

REFEREED PAPERS

W-1. Event-Related Potentials during Visual Proverb Presentation in  
Some Patients in a Confusional State

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The core behavioral features of confusional states are alterations in level of arousal, disturbances of attention and impairment in the logical stream of thought (Geschwind, 1982 in Lee & Hamsher, 1988). Confusional states have been known by different names and the DMS-IV uses the term delirium which is characterized by a disturbance of consciousness, reduced clarity of awareness of the environment, easily distracted by irrelevant stimuli, and an accompanying change in cognition. The latter may include memory impairment, disorientation, language disturbance and perceptual disturbances. Behaviorally, these patients have been observed to show language and communicative impairments including metaphorical language use. The question thus arises at what level these patients show adequate semantic processing and at which point it breaks down. One means to investigate this question is to use the ERP technique, and in particular the occurrence of the N400.

The event-related potential (ERP) technique has been used to investigate the brain's responses to the processing of linguistic information such as lexical access, and semantic and syntactic processing. A large negativity occurring bilaterally in posterior areas about 400 ms after presentation of a semantically anomalous cue has been coined the N400 (Kutas & Hillyard, 1983, Kutas & van Petten, 1994) and is related to semantic processing. The N400 to semantic anomalies has, for example, been elicited in response to phonological mismatches, word pairs, random word lists, ambiguous words in context, faces, color patches, or pictures (for an overview see Segalowitz & Chevalier, in press).

The goal of our investigation was to investigate whether the N400 as an indicator of semantic processing could be elicited in patients in a confusional state using as stimuli highly automated language such as familiar proverbs and their "false" counterparts and to relate these findings to the patients' ability to interpret the proverbs.

### Method

*Stimuli.* The stimuli consisted of 150 German sentences, 75 of which were German proverbs whose overall familiarity had been established in previous research (Grzybek, 1991). The other 75 sentences were “false” proverbs in the sense that the last word or phrase of each proverb had been replaced by another word or phrase thus producing a semantically well-formed sentence, whose meaning was different from the one of the proverb it was derived from.

Example:

Proverb: *Der Apfel fällt nicht weit vom Stamm.*

(Literal translation: \*The apple doesn’t fall far from the stem).

“False” proverb: *Der Apfel fällt nicht weit vom Tisch.*

(Literal translation: \*The apple doesn’t fall far from the table).

*Subjects.* Subjects were 10 right-handed non brain-damaged controls and 4 right-handed patients in a confusional state.

*Tasks.* The stimuli were displayed word-by-word in black letters on a white background screen. Each word was presented for 1500 ms with an interword interval of 200 ms and an intertrial interval of 3200 ms. All subjects were instructed to simply look at the words on the screen and to decide silently for themselves whether the words formed a “correct” sentence or not. In case the patient was unable to read, the proverbs were presented auditorily through headphones.

In a second session, all subjects had to (a) do a proverb completion task, and (b) provide the meaning of the proverb by freely interpreting the proverbs and/or by a multiple-choice task.

Example for (a):

*Lügen* .....

Correct completion: . . . *haben kurze Beine.*)

(Literal translation: \*Lies have short legs.)

Example for (b), multiple choice task:

*Lügen haben kurze Beine.*

1. Wer lügt, dem werden die Beine abgehackt.  
(People who lie have their legs chopped off)
2. Wer lügt, der kommt nicht weit. (Correct interpretation)  
(People who lie won’t make it very far)
3. Wer kurze Beine hat, der lügt viel.  
(People who have short legs lie a lot.)

*Data analysis.* EEG activity was continuously recorded from 5 scalp Ag/AgCl electrodes (Fz, Cz, Pz, C3, C4) with reference to linked earlobes while the subjects were looking at the screen. The averaged ERPs were investigated for occurrence of the N400.

### Results

The N400 could be identified in the averaged ERPs for each individual control subject and each patient in response to “false” proverbs. The ERP amplitudes in response to the “false” proverbs in the 200 to 500 ms window were significantly different from the ERP amplitudes in response to the regular proverbs.

All control subjects were able to complete all proverbs correctly in a proverb completion task and to select from given alternatives the correct interpretation of all proverbs presented. Similarly, all patients were able to correctly complete all proverbs. However, all patients showed severe problems in matching the proverb with the correct interpretation; and free oral interpretation of the proverb was even more impaired.

### Conclusion

Highly automated language known to all patients was used as stimuli. The N400 was elicited in all patients in response to meaningful sentences, which, however, differed from the original proverb. Behaviorally, the patients were severely impaired in providing the meaning of the proverbs. This seems to be an indicator that the N400 does not specifically measure semantic processing at a higher cognitive level. Considering the severe neuropsychological deficits of the patients investigated such as attention, orientation, and memory problems, one wonders whether it was the disruption of automaticity or familiarity, or some sort of long lasting mismatch negativity that was responsible for producing the N400.

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## W-2. Working Memory Deficits in Alzheimer's Disease

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The phonological loop and central executive components of working memory were examined in patients with Alzheimer's disease (AD patients) and elderly controls. Patients with Alzheimer's disease showed reduced verbal spans, with smaller phonological similarity and word length effects. They also showed a decreased performance in tasks examining processing speed and articulation rate. However, phonological analysis was normal. With regard to the central executive, AD patients showed deficits in an alphabetical span task in which subjects were asked to recall a random series of words in their alphabetical order, while they performed normally on a dual task in which they had to perform simultaneously a digit repetition and a visuo-motor task. These results suggest that Alzheimer's disease may affect several components of working memory but all aspects of the central executive mechanism are not necessarily affected.

### *Introduction*

Working memory has been found to be impaired in Alzheimer's disease (AD). Most studies reported reduced verbal spans although the different subcomponents of the phonological loop (phonological store and articulatory rehearsal system) appeared to be intact in the disease (Morris, 1984, 1987). As AD patients also exhibited specific impairments in dual tasks (Morris, 1986; Baddeley, 1991), the hypothesis was made that the AD working memory deficit could result from an impairment affecting the central executive (Morris, 1984). However, recent data observed that a specific phonological loop deficit (more precisely of the phonological store) may also exist in AD patients, in addition to a central executive dysfunction (Belleville, Peretz & Malenfant, 1996). Given these contradictory results, the aim of this study was to re-evaluate the functioning of the phonological loop and central executive in a single group of patients.

### *Methods*

Ten subjects meeting the NINCDS-ADRDA criteria for probable or possible Alzheimer's disease and 11 elderly controls were evaluated on different

working memory tasks. The articulatory rehearsal mechanism and phonological store were examined by comparing the span performance for respectively short and long words and for similar and dissimilar words.

Articulation rate was measured by asking subjects to repeat five times two mono-syllabic words as rapidly as possible. We also investigated the capacities of phonological discrimination. The central executive component was examined by means of a dual task (Greene et al. 1996) in which one task was to give continuously sequences of digits at the subject span and the second was to present a trail of boxes which the subjects were required to place a cross in each box, following the trail. Both tasks were firstly executed separately and thereafter simultaneously, during 2 minutes. We also administered the alpha span task (Belleville et al., accepted) evaluating the manipulation capacities of the central executive, in which subjects were asked to recall a random series of words in their alphabetical order. The storage demand was equalized across subjects by adjusting the list length according to individual span. Finally, processing speed was evaluated in both groups. The measure used was correct response time to decide if two presented letters are similar.

### Results

AD patients had inferior results to the control group for processing speed [ $t(18) = 2.29, p < 0.05$ ], digit span [ $t(19) = 3.89, p < 0.05$ ], word span [ $t(19) = 3.89, p < 0.001$ ] and articulation rate [ $t(19) = 3.43, p < 0.005$ ].

However, no differences were observed in phonological discrimination abilities [ $t(16) = 1.41, p = 0.18$ ]. Concerning the phonological similarity effect, a 2 (group)\*2 (similar/dissimilar words) ANOVA showed a group effect [ $F(1, 19) = 11.71, p < 0.005$ ], a type of word effect [ $F(1, 19) = 29.72, p < 0.0001$ ] and an interaction between group and type of words [ $F(1, 19) = 11.37, p < 0.005$ ], indicating that AD patients had a smaller phonological similarity effect than controls. The word length effect was evaluated by a 2 (group)\*2 (short/long words) ANOVA which revealed a group effect [ $F(1, 19) = 12.99, p < 0.005$ ], a type of word effect [ $F(1, 19) = 61.65, p < 0.0001$ ] and an interaction between group and type of words [ $F(1, 19) = 5.19, p < 0.05$ ]. With regard to the central executive, the alpha span task showed that AD patients were impaired in manipulating information compared to elderly subjects [ $t(16) = 3.83, p < 0.005$ ]. However, for the dual task, both groups had a similar decreased performance when the performance for the execution of both tasks separately was compared to that of both tasks performed simultaneously [ $t(16) = 1.51, p = 0.15$ ]. No significant correlation was observed in AD patients between span tasks, capacities of central executive, speed processing and articulation rate. However, in control subjects there was a significant correlation between short word span and processing speed ( $r = -0.79, p < 0.01$ ), short word span and articulation

rate ( $r = 0.63$ ,  $p < 0.05$ ), long word span and articulation rate ( $r = 0.63$ ,  $p < 0.05$ ), digit span and repetition of digit sequences in dual task ( $r = -0.83$ ,  $p < 0.005$ ), word span and manipulation of information in alpha span task ( $r = 0.81$ ,  $p < 0.05$ ).

### Discussion

These results suggest that Alzheimer's disease may affect several component of working memory, namely the phonological store, the articulatory rehearsal system and the central executive mechanism.

Concerning the central executive, results show that some aspects of functioning may be impaired while other aspects are not affected in the same way and that Alzheimer's disease does not necessarily affect dual task coordination in the early stages of the disease.

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## W-3. Activation-Inhibition Processes and Implementation of Hemispheric Lexical Competence

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The right hemisphere (RH) is usually thought to subtend an incomplete lexicon limited to short and high-imagery words, but this issue remains controversial. Intra-hemispheric activation and interhemispheric inhibition can be viewed as regulatory mechanisms of cerebral activity : manipulating these mechanisms, the aim was to investigate the upper-limits of RH lexical competence. Eight normal right-handed

subjects performed a lexical decision task presented tachistoscopically in divided visual field, while keeping 2 or 6 items in memory. Memory load consisted in either words or shapes. Particularly, it was hypothesized that the 2-words-load may activate the left hemisphere (LH), and strengthens cross-inhibition on the RH, and that the 6-words-load may overload the LH and allow for a release of inter-hemispheric inhibition. As expected, left visual field-RH lexical decision performance markedly improved as concurrent word-load increased, specially for long and low-imagery words. These data suggest that the RH can mediate a complete lexical-semantic network and that the accessibility threshold of these representations can be modulated by interhemispheric inhibition, as well as by intrahemispheric activation as suggested by our previous work.

