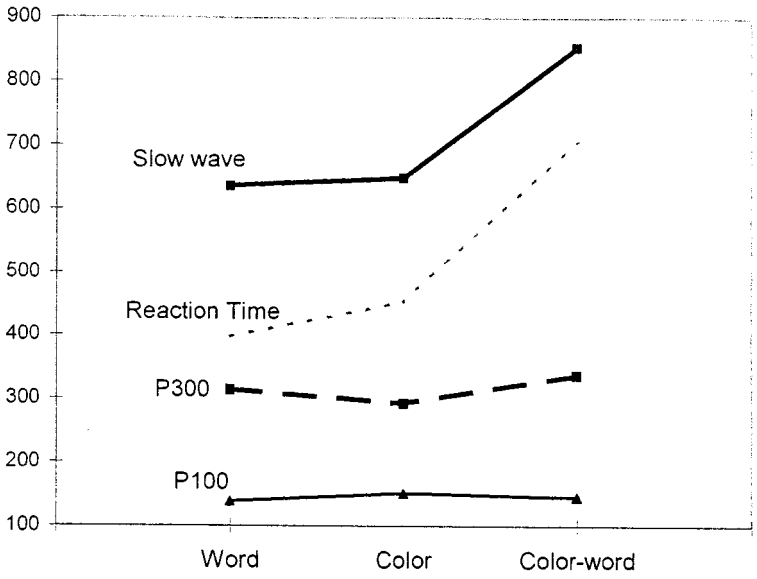

FIG. 31. Figure illustrating the latency of each component (P100, P300, and SW) for the three experimental blocks.

Normally, the standard P300 effect is seen during an oddball manipulation in which the rare stimulus presentation elicits a larger P300 amplitude than the frequent stimulus presentation. These parameters were not manipulated in our study since each block contained the same amount of trials. Despite a clear presence of the P300, it is not surprising to observe an absence of oddball effects in our task. More importantly, we also detected a major negative component following the response. Given its latency and distribution, this component appears to be a typical SW. The significance of this component is not as well documented as the earliest components, but Rosler and Heil (1991) have identified a parietal negative slow wave related to postevaluation and stimulus expectation. In our study, we observed a parietal, negative SW which was significantly delayed and amplified in the interference condition. Another study reported a slow negative deflection influenced by Stroop interference (Rebai, Bernard, & Lannou, 1997). These results may be attributable to the fact that expectations elicited by the Stroop interference task were greater than those induced by word or color naming. In brief, our study demonstrates that late cognitive processes are probably more involved than the early selective attention processes in the interference effect.

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