#### W-4. "Syntactic" Processing of Complex Numbers: Neuropsychological Study

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The production of syntactic errors of various types by single patients in number transcoding tasks has been interpreted as resulting from a dissociation between dealing with arabic script (impaired) and dealing with alphabetical script (preserved). This interpretation does not hold for patient R.M., who makes syntactic errors in a variety of tasks, including some, never administered before, that do not use the arabic code and yet need syntactic competence. A genuine disturbance to a syntactic component is a more likely interpretation for R.M.'s as well as previously described cases.

#### *Introduction*

The production and comprehension of complex numbers has a syntactic component that in production is assumed to be shared between the written and spoken modalities (see McCloskey, 1992). A disturbance to this component would provoke "syntactic errors" (Deloche and Seron, 1982). These errors involve the syntactic assembly of the number's elements: on the whole, this type of error does not respect the number's magnitude while the lexical elements are left intact (e.g. 83 may be transformed into "eight hundred and three"\*).

We describe here the case of patient R.M. who makes exclusively syntactic errors in a series of number transcoding tasks. We will argue that his performance, very similar to that of previously described patients, may well be explained with a single specific deficit of the syntactic production mechanism.

#### *Case Report*

R.M. was a 62-years-old cattle dealer with 7 years of education, in the early stages of an Alzheimer's disease. At the time of this study he was alert

and co-operative. A mini-mental state examination obtained a score of 27/30. R.M.'s language was fluent, free of syntactic problems and only occasionally affected by anomia. No reading or writing disorders were present. Mild memory problems and apraxia were detected. In a routine assessment of calculation abilities the most evident disturbance was in reading Arabic numbers. This led to the present study.

*Experimental investigation on numbers and calculation.* R.M. counted normally from 1 onward and from 99 backward. His digit span was 6. He was good at personal and non personal number facts and cognitive numerical estimates.

His written calculation was good: in particular he was slow but 100% correct with additions and subtractions of 4-5 digits plus or minus 4-5 digits and with multiplications of 2-3 digits and results of 4-5 digits. Mental calculation was excellent with simple numbers. With more complex ones R.M. could still perform correctly in about a half of additions and subtractions. However when the result represented a shift in magnitude order with respect to the first operand (e.g. 105-10) he was never able to provide a correct answer, errors being of the syntactic type.

He could always detect spoken or alphabetically written non existing numbers (i.e. "forty fifteen"), and he could match easily spoken to written Arabic or alphabetic numerals.

R.M.'s performance was perfect (100% correct) on magnitude judgements with homogeneous codes (oral and written presentation) while he was 93% correct with dishomogeneous codes. He was perfect (100% correct) at "what comes next?" tasks only if the code or the magnitude order did not change in the problem. In these latter cases his performance dropped to 50% correct. R.M. could not build a number (orally or in writing) from separately presented digits (he failed in 100% of the cases). He finally failed in the following transcoding tasks: reading aloud of Arabic numbers (51% correct), dictation of Arabic numbers (86%), Arabic to written number names transcoding (72%) and vice versa (65%). In all these tasks errors were only of the syntactic type. An analysis of these errors revealed, however, that they were determined by a variety of violations including: (a) "decomposition" errors the most frequent of various type (for example instead of 215: 20015 or 2, 15; instead of 2015: 2, 0, 15); (b) "zero" errors: with deletions, additions that were not determined by decompositions, or transpositions of zeros; (c) "mis-ordering" errors (1151 instead of 1511).

### *Discussion*

Published cases showing a large majority of syntactic errors in number transcoding may be divided into two categories. A first group of patients (e.g. those of Cipolotti, Warrington and Butterworth, 1995 or Noël and Seron, 1995) makes only one type of syntactic error, thus showing the loss of one specific syntactic rule. Other patients, more similar to R.M., make

instead a wide variety of syntactic errors. Their disturbance has been, however, interpreted (e.g. Cipolotti, 1995) as resulting from a dissociation between reading Arabic script (impaired) and reading alphabetical script (preserved). This interpretation is very unlikely for R.M., since his difficulties with arabic script appear only when the task is demanding in terms of syntax and, more importantly, since his syntactic disturbances appeared also in syntax demanding tasks that did not, however, imply the use of arabic script (like building a number orally from separately orally presented digits).

In conclusion, all failures found in R.M. can be accounted for by positing a disturbance to a unique syntactic processor, whose production mechanisms would be disrupted (no positive evidence was found of a syntactic comprehension problem). Indeed all tasks where R.M. fails (and where he commits syntactic errors) are those (like Arabic numbers reading) where syntax must be generated with little or no help. On the contrary, R.M.'s performance is perfect on tasks where syntactic information is made explicit in the stimulus (like in reading number names) or can be ignored (like in written calculation). Since R.M.'s linguistic production and comprehension were not agrammatic, this syntactic component has to be number specific.

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### W-5. Psychophysiological Evaluation of Treatments on Visual Attentional Processes in Young Girls Who Survived to Acute Lymphoblastic Leukemia (All)

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Cranial irradiation (CI) and intrathecal chemotherapy (IT-C), while decreasing the risk of CNS relapse in ALL, have neurotoxic effects. The long-term effects of

IT-C or a combination of IT-C and CI on visual attention were evaluated in girls. While the smaller differences between the reaction times for the two conditions obtained in the IT-C group may be related to a different strategy in resources allocation, the shorter latencies obtained on a prefrontal positivity (PP) in irradiated patients could be related to an incomplete maturation of the prefrontal lobes or a dysfunction of the connections between the basal ganglia and prefrontal lobes.

### *Introduction*

ALL is a frequent cause of mortality in children. Today, treatments of ALL allow full recovery in 91% of the patients (Sallan & Dalton, 1996). Cranial irradiation (CI) and intrathecal chemotherapy (IT-C) decrease the risk of CNS relapse but meanwhile, have neurotoxic effects. Research has demonstrated the negative late effects of anticancer treatments on cognitive functioning, especially in irradiated girls (Mulhern, 1994). Moreover, they seem to affect cognitive processes as revealed by IQ attentional indexes (Brown & Madan-Swain, 1993). In order to obtain more specific attentional measures, a psychophysiological approach was used.

### *Methods*

*Subjects.* Three groups of girls aged between 6 and 11 years were evaluated: 10 treated with IT-C only, 9 with IT-C+CI and 10 normal controls. For the experimental groups, an 18 month post-treatment period, an absence of CNS leukemia and a complete remission at testing time. Controls had a normal range IQ and no psychiatric diagnosis excluding simple phobia. There were no significant differences between groups for age, but a significant difference was obtained for the Full Scale IQ (FSIQ) with the irradiated group having a lower mean (92.12) compared to the control group (110.8).

*Task.* A 10 minute visual "oddball task" was used. 120 stimuli consisted of a moose (frequent stimuli) while the 40 others consisted of a raccoon (rare stimuli). Subjects were asked to press, as accurately and as fast as possible, one of two buttons placed in front of them : left button/left hand for the moose and right button/right hand for the raccoon. The rare stimuli constituted the more attentional demanding condition, usually characterized by more errors, longer reaction times, larger amplitudes and longer latencies for event-related potentials (ERPs) when compared to frequent stimuli.

*Measures.* EEG was recorded from 30 electrodes placed according to 10-20 system-revised (Jasper, 1958) and averaged to obtain the ERPs. The maximum positive peak comprised in a 325 to 1000 ms window was selected on each electrode. Five electrodes groupings were made: prefrontal (4 electrodes), frontal (7 electrodes), central (5 electrodes), parietal (7 electrodes) and occipital (3 electrodes).

### *Results*

Due to the lack of distribution normality and variance homogeneity, non-parametric tests were used: Kruskal-Wallis (KW) to evaluate group differ-

ences, and Mann-Whitney U tests to locate the significant differences. Dependent variables were: number of errors and reaction times (RT), PP amplitudes and latencies on the five scalp regions.

The descriptive statistics showed the following pattern: the IT-C and IT-C + CI group had longer reaction times for the frequent stimuli (IT-C: 594ms 125 and IT-C + IC: 563ms 121) when compared to controls (506ms 60) and a similar trend was found for the rare stimuli (IT-C: 611ms 140, IT-C + CI: 632ms 142, controls: 541ms 57). The IT-C group was slower for the frequent stimuli and the IT-C + CI group for the rare. However, no significant differences between groups were found on these variables or for the number of errors. Nonetheless, we found a significant group effect for the reaction time difference (K-W(2 = 7,39);  $p < 0,05$ ): the IT-C group showed a significantly smaller difference between rare and frequent (17ms 48) stimuli than the control (34ms 35) ( $p = 0,05$ ) and T-C + CI groups (68ms 32) ( $p < 0,05$ ).

No significant group differences were observed on PP amplitudes and latencies. Meanwhile, on the prefrontal region, the IT-C + IC group tended to have smaller mean PP latency (610ms 126) than both the IT-C (758ms 140) and control (709ms 112) groups (K-W(2 = 5,45);  $p = 0,065$ ).

### *Discussion*

Our results suggest that the IT-C group processed equally frequent and rare stimuli while the IT-C + CI and the control groups processed them differently. However, we can observe that, even if not significant, IT-C + CI group showed the slowest reaction times for rare stimuli. It appears that the two experimental groups tended to use different strategies.

At an electrophysiological level, we observed a tendency to have shorter PP latencies for the rare stimuli in the IT-C + CI group. These results could reflect a particular vulnerability of the frontal region at the time of the irradiation induction (Rodier, 1979). It could also be related to the physiopathological model that some authors have proposed to explain frontal lobe deficits observed in irradiated patients. This model depicts a disruption of the connections between the basal ganglia (particularly affected by irradiation) and the frontal lobes (Brown & Madan-Swain, 1993). Both regions are involved in attentional processes.

Überall et al. (1996) showed significantly longer P300 latencies for the rare stimuli in IT-C + CI group compared to IT-C group and normal control children on an unspecified region. They also showed, significantly smaller P300 amplitudes in the left frontal region (associated with concentration difficulties) in the IT-C + CI group compared to the IT-C and control groups. However, the subjects of the latter study were older and had a 7 year post-treatment duration average. This suggests that brain functioning deficits could slowly increase with time elapsed from treatment. The present study underlines that ERPs could provide useful tools in the evaluation of cognitive development in long-term survivors of ALL.

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## W-6. Response Regulation in ADHD Children: Brain Preparatory Processes in a Spatial Stimulus-Response Compatibility Paradigm

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Carefully selected hyperactive children were compared to matched controls in a stimulus-response compatibility paradigm to investigate response organization in ADHD. Brain activity over the motor cortices was recorded while subjects responded to arrows with the compatible (same direction as arrow) or incompatible (opposite to arrow) hand depending on the color of the stimulus. Behavioral results indicate that the hand used to respond is an important factor in differentiating the groups. On the basis of computed Lateralized Readiness Potentials, we discuss the hypothesis of a regulation problem in the control of the dominant hand in the motor stage of information processing for hyperactive children.

### Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most prevalent childhood psychiatric disorders. Although its name suggests an encoding deficit, recent evidence pointed to a response organization deficit in ADHD (Robaey, 1993 for a review). Behavioral and pharmacological studies locate the deficit and the effect of medication on the motor output of information processing. In a pilot study, we tested the hypothesis that ADHD children have difficulty inhibiting a prepotent response in the period in which the alternative appropriate response is being initiated and executed. Behavioral measures were used in combination with Lateralized Readiness Potentials (LRPs), a measure of the differential activation of the two hemispheres, which indexes motor preparation (Coles, 1989).

## Methods

*Subjects.* Eight 6 to 9-year-old right-handed boys were diagnosed with ADHD on the basis of a semistructured psychiatric interview (DISC 2.3) administered to the parents by a trained psychiatrist. Except for oppositional disorder (a frequent co-morbidity) and enuresis, encopresis and simple phobia (frequent in young children), all psychiatric diagnoses, as well as an abnormal neurological examination and/or an  $IQ < 85$  were exclusion criteria. Finally, all our ADHD subjects presented very high hyperactivity score(s) (at least two standard deviations superior to the mean) on one or both Conners Parent and Teacher Rating Scales (Goyette, Conners and Ulrich, 1978), and were characterized as inattentive *and* hyperactive-impulsive according to the DSM IV. Eight right-handed non-hyperactive (CTL) boys (no psychiatric diagnoses, normal score on the Conners Scales, a normal neurological examination and an  $IQ \geq 85$ ) were matched on age with each ADHD subject (2 months maximum difference).

*Task.* In a 20-min mixed stimulus-response compatibility paradigm, children were instructed to squeeze one of two dynamometers as accurately and as fast as possible in response to a left or right-pointing arrow presented on a computer screen. The color of the arrow determined whether the response was to be compatible (e.g. right arrow–right-hand squeeze) or incompatible (right arrow-left squeeze; experimental condition). Three-hundred stimuli were presented one at a time for 350 milliseconds, with an intertrial interval varying from 2500 to 3000 ms. Stimuli were divided in 4 categories: 100 compatible arrows pointing to the left (left-hand response), 100 compatible arrows pointing to the right (right-hand response), 50 incompatible arrows pointing to the left (right-hand response) and 50 incompatible arrows pointing to the right (left-hand response). A one-minute pause was inserted every 50th stimulus.

*Measures.* Behavioral (response times and accuracy) and EEG measures were performed while the child was doing the task. For each subject, the electrical activity measured over the motor cortices (electrodes C3-C4) was averaged over all correct responses within each condition for each hand, providing event-related potentials (ERPs) in which activity not relevant to the task is canceled out. A right-left amplitude subtraction was then performed on these ERPs to obtain the differential activation of each hemisphere before the response, or LRPs.

## Results

Accuracy analyses showed a GROUP X HAND interaction ( $p < .05$ ). All differences were in favor of control subjects, with the most important difference in the right incompatible condition (13.75%; other differences were 4% for left-hand incompatible, 7.5% for the left-hand compatible and 6.25% for the right-hand compatible).

Analyses of adjusted reaction times (Enns and Cameron, 1987) suggest a tendency for ADHD children to be *faster* than CTL with their left hand in the compatible condition, a tendency which *decreased* for incompatible trials. In contrast, ADHD subjects tended to be *slower* than CTL with their right hand for compatible trials, with this difference tending to *increase* for incompatible trials (GROUP X CONDITION X HAND,  $p = .06$ ).

For all subjects, LRPs' showed a negative peak around 100 ms before the response, which was maximum on the central regions contralateral to the responding hand. In the 600-200 ms preceding the response, this negativity was larger on the ipsilateral central regions, reflecting the activity of the cortex controlling the non-responding hand. The maximum peak in the 600-200 ms window was selected on the C3-C4 electrode (LRP400). Only descriptive statistics could be performed because of the small number of subjects. ADHD subjects showed a similar amplitude to CTL for left-hand responses ( $-3.4 \mu\text{V}$  for ADHD and  $-2.52 \mu\text{V}$  for CTL), while their right-hand response amplitude was diminished as compared with CTL ( $0.15 \mu\text{V}$  for ADHD and  $-2.64 \text{V}$  for CTL). These differences were larger for incompatible trials.

### Discussion

The results obtained from the accuracy (GROUP X HAND) and response time (GROUP X CONDITION X HAND tendency) data underline the importance of the hand factor in comparing the two groups on this task. The differences obtained with the psychophysiological data, although not statistically significant, suggest that during the 600-200 ms period preceding a right hand response, the cortices corresponding to both the non-responding hand and the responding hand were equally active in ADHD children, canceling out the difference between hemispheres. In contrast, the cortex corresponding to the non-responding hand was most active in CTL. A possible explanation for these data would refer to regulation problems in the control of the dominant hand during the motor output stage in ADHD children. Power analyses having set to twenty the number of subjects needed to detect a significant difference with such data, we will present the analyses of data just obtained in 20 ADHD and 20 CTL children.

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## W-7. Autism Etiology: A Face-Processing Perspective

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Despite numerous reports of brain differences, no convincing account has been offered relating implicated anatomical and neurochemical deficits to autism's pathognomic social, communicative, and obsessive/repetitive features.

Anxiety and affective disorders appear to be strongly related genetically, share high rates of diagnostic and symptom comorbidity, and take non-genetically-determined forms of expression (Andrews, Stewart, Allen, & Henderson, 1990). Earlier onset may be related to greater genetic penetrance (e.g., Battaglia et al., 1995).

This paper argues that autism may be the resultant of very-early-onset anxiety/affective disorder, consequent interruption of establishment of face-processing during a biologically important period. In this account, brain differences in autistic individuals reflect (1) underlying pathology shared with 'typical' neuropsychiatric disorders, and (2) subsequent atypical developmental experiences.

The universality and adaptive importance of infant-caregiver eye-contact and social interaction are recognized. Social communication in infancy is not seamless, however: infants frequently find the level of stimulation overwhelming, and intermittently withdraw (Parritz, Mangelsdorf, & Gunnar, 1992). It is suggested that early or precursor anxiety disorder symptoms could subvert typical infant self-regulatory behaviors into a maladaptive aversion to social interaction. If sustained through the period during which the infant's visual system is characterized by low spatial resolution, it may prevent the establishment of configurational perception and undermine later development of joint attention, social referencing and language (Trepagnier, 1996).

Autism is genetically determined (Bailey et al., 1995). Family studies, which have generally looked for one or two specific anxiety or mood disorder diagnoses have nevertheless found elevated incidence of anxiety and/or affective disorder among first degree relatives of autistic probands (e.g., Smalley, McCracken, & Tanguay, 1995). Recent discoveries of soft signs in 'typical' anxiety/affective disorder patients are consistent with a shared underlying pathology hypothesis, e.g., findings of vestibular dysfunction, of-

ten associated with autism, in persons with panic disorder (Jacob, Furman, Durrant, & Turner, 1996).

Studies of autistic individuals show anomalous face-processing, for identification and emotion interpretation, in contrast to non-autistic controls matched for verbal and nonverbal test scores, despite comparable performance in non-face, non-configuration tasks (e.g., Tantam, Stirling, Mognaghan, & Nicholson, 1989), and qualitative and quantitative atypicality of social gaze (e.g., Phillips, Baron-Cohen, & Rutter, 1992). These findings are consistent with unawareness of face-borne information due to failure of early developmental processes, rather than alternative explanations, such as more general perceptual deficits, or social unease.

This hypothesis points to a need for studies of autism to include reference populations with pediatric psychiatric disorder, and a need for further investigation of autistic face and configuration-processing. It also suggests that the early intensive behavioral interventions which have had the best success so far with autistic children (Lovaas, 1987) should include processing face-borne information as a treatment target. The long-term goal will be to identify infants at risk and intervene before atypical development is established.

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### W-8. Lexicon Size and Foot Preference in the African Grey Parrot (*Psittacus erithacus*)<sup>13</sup>

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To study footedness and lexicon size in African Grey parrots, an international survey of parrot owners was conducted. Responses were obtained from 524 individuals, including 70 owners of African Grey parrots (all animals  $\geq 10$  months old). Right-footed African Grey's ( $N = 36$ ) had significantly larger lexicons than left-footed African Grey's ( $N = 34$ ;  $p = .01$ ). This difference could not be accounted for by group differences in training efforts or socialization/housing with conspecifics. Other investigators have provided convincing evidence of lateralization, in the avian brain, for the analysis and memory of differing types of stimuli. In addition, there appears to be preferential left hyperstriatal activation for long-term memory consolidation. Our results suggest a relationship between lateral asymmetry for motor preference and asymmetric CNS mediation of a "higher cognitive" function (i.e., the categorization and long-term mnemonic processing of human speech sounds).

Functional hemispheric asymmetry may well be a fundamental feature of all vertebrate brains (cf. Bauer, 1993; Cantalupo, Bisazza, & Vallortigara, 1995; Fabre-Thorpe, Fagot, Lorincz, Levesque, & Vauclair, 1993). With regard to asymmetry for limb preference, most agree that there is limb dominance in an animal that is neither primate nor mammal, that is, the parrot (Snyder, Harris, Ceravolo, & Bonner, 1996). Indeed, Corballis (1983, p.116) suggested that foot preference in parrots constitutes "the most striking analogy to human handedness."

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Parrots are also among the relatively few species that can acquire a large number of novel human speech sounds. It might be supposed that inasmuch as human beings show cerebral dominance for handedness as well as for speech, then, by extension, we might expect to find cerebral dominance in any non-human species, like parrots, that shows handedness (or footedness) along with a well-developed capacity for vocalization.

### *Method*

Data from parrot owners were solicited by means of a 10-item questionnaire published in *Bird Talk Magazine* (Snyder, 1995). The questionnaire and methods for testing foot preference have been described by Snyder et al. (1996).

### *Results*

Responses were received from parrot owners throughout North America, Europe, and Australia. Of 524 animals, 91 were identified as African Grey Parrots (genus *Psittacus*). The African Greys had the largest lexicons by far, and all other genera showed a "floor effect" (e.g., all 51 Macaws were reported to have learned  $\leq 10$  words).

Of the 91 responses from owners of African Greys, 64 owners provided lists of their pets' vocabularies. Each word was counted only once, regardless of word-length. No relation was found between training effort and lexicon size, and the lexicon size for the 43 parrots housed alone did not differ from that of the 48 group-housed animals.

Of the 70 African Grey parrots who were  $\geq 10$  months old, 34 were left-footed and 36 were right-footed. The right-footed parrots had larger vocabularies (Mean = 87.33 words,  $SD = 73.98$ ) than the left-footed parrots (Mean = 49.57,  $SD = 50.30$ ), and this difference was significant ( $p = .01$ ). Despite substantial variability in lexical size in both groups, as shown by the large standard deviations, this significant difference is associated with a medium effect size of .69.

### *Discussion*

Other than an early report by Grzimek (1949), ours may be the only one to search for and to find a relation between lateral motor asymmetries in parrots and vocal capacity as indexed by the ability to learn and remember human speech. The question still remains, why is footedness related to lexicon size at all? Lexical size does *not* represent merely the motor output of typical non-species vocal calls, but rather reflects the learning and memory for human speech sounds. The distinction is important because, although there is likely to be bilateral innervation of the syrinx in support of the motor control for vocalization within order *Psittaciformes*, there is ample evidence

that, within the avian brain, each hemisphere is differentially involved in memory formation (Rogers, 1993). For example, lesion studies of chickens have shown that the intermediate medial hyperstriatum ventrale (IMHV) region of the left hemisphere is involved in both early and later stages of memory formation and storage. In contrast, the right hemisphere IMHV region appears to be more preferentially involved in the early stages of memory processing (Cipolla-Neto, Horn, & McCabe, 1982). Further evidence for hemispheric lateralization of memory formation, in this case for imprinting memory in chicks, appears in the form of clear changes in synaptic density within the left, but not the right, IMHV (Bradley, Horn, & Bateson, 1981). Imprinting memory also is associated with a significant increase in the number of NMDA receptors in the left, but not the right, IMHV (McCabe & Horn, 1988).

Evidence also suggests that the left and right hemispheres of the avian brain are differentially specialized for the analysis and encoding of specific categories of stimulus attributes. For example, it has been proposed that, at least for the chicken, the right IMHV adds "depth" of processing of a new association by contributing contextual information during learning, such as topographical, spatial and social cues, the detection of novelty, and/or visual identification of conspecifics (Horn & Johnson, 1989; Vallortigara, 1992; Vallortigara & Andrew, 1991). Conversely, the left hemisphere appears to lead in the categorization of objects during encoding for later recall (Vallortigara, Regolin, Bortolomiol, & Tommasi, 1996). Given this evidence for hemispheric specialization in the chicken brain for different aspects of stimulus analysis, recognition, and/or encoding for later recall, is it possible that in the parrot brain one hemisphere (i.e., the left hemisphere) is also more involved in the encoding of new words into a parrot's lexicon?

As mentioned above, vocabulary size depends primarily on the parrot's ability to learn, rehearse, and memorize novel vocal calls that are not species-specific. Furthermore, any parrot owner will attest to the fact that parrots form associations so that certain words are used in the same situations, and to mark particular events. Parrots' use of human speech sounds suggests that parrots can classify sounds along a variety of dimensions. We propose that the development and use of a verbal lexicon depends, at least in part, on the "categorizing properties" of the left hemisphere.

In summary, although careful functional neuroanatomic examination of the memory system in the psittacine brain has not been explored, there is ample evidence for lateralization of the avian brain in other families (e.g., chickens), indicating preferential left IMHV involvement in long-term consolidation of information for later recall, as well as left-hemisphere specialization for the categorization of information. The current results suggest that right-footedness in the African Grey parrot represents a behavioral index of contralateral hemispheric specialization for both motor control and for other (cognitive) functions.

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## W-9. Working Memory Deficits in HIV-1 Infection

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Working memory can be defined as the temporary storage of information while processing the same or other information. Because recent research has implicated frontal-subcortical circuits in working memory, it was hypothesized that individuals with HIV-1 infection may demonstrate working memory deficits because of the affinity of the disease for frontal-subcortical circuits. Twenty HIV-1 positive individuals and 20 seronegative controls were administered the calculation span (C-

span) task developed by Daneman and Carpenter. Results indicated that only seropositive subjects who met criteria for AIDS differed from control subjects on the C-Span. Thus, as assessed by the calculation span task, working memory deficits are evident only in later stages of HIV-1 infection.

### *Introduction*

Working memory can be defined as the temporary storage of information while processing the same or other information (Baddeley, 1986; Saltouse & Babcock, 1991). There are several compelling reasons to assume working memory may be affected in HIV-1 dementia: (1) HIV-1 infection has been demonstrated to affect frontal-subcortical circuits (Navia, 1986; Cummings, 1990) (2) current research has implicated the role of frontal-subcortical circuits in working memory (Williams & Goldman-Rakic, 1995), and (3) speed of information processing has been demonstrated to be slowed in HIV-1 infection, only with the increase in cognitive load; i.e. choice reaction time demonstrates differential slowing, but simple reaction time does not (Martin et al., 1989, 1992; Law et al., 1995; Miller et al. 1991).

In the current study, we investigated the possibility of diminished capacity in working memory as a potential mechanism of cognitive dysfunction in HIV-1 infection. We administered the Calculation Span, a task that includes both a storage component and a processing component (Daneman & Carpenter, 1980) that gradually increases storage load while pace is kept constant. We hypothesized that if working memory is affected in HIV-1 infection due to frontal-subcortical pathology, then HIV-1 infected individuals would demonstrate a diminished capacity in working memory as assessed by the Calculation Span.

### *Method*

*Subjects.* Experimental subjects were 20 seropositive individuals. They were recruited from the infectious disease clinic at the VA Medical Center-West Los Angeles and from AIDS Project Los Angeles. Ten of the subjects met the criteria for AIDS and 10 were medically asymptomatic. All subjects were ambulatory, without serious medical illness, and were volunteers. The seronegative subjects were recruited by newspaper advertisements. Serostatus for the 20 control subjects was confirmed through ELISA testing. Exclusion criteria included loss of consciousness greater than 5 minutes, past diagnosis of major psychiatric illness, and history of opportunistic infection of the CNS. Control and experimental subjects did not differ on measures of age, education, or verbal intelligence based upon their performance on the North American Adult Reading Test (NAART)(Blair & Spreen, 1989) (See Table 9).

*Procedure.* Subjects were administered the following instruments: (1) Beck Depression-Inventory, (2) Structured Clinical Interview for DMS-III-R (SCID), modified version, (3) Drug and Alcohol Survey, (4) NAART, and

TABLE 9  
Demographic Information for Seropositive versus Seronegative Subjects

Subjects	Age (mean)	Education (mean)	NAART (mean)
Seropositive	39.8	13.8	107
Seronegative	39.2	14.3	111

(5) Calculation Span (CSPAN)(Daneman and Carpenter, 1980). The CSPAN task involves the presentation of simple arithmetic problems which the subject is to solve while also remembering the last digit in each problem. The answer to the processing questions is never the same as the target digit. The task begins with the subject required to solve one problem and to remember one digit. There are nine "levels", each additional level adds one arithmetic problem and thus, one additional digit to remember so that the capacity load is increased by one digit each time. Four variables are scored; (1) Simple Span which corresponds to the number of digits a subject could recall, (2) Absolute Span which corresponds the subjects ability to consistently remember a certain length of digits, (3) Total Span which corresponds to the total number of digits reported across all 9 levels, and (4) errors, which corresponds to the number of errors made on the simple arithmetic problems.

### Results

An ANOVA was used to compare the three groups on the CSPAN variables with Control, Asymptomatic, and Symptomatic as the independent factors and Simple Span, Absolute Span, Total Span, and errors as the dependent measures. A trend was evidenced for Total Span,  $F(2, 28) = 2.96; p = .06$ . Follow-up pairwise comparisons revealed that the Asymptomatics differed significantly from the Symptomatics on total span ( $p = .05$ ). This finding indicates a diminished working memory capacity in symptomatic HIV-1 infected individuals. There were no significant differences in performance on the other variables, simple span, absolute span or number of errors. A comparison of seronegative subjects (Controls) versus seropositive subjects (asymptomatics plus symptomatics) was not significant. A comparison of controls versus symptomatic patient revealed a significant difference in performance on total span ( $p = .02$ ) and a trend on simple span ( $p = .09$ ).

### Discussion

Overall, diminished working memory capacity was significantly related to disease severity. Asymptomatic HIV-1 infected individuals did not differ significantly from controls on measures of capacity, consistency, and errors. However, the HIV-1 infected individuals that met criteria for AIDS demonstrated significantly poorer working memory from both the controls and the

asymptomatic patients. Thus, as assessed by the calculation span task, working memory deficits are evident only in later stages of HIV-1 infection.

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## W-10. The Psycholinguistic Reality of Morphophonological Changes during Derivation

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The present study investigates the role of morphological structure in the organization of the English Mental Lexicon. Motivated by the Marslen-Wilson et al. (1994) study, we investigated the representation and access of derived words in the performance of English-speaking subjects. Adopting as a point of departure Kiparsky's (1982) proposal for the organization of the lexicon, we investigated the effect of the *type of suffix* (Level 1—phonological change in derivation versus Level 2—absence of phonological change in derivation) on the subject's on line performance during word recognition and the possible implications for mental representation.

Previous studies on priming of inflected forms have shown the importance of morphemic relatedness in the organization of the mental lexicon (Kehayia & Jarema, 1994) and have supported the hypothesis that the lexical representations of derived forms are stored in morphologically decomposed

form (Laudanna, Badecker & Caramazza, 1989). However, the role of phonological change in morphological decomposition has not been addressed. The questions investigated here were: (1) is the access of derived words influenced by the level of the suffix, (2) does phonological change during derivation play a role in the access of suffixed words? (3) what is the role of orthographic similarity in the access of derived words? (4) how is the organization of the mental representation of derived words influenced by the morphophonological properties of their suffixes?

### *Method*

*Procedure.* Our experiment consisted of a masked lexical decision task with priming. The subjects initially saw the mask (####) for 150msec, then a letter string, the prime, (either a word or nonword) for 75msec and finally the target. They were asked to decide whether the target was an English word or not by pressing the YES-NO keys.

*Subjects.* The participants in this study were 20 University students aged between 19–29 years.

*Stimuli.* The word list consisted of 611 pairs of stimuli: 368 word pairs and 243 nonword pairs. Experimental stimuli comprised words suffixed with Level 1 suffixes: deverbal nouns in -ion, e.g. digest-digestion, conclude-conclusion and deceive-deceptive, as well as words suffixed with Level 2: deverbal nouns in -ness, e.g., sad-sadness, happy-happiness and denominal adjectives in -ful, e.g. doubt-doubtful. The control pairs matched the prime word for frequency, grammatical category, number of syllables and syllabic structure. Filler pairs comprised a set of regular and irregular verbs inflected for the past and gerund form. Finally, nonword stimuli respected the same experimental and filler categories as the words.

### *Results*

Our results in general confirmed our hypotheses that morphological structure and the morphophonological attributes of each affix were reflected in the reaction times (RTs) during word recognition of the derived forms.

(a) Derived words suffixed with Level 1 suffixes yielded RT patterns that were significantly different (longer) than those with Level 2 suffixes ( $p < .01$ ,  $F(1, 17) = 37.68$ ). RTs for derived word targets suffixed with L1 were always longer than those suffixed with L2 suffixes, e.g., digest-digestion (529ms) and sad-sadness (494msec). These results denote an effect of morphophonological transparency in the priming and access of derived word targets.

(b) The effect observed in (a) was found to be true not only in accessing different lexical categories but also within the same lexical category. Thus, when we compared deverbal nouns digest-digestion (Level 1) with deadjecti-

val nouns sad-sadness (Level 2) we found them to be significantly different from each other ( $p < 0.01$ ,  $F(1, 17) = 13.3$ ). We obtained similar results when we compared deverbial adjectives digest-digestive (Level 1) with denominal adjectives in delight-delightful (Level 2). Level 1 suffixes yielded always longer RTs than their Level 2 counterparts. Again, these results provide evidence that morphophonologically transparent forms are accessed faster when primed by their base forms than opaque ones.

(c) However, when intralevel comparisons were conducted, nonsignificant differences were found. More specifically, within L1, the -ion group was not statistically different than the -ive group, nor was the -ness group significantly different than the -ful one. This result added more validity to our L1 vs L2 distinction. Even when we compared each group with its match, e.g. digest-digestion vs digest-digestive, sad-sadness vs happy-happiness we didn't obtain any statistically significant differences.

(d) When further intragroup comparisons were made, non-significant differences were obtained. Thus, the -ion groups yielded similar RTs (digest-digestion, conclude-conclusion, deceive-deception). Similar was the case for the -ive group. Thus, digest-digestive, conclude-conclusive and deceive-deceptive yielded non-different RTs, even though in the case of digest-digestive we do not have any phonological change. Therefore, we postulate that the morphophonological level information and the process it implies must be intrinsic in the representation of the derived form.

(e) Finally, when we compared the order of presentation (suffixed word vs base form) we obtained statistically significant differences between priming with the base form and priming with the suffixed word ( $p < .05$ ). Thus, digest-digestion was significantly faster than digestion-digest. This difference implies that base forms and derived words are not accessed in the same way. Nevertheless, we obtained significant priming in both cases when compared to the baseline.

The above results confirm the role of the morphological transparency in the access and representation of derived words. They also bear important evidence on the role of phonological change during derivation and have implications for lexical access and representation. An interpretation of these results is proposed in the light of current linguistic and psycholinguistic theories of the organization of the mental lexicon.

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## W-11. Memory, Attention, and Estimation of Time<sup>14</sup>

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Our experiments investigated the involvement of working memory and attention in time estimation. Healthy subjects performing a verbal time estimation task either alone or with a concurrent working memory or attentional secondary task were compared with three global amnesic patients performing the time task alone. Results showed that accuracy of performance in healthy subjects was markedly poorer when the secondary task involved working memory, paralleling a pronounced underestimation of time intervals in amnesic patients. No such effect was observed when the secondary task involved attention.

### *Introduction*

The long search for a specialised time receptor or “internal clock” has failed to find such a mechanism. Time, it would seem, is a cognitive construction; although the nature of this construction remains unclear. Some have argued that the amount of material stored (or accessed) during an interval determines its apparent duration (Fraisse, 1984); others hold that attentional factors are the crucial determinants (e.g. Marshall & Wilsoncroft, 1989). Time, then, is a construction arising either from memory or attention.

Thomas and Weaver (1975) proposed that experienced duration arises from the parallel functioning of (1) a non-temporal processor that encodes stimuli and (2) a temporal processor that encodes temporal information, both processors sharing a common attentional pool of limited capacity. In support of this view, Macar et al. (1994) have reported that when attention is controlled by the subject, the subjective estimation of duration shortens as the amount of attention devoted to the temporal task diminishes. Contrasting evidence, however, (e.g. Fortin et al., 1993) shows that the forced deployment of cognitive resources on a short-term memory task (with concurrent temporal task) has a particularly strong effect upon the experienced duration of a target interval. Moreover, studies investigating time estimation in amnesic patients (with preserved attentional capacity) have shown marked inaccuracy of time estimation (Nichelli et al., 1993).

Such discrepancies reflect, in part, paradigmatic differences: memory may

<sup>14</sup> This project was supported by a European Science Foundation grant.

play the major role in retrospective estimation of time (in which subjects are unprimed for time estimation), but attention may predominate in prospective estimation. This would not explain the results of Fortin et al.'s (1993) prospective experiment; on the other hand, on the attentional hypothesis, prospective duration estimates should reflect the workload demands of a task.

Working memory may play a role in prospective time estimation: if an individual has to estimate time while executing a concurrent attentional task that relies on working memory, estimates would be affected; whereas if the attentional task places little demand upon working memory, time estimates should remain fairly accurate.

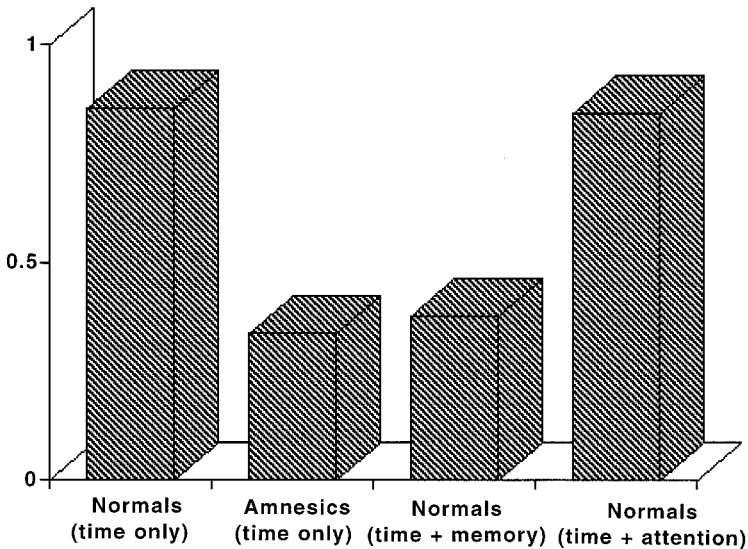
### *Method*

Three groups of healthy subjects (mean age 27.1 years) performed 3 computerised prospective time estimation tasks: (1) time only (while reading random numbers aloud to prevent counting); (2) time plus a memory task (memorising a sequence of letters before the interval started and performing a recognition task during the interval); (3) time plus a concurrent attentional task (searching a display for a letter rhyming with the letter T). The intervals ranged from 10 to 40 seconds. In (2) and (3), concurrent task difficulty was manipulated by varying the length of the sequence to be memorised, and (in the searching task) increasing the number of letters in the display. An additional group of 3 global amnesic patients were tested on the prospective time estimation task only. Individual estimates were plotted as linear function of the actual time; accuracy of performance was defined as the slope of the subject's regression.

### *Results*

On task 1 (time only), the amnesics were far less accurate than the healthy controls ( $F = 118.555$ ,  $p < .0001$ ). Performance of healthy subjects was analysed further. Results on the time-only task were compared with those on the time-plus-memory task and on the time-plus-attention task. This comparison showed a significant difference across groups ( $F = 84.207.368$ ,  $p < .0001$ ). Post-hoc comparisons showed a considerable drop in the accuracy of the normal subjects' performance with the memory secondary task ( $p < .0001$ ). Performance on the time-only task was similar to that on the time-plus-attention task. There was a significant difference between performance on time-plus-memory, and time-plus-attention ( $p < .0001$ ). The performance of healthy subjects on time-plus-memory did not differ significantly from the amnesic patients ( $F = .760$ ,  $p = .39$ ) (see Fig. 12).

A with-in subjects comparison ascertained whether increasing the load on the memory task would impair performance on the time task. This comparison showed a significant difference ( $F = 2.968$ ,  $p = .05$ ); i.e. increasing the working memory load (by lengthening the sequence of letters) resulted in a



**FIG. 12.** Accuracy of performance of amnesics and healthy subjects on the verbal time estimation task (with and without a secondary task).

greater decrement in the accuracy of the time estimates. On the attentional task, no significant difference was found: increasing the attentional load by increasing the display size had no effect on the accuracy of time estimation.

### Discussion

The possibility that the interference effects in time estimation in dual task experiments could result from the subject's need to coordinate two activities is not supported by these preliminary data. The important factor is the nature of the secondary task. The fact that we observed a consistent drop in accuracy in dual tasks that rely upon a memory, rather than an attentional, component, argues a major role for working memory in prospective time estimation. The inaccuracy of subjects engaged in the dual task with a memory component parallels the performance of amnesic patients; whereas the performance of subjects engaged in a dual task with an attentional component seems to follow closely the pattern described by the power law (the relationship between the magnitude of the original stimulus and the intensity of the experience it provokes) reaching an exponent close to 1. These preliminary data support memory-based accounts of time perception.

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## W-12. Selective Preservation of the Absolute Spatial Location of Component Parts in Dementia: A Peculiar Case of Spatial Memory

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Although scoring procedures for the Rey Complex Figure do exist, much of the information about specific performance difficulties is lost when these methods are used. We report a patient (N.A.) with dementia who, on two separate occasions, reproduced the *absolute* position of component parts of the Rey, but was unable to recall its major configurational elements. This performance is discussed within a framework that implies that various spatial properties from vision may be dissociable. This argument suggests that Rey performance (in some cases) might be evaluated more appropriately by considering performance along different spatial/visual dimensions.

## W-13. Laterality Effects in Computer Mouse Control

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The speed and accuracy of computer mouse movements by experienced and novice mouse users were examined. Significant between hand differences were seen for righthanders, for the final targeting positioning, but not for the ballistic transport movements. No between hand effects were seen in lefthanders. There were speed/accuracy trade-off effects in the left and right visual fields and accuracy effects in the top vs. bottom visual field. Finally, there were sex differences in the ballistic transport but not the final targeting movements. Experiments using the computer mouse as response element cannot assume that the mouse is moved equally quickly and accurately to all quadrants of the computer screen.

## W-14. Frontal Lesions Produce a Dual-Task Deficit in Simple Rapid Choices

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This study tested the suggestion that frontal lesions produce a dual-task deficit in elementary tasks. We compared the performance of 8 patients with unilateral frontal excisions, 8 patients with temporal excisions and 8 controls in three rapid choice tasks involving either (1) a single choice, (2) two overlapping choices with variable inter-stimulus delays, or (3) two successive choices with variable inter-response delays. In the single-choice task, response time (RT) was similar in frontal and temporal groups. However, in both dual tasks, frontals showed larger increases in RT compared to other groups. This effect was seen on both responses and was independent of the delay. These observations indicate that a frontal dual-task deficit can be found in elementary choice tasks and that this deficit is not very sensitive to inter-choice separation.

Frontal lesions affect executive or cognitive control processes that contribute to a wide variety of tasks. It has been suggested that dual tasks may provide valid measures of executive processes and executive deficits (ex. Della Sala et al., 1995). Dual tasks do recruit fundamental executive processes involved in controlling processing efficiency and avoiding crosstalk between the overlapping tasks. There is evidence that dual tasks are sensitive to frontal lobe damage (Baddeley et al., 1997) and closed-head injury (Hartman et al., 1992) using tasks such as tracking and digit span. However, if frontal lesions produce a basic dual task deficit it should appear in elementary tasks that incorporate few instrumental processes in addition to the executive processes involved. The present study examined whether frontal lesions produce a dual-task deficit in elementary tasks using rapid choice responses in single-task and dual-task situations.

### *Methods*

*Subjects.* Eight patients with a unilateral frontal excision (6 right) were compared to 8 patients with temporal excisions and 8 controls. Groups were matched in age (mean, 36 yrs) and education level (mean, 12 yrs). Frontal excisions were variable in extent but included mostly dorsal structures (medial and lateral).

*Procedure.* In all tasks, subjects responded by rapid keypresses to the presentation of characters presented centrally on a monitor. In the *single choice task*, a central fixation cross (1 sec), was followed by a 500-ms delay and by the letter A or B (50 ms) eliciting the response. In the *successive choice task*, the letter (S1) was followed by a digit (1 or 2, S2). Subjects responded

to each stimulus as soon as it was presented and S2 followed the first response (R1) by 55, 300, or 600 ms (RSI). In the *overlapping choice task*, S1 and S2 were separated by an unpredictable delay of 55, 300 or 600 ms (SOA) and subjects were to execute the two responses together (R1–R2) after S2. Stimuli A and 1 were mapped to the left button of the mouse, B and 2 to the right button. The three tasks included three blocks of 48 trials each, preceded by a practice block and a 3-sec interval separated consecutive trials.

## Results

Mean response times in the three tasks are given in Figure 1. In the *single-choice task*, the ANOVA revealed a small but significant effect of group ( $F(2, 21) = 5.7, p = .01$ ). However, the frontal group did not differ significantly from the temporal group (Tukey's HSD = 43.1, n.s.) but only from controls (HSD = 132.6,  $p < .05$ ).

In the *successive choice task*, the analysis on the response time of R1 (RT1) revealed a significant slowing in frontals ( $F(2, 21) = 8.9, p .002$ , HSDs > 110.8). As expected, there was no effect of RSI or interaction on RT1 in this task since the delay was unknown before R1 ( $F_s < 1.0$ , n.s.). For R2, a small group effect ( $F(2, 21) = 5.5, p = .01$ ) was found, but the two patient groups did not differ (HSD < 111.5, n.s.). A significant RSI effect ( $F(2, 42) = 125.9, p < .001$ ) was also obtained as expected from the literature (ex. Welford, 1952) but there was no interaction ( $F(4, 42) = 1.4$ , ns).

In the *overlapping choice task*, RT1 was computed from S2 onset. The analysis of RT1 showed the expected SOA effect ( $F(2, 42) = 153.8, p .001$ ). More importantly, the frontal group was again significantly slower than the other two groups ( $F(2, 21) = 11.8, p .001$ , HSDs > 150.7) and there was no interaction ( $F(4, 42) = .8$ , ns). RT2 which was highly correlated to RT1 in this task, showed the same pattern of results, an effect of SOA ( $F(2, 42) = 142.1, p .001$ , all HSDs > 36.6), a significant slowing in the frontal group ( $F(2, 21) = 16.5, p .001$ , HSDs > 169.3) and no interaction ( $F(4, 42) = 1.1$ , ns).

Error rates were below 2% in all tasks except for R2 in the overlapping choice task where it was significantly higher at the long delay (5% errors vs 2% at other delays ;  $F(2, 42) = 17.1, p .001$ ). No group differences were found on error rates.

## Discussion

Frontal patients did not differ from temporal patients in the single choice task whereas they were slower in the first choice of dual-tasks whether the two responses were grouped or not. These results show that the concurrent preparation of a second rapid choice slows processing of the first choice much more after a frontal lesion and that this effect is still present when the

second choice is about a second away. Frontals are also slower in many single tasks including complex single-choice tasks. The mechanisms of these different speed decrements are not yet understood as is the case for the errors produced by frontals in many tasks. However, the slowing observed here indicates that the performance cost of a dual task is greater after frontal lesions even in elementary tasks. Sequential response deficits are often observed after frontal lesions (ex. Luria, 1966) and the present data suggest that the preparation of a sequence of only two responses is deficient. Finally, the curves of RT as a function of delay were found to be similar in the three groups, indicating that the frontal dual-task deficit does not appear to be much affected by the time available to process the first choice when that time is unpredictable.

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### W-15. A Role for Executive Processes in Prospective Remembering

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Two prospective memory tasks were given to younger and older adults as well as brain-injured patients with frontal or posterior damage. Participants were also given the Stroop Color and Word Test and the Wisconsin Card Sort Test as measures of frontal functioning. Participants were measured on clock-checking behavior and accuracy of prospective remembering in the two tasks. Comparisons among the groups on these measures and on correlations between prospective remembering ability and frontal functioning are presented. Implications for theories of prospective memory as well as executive functioning are discussed.

A role for executive processes in prospective remembering failures of prospective memory are common in everyday life, yet not widely studied in the

laboratory. A prospective memory task is one in which an individual must remember to perform an action at a future time (although see Crowder, 1995, for a very different interpretation of prospective remembering). Einstein and McDaniel (1990) have suggested that prospective memory actually involves two components: remembering that something needs to be remembered (the prospective component), and remembering the information itself (the retrospective component). They also make the distinction between event-based prospective memory, which requires some action when an external event takes place, and time-based prospective memory, in which action is required after a specified time interval has passed. According to Einstein and McDaniel, time-based remembering relies much more heavily on self-initiated memory processes because no external event acts as a cue for remembering. The individual must continuously shift attentional resources between other tasks and the monitoring of time. This “multi-tasking”, executive aspect of time-based prospective memory may be especially vulnerable to problems with planning and the reallocation of attentional resources, and suggests a prime role in these tasks for the frontal lobes.

In Cockburn's (1995) case study of a frontal lobe patient, it was found that the patient could remember to perform actions when they were embedded in an ongoing activity, but had great trouble when the task involved suspension of one activity in order to begin another (known as contextual shift, see Kvavilashvili, 1992). This highlights a third distinction in the classification of prospective remembering tasks. Some are embedded within an on-going task and require contextual shift to accomplish. Others are disembedded, or outside of whatever the participant is doing, and do not, therefore, require shifts of attention.

The present study involved participants who were asked to complete a survey of general knowledge (presented and responses recorded on computer). There were two prospective memory tasks within the general knowledge task: (1) to inform the researcher of how far the individual had progressed every five minutes (a time-based, disembedded task, performed three times over the course of the experiment, and requiring a contextual shift away from the survey), and (2) to type the participant's name into the computer upon completion of the survey (an event-based, embedded activity, performed once and cued by the end of the survey). The only time-piece available to the participants was on the computer and was accessed by pressing a specified key. Our primary dependent measures were: number of clock checks, timing of clock checks relative to 5 minute epochs, and accuracy on each of the two prospective memory tasks.

We also administered several other cognitive measures to each participant. These included: an intelligence test (the Kaufman Brief Intelligence Test), and two measures thought to be sensitive to frontal functioning, the Stroop Color and Word Test and the Wisconsin Card Sort Test–WCST. These two measures assess subtly different frontal lobe processes. The Stroop test pri-

marily assesses sensitivity to interference from competing stimuli, while the WCST proports to measure an individual's tendency to perseverate—a difficulty in shifting from one aspect of a task to another, or from task to task. By correlating these two measures with performance on the prospective memory tasks, we have begun to address which cognitive processes are crucial to prospective forms of remembering and whether they might be mediated primarily by the frontal lobes.

Our participants included 15 younger adults (undergraduates from our university), 15 older adults (alumni 55 years or older), and 7 patients with damage to the frontal areas of the brain, all with circumscribed lesions to the frontal lobes, and with no other lesions or medical complications. We have also included 7 posterior patients to act as brain-injured controls.

Results will be presented at the conference. These include an ANOVA on accuracy in the embedded task, as well as average number of clock checks. A chi square will be presented demonstrating different accuracies on the disembedded task for each of the three groups. Clock checks are noted to be much more evenly distributed across the 5 minute epoch for older adults as compared to younger adults, while frontal patients show much less checking than other groups. Finally, correlations will be presented estimating the relation of prospective memory performance to the two “frontal” tests (the Stroop test and the WCST).

The implications of the data on theories of prospective memory will be discussed, as well as speculation on how executive functions mediated by frontal mechanisms operate in this kind of memory task.

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### W-16. Arousal and Selective Intention and Attention to Stimuli Presented to the Left and Right in Depressed and Anxious Patients

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To examine how attention mechanisms influence the processing of emotions in the cerebral hemispheres, groups of depressed ( $n = 8$ ), anxious ( $n = 8$ ) and control subjects ( $n = 13$ ) had to report one stimulus by a key press with one hand and another stimulus by another key press with the other hand in a reaction time task.

Stimuli were presented to the left or the right of a central fixation point. They were preceded by no cue or by a cue. The cues indicated either the hand for the response (intention) or the side where the stimulus was going to appear. Depressed subjects responded faster to stimuli presented on their left. All subjects responded faster to valid cues. These findings support the view that depression is associated with an arousal bias. The situation for anxiety remains equivocal.

### W-17. Closed-Loop Sensorimotor Control and Acquisition after Frontal Lesions

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Patients with unilateral frontal excisions were compared to patients with temporal excisions and controls on a mirror tracing task. Mirror tracing of a star shape was tested in ten learning trials after training with linear trajectories. The frontal group showed longer tracing times and more frequent oscillation episodes a sign of motor control problems. Again, learning curves were similar in all groups. Thus, frontal lesions can affect control of simple movements in novel sensorimotor conditions but do not appear to affect the rate of acquisition of a new mapping. These results suggest that frontal cortex is more important for closed-loop motor control than sensorimotor learning.

In humans, there are few data on the implication of frontal cortex on simple visuomotor control and visuomotor learning. Frontal lobe lesions appear to produce little difficulty in executing many visually-guided movements (Stuss & Benson, 1986). However, functional imaging studies suggest that the frontal lobes are involved in some forms of visuomotor control or learning (Lang et al. (1988) for inverted tracking; Grafton et al. (1994) for rotary pursuit), although activation of frontal regions in a task does not necessarily entail that their role is critical for this task. However, their anatomical connections suggest that premotor and prefrontal cortices should play a critical part in some types or some components of movements. The present study examined the effects of large unilateral frontal lesions on visuomotor control and acquisition in mirror tracing, a movement which requires a transformation of the natural visuomotor mapping.

#### *Subjects*

Twelve patients with unilateral frontal excisions were compared to 12 patients with temporal excisions and 12 control subjects matched for age (40 years) and education level (11 years). Resections were performed for drug-resistant epilepsy or tumors. Testing took place at least one year following surgery. Frontal excisions were variable in extent but mostly affected dorsal

prefrontal and premotor regions. None of the patients exhibited sensory or motor impairment nor any deficit on visuospatial abilities, neglect, optic ataxia, apraxia, or aphasia.

### *Procedure and Results*

The task consisted in tracing a four-point star pattern (within boundary lines 1.7 cm apart) using only indirect visual feedback from a vertical mirror. Following a baseline trial with no mirror, a training phase involved the mirror tracing of 12 lines (4 verticals, 4 horizontals, 4 right angles). Subjects then completed one mirror-tracing trial with a rotated star, followed by 10 trials of the standard star with a 30-min. delay between trials 5 and 6. After a two-hour delay, one last trial was performed with each star.

In the baseline trial, tracing time was similar in the three groups ( $F(2, 24) = 3.3$ , ns). An ANOVA on the average mirror-tracing time on trials 1, 5, 6, and 10 showed that frontals presented longer tracing times than the other groups ( $F(2, 24) = 16.1$ ,  $p < 0.001$ ; F vs T:  $t(16) = 5.2$ ,  $p < 0.001$ ; T vs C:  $t(16) = 0.56$ , n.s.). However, all groups showed an improvement across trials, ( $F(3, 72) = 10.7$ ,  $p < 0.001$ ) and there was no group by trial interaction. An analysis on the two trials separated by two hours revealed the expected group difference ( $F(2, 23) = 12.9$ ,  $p < 0.001$ ; F vs T:  $t(15) = 4.4$ ,  $p < 0.001$ ; T vs C:  $t(15) = 0.1$ , n.s.), but no significant effect of the delay and no interaction (Fig. 13).

Tracing precision was analyzed using both the number of boundary crossings and the number of oscillation episodes; the latter being periods of non-progressive movement and multiple direction changes which are regularly observed in adaptation to transformed mappings. The ANOVA on boundary crossings showed no significant effects of group or practice. However, the average number of oscillation episodes showed a significant effect of group, frontals showing a higher frequency of these episodes ( $F(2, 24) = 10.3$ ,  $p = 0.001$ ; F vs T:  $t(16) = 4.0$ ,  $p < 0.001$ ; T vs C:  $t(16) = 0.1$ , n.s.), a significant effect of practice ( $F(3, 72) = 10.3$ ,  $p < 0.001$ ) and no interaction (Fig. 14).

### *Discussion*

Large unilateral frontal lesions extending to lateral and medial premotor cortex do not appear to produce problems in the tracing of a complex shape in normal visuomotor conditions. This is consistent with the general lack of deficit in visually-guided movements after frontal lesions that spare primary motor cortex. In mirror tracing however, frontals show an increased tracing time and more frequent oscillation episodes. The slow tracing may be due to a general slowing often observed after frontal lesions in complex tasks, but some of the slow tracing time must be due to the numerous oscillation episodes which involve multiple time-consuming direction reversals most

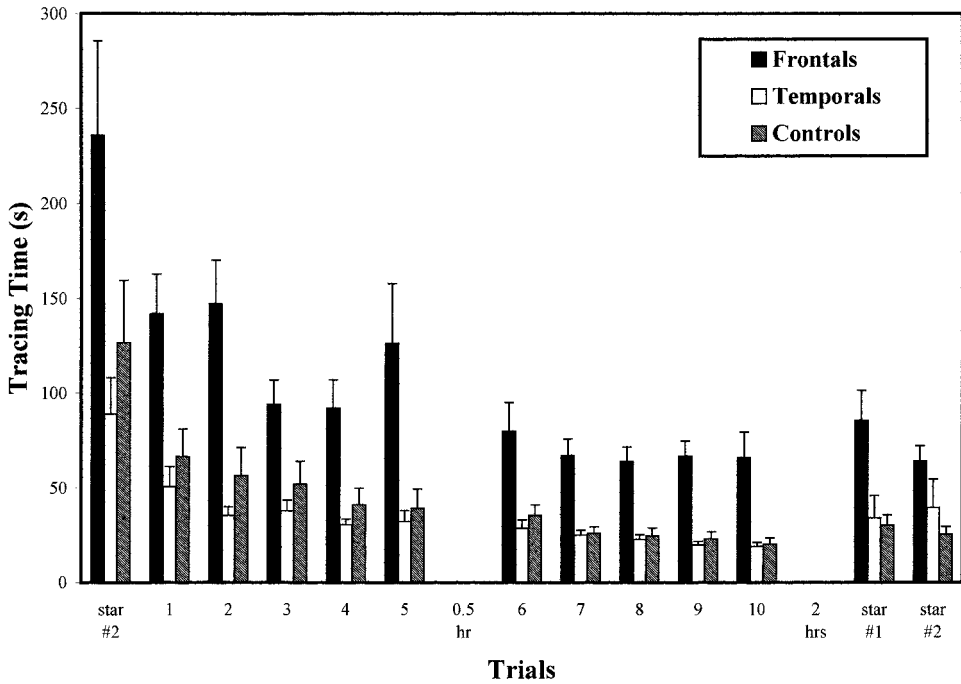


FIGURE 13

often in the axis orthogonal to the correct movement. These oscillations are a measure of an intermittent loss of sensorimotor control and temporary take-over of control by the prepotent natural visuomotor mapping (Smith & Smith, 1962 ; Cunningham, 1989). The frequency of these oscillations in frontals suggests that frontal lesions do produce visuomotor control problems after frontal lesions in transformed space. This problem could represent a greater interference from the prepotent natural visuomotor mapping, or the natural mapping may be used by default when the intentional control fails to specify the correct movement on time.

The visuomotor control problem of frontals does not prevent acquisition of the visuomotor skills examined here confirming some earlier reports on patients with diffuse lesions (Ewert et al., 1989) and our own data on discrete movements after frontal excisions (Chouinard et al., submitted) but in contradiction to other reports (Ackermann et al., 1996, Canavan et al., 1990). The learning observed may be attributed to the remaining frontal cortex or to structures external to the frontal lobes. However, the data suggest that large lesions in premotor and prefrontal cortex do not prevent this type of learning. This dissociation between deficient control in transformed space and normal acquisition and use of learned motor programs after frontal lesions points to

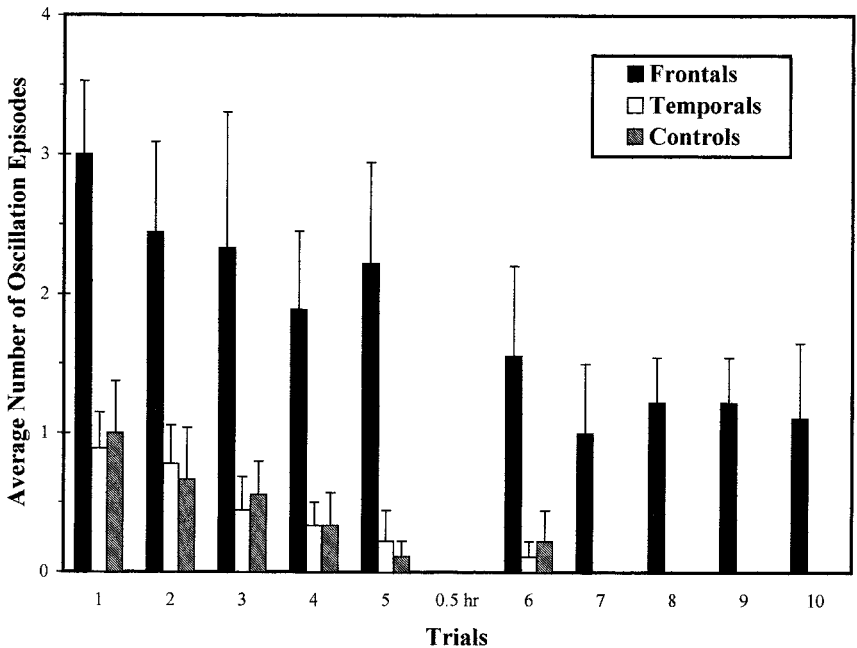


FIGURE 14

a role of frontal cortex in closed-loop motor control which is necessary when learned motor programs are inappropriate.

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## W-18. Language Acquisition in Children with Partial Epilepsy<sup>15</sup>

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A longitudinal linguistic analysis of six children with partial epilepsy (PE) was conducted to determine in what ways, if any, linguistic performance in this clinical group with neurogenic disorder differed from patterns and levels of performance in a normative sample of control subjects. The epileptic subjects were followed for about five years since the age of three years. They were evaluated yearly on aspects of language comprehension and production at the lexical and morphosyntactic levels. Their performance on three tests of linguistic comprehension (pointing task, understanding of questions and prepositions) and three tests of linguistic production (repetition, verbal fluency, morphosyntax) was compared to that of 96 control children at each age level. The course of language acquisition in these children with PE revealed a striking pattern: although marked deficits were originally present, language comprehension gradually improved to reach normal or near-normal levels, while language production remained quite poor and failed to improve over time. This dissociation in the development of linguistic performance in these children suggests a complex interaction between cerebral maturation dynamics and dysfunction modulating the course of stages in language development.

### *Introduction*

The consequences of neurogenic disorder on language performance and competence are relatively well-known and understood. This knowledge, however, is mostly derived from observations and studies with adult brain-damaged individuals; little is known about the cognitive consequences of early brain damage. The investigation of language acquisition in children with PE may help elucidate aspects of the consequences of brain damage on language development. The clinical manifestations of PE are generally characterized by brief ictal episodes localized in one hemisphere and without loss of consciousness. These episodes usually occur in childhood and have generally disappeared by the early teens (Aicardi, 1986). The child affected with PE is still able to meaningfully interact with his or her environment. As such, the investigation of language development in these children may contribute to central issues in developmental neurolinguistics.

In this perspective, two important conditions must be met: clinical and

<sup>15</sup> We thank Dr. Claude Chevrie-Muller for making the clinical subjects available to us. This work was supported by grants from INSERM (M.-T. Le N.) and from FCAR and FRSQ (H.C.). The first author also acknowledges the generous support of INSERM.

experimental observations should be collected with reference to common normative language protocols; evaluation of linguistic abilities should span the period from oral language acquisition to the first years of primary education. In the present study, we attempted to determine how language (comprehension and production) development in children with PE differs from that of normal age-matched populations.

### *Method*

*Subjects. Clinical subjects.* Six children were selected from the Department of pediatrics, Necker Children and La Salpêtrière hospitals. Inclusion criteria were a language disorder associated with a diagnosis of partial epilepsy and an epileptic focus localized in the left temporal lobe. Epileptic subjects were tested a minimum of two and a maximum of six times, between the ages of 3 years and 9 years.

*Control subjects.* The groups of control subjects were balanced for sex and family sociocultural level. Subjects came from urban settings. Exclusion criteria were a sensory or neurological impairment and a mother tongue other than French. The reference group was made up of 576 children distributed over six age groups (45, 54, 66, 75, 84 and 96 months). For all subjects, exclusion criteria were a development quotient under 90, a genetic or psychopathologic disorder, or an auditory impairment as revealed by an audiometric examination.

*Tests.* Subjects were given a battery of six language tests, three of linguistic comprehension and three of linguistic production. Comprehension tasks included *pointing* (subject was asked to choose which of a set of images or objects has been named by the experimenter), *understanding of narrative* (subject was required to answer to what, where, who does, how, why-type of questions in the context of a story, "The fall in the mud"), and *understanding of prepositions* (representation of space, quantity and partition). The linguistic production tasks included *repetition* (repeat simple words spoken by the experimenter), *verbal fluency* (number of different words uttered in a 20 min controlled play session) and *morphosyntax* (as measured by MLU). Normative data on all these tasks are found in Chevrie-Muller (1981).

*Procedure.* Subjects were tested individually in a quiet room, with one parent present for younger subjects. testing lasted about two hours, including resting periods. Order of test presentation was the same for all subjects.

### *Results*

Performance scores of the six children with PE were plotted in reference to the mean of the control group, at each age level, for each particular task. The evolution of the clinical subjects' linguistic performance is presented in

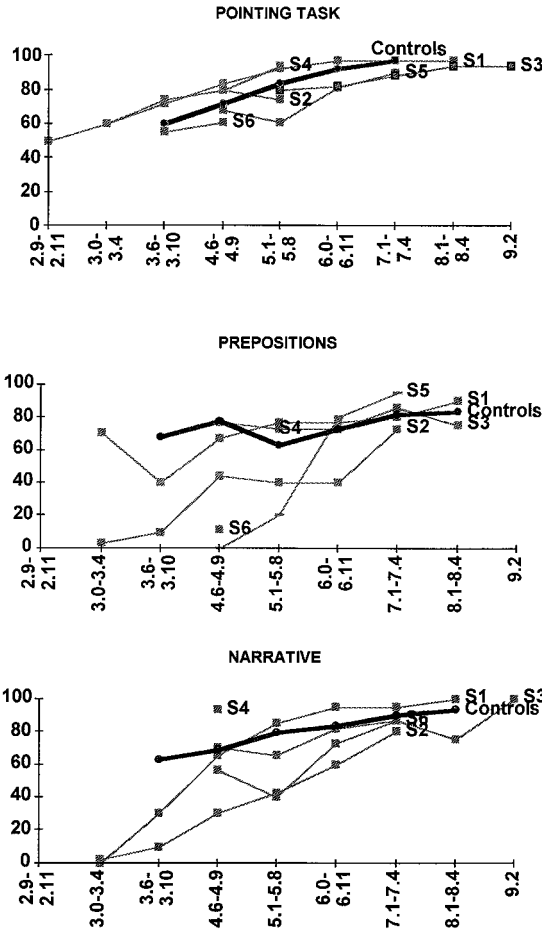


FIG. 15. Linguistic comprehension.

Figure 15 (comprehension) and Figure 16 (production). Observations showed that children with PE demonstrate marked and sustained deficits in aspects of linguistic production and gradual improvement, over 4–5 years, in aspects of linguistic comprehension.

*Discussion*

The purpose of this study was to determine to what extent, if any, stages of language acquisition in PE differed from normal populations of children. Our data do not demonstrate a unique profile of linguistic performance and suggest, however, a clear dissociation between linguistic comprehension and production performance. Comprehension is initially poor but reaches normal

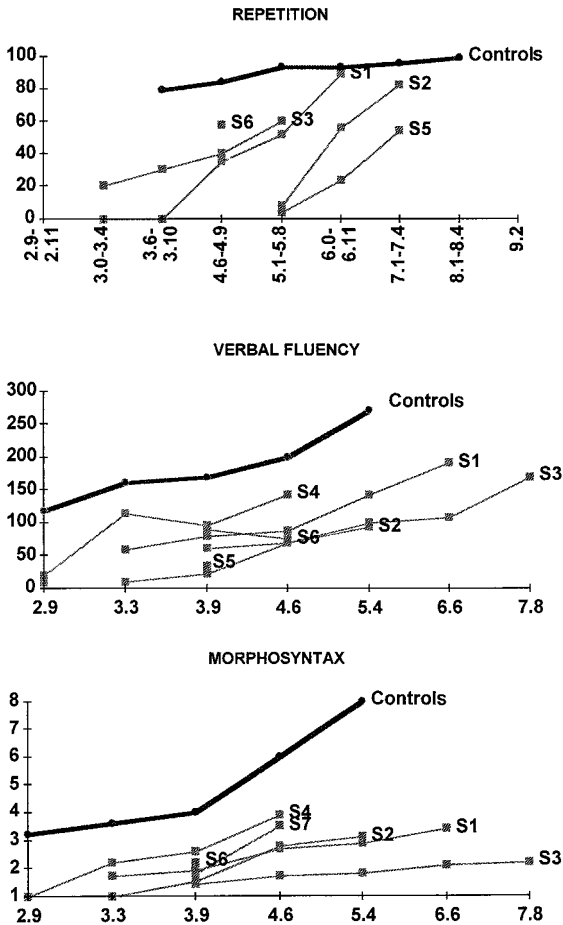


FIG. 16. Linguistic production.

levels around 7–8 years of age. This pattern of gradual acquisition to normal levels is the same in all three tasks of comprehension and suggests that the initial difficulty experienced by these children with PE tapers off with time. In contrast, linguistic production performance is, in all cases, inferior to the control groups'. Even at later stages, children with PE still show evidence of serious deficits: at later stages (8 years), they are still performing well under the early stage level of control subjects' (3–4 years).

This dissociation between broad linguistic domains suggests that these aspects of linguistic competence and performance are differentially affected by neurogenic perturbation. Language acquisition in PE is apparently characterized by a gradually compensated delay in comprehension and a sustained deficit in production. To the extent that this dissociation can be taken as an

index of cortical areas involvement, it seems reasonable to speculate that anterior cerebral structures may be affected to a greater level than posterior structures.

To our knowledge, this study represents one of the first exhaustive, longitudinal attempts to follow language acquisition following cerebral dysfunction in early childhood. It suggests first, that language does not necessarily develop in linear fashion and, second, that the effects of cerebral damage are not uniform.

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### W-19. Event-Related Potentials when Switching Attention between Task-Sets<sup>16</sup>

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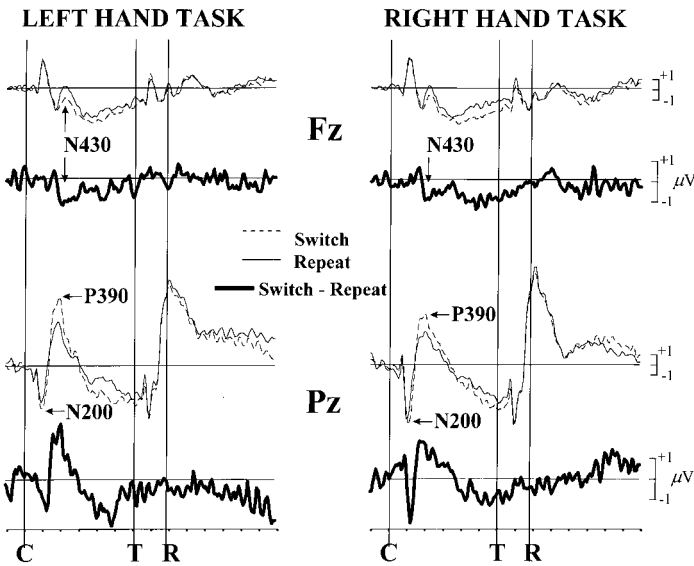
\*Rotman Research Institute of Baycrest Center, Toronto, Canada; †Ben-Gurion University of the Negev, Beer-Sheeva, Israel; and ‡Cuban Neuroscience Centre, Havana, Cuba

Cues designating one of two possible tasks preceded a target requiring a discriminative button-press response. The two tasks occurred randomly so that on each trial the subject either repeated the task from the previous trial or switched to the other task. Bi-occipital (N200), parietal (P390) and fronto-central (N430) event related potentials (ERPs) to the cue stimulus were larger for switch than repeat tasks. These results suggest that both posterior and frontal cortices participate in switching. The N200, P390, and N430 may reflect perceptual (stimulus), conceptual, and response-set shifting, respectively.

## Introduction

The ability to switch attention between tasks is an essential control function for human cognition, enabling the individual to shift the course of thought or action according to situational demands (Rogers & Monsell, 1995). Abnormalities of task-set switching are often observed after frontal

<sup>16</sup> This research was supported by the OMHF, the Scottish Rite Charitable Foundation of Canada, and the Community Foundation of Greater Toronto. We thank Dr. Alan Evans of the International Consortium for Brain Mapping (ICBM) for the probabilistic tissue maps used in this work.



**FIG. 17.** Switch ERPs at mid-frontal (Fz) and mid-parietal (Pz) sites. The three vertical bars represent the Cue, Target, and Response. The size of the difference waveform (thick line) is twice that of the raw ERP waveforms.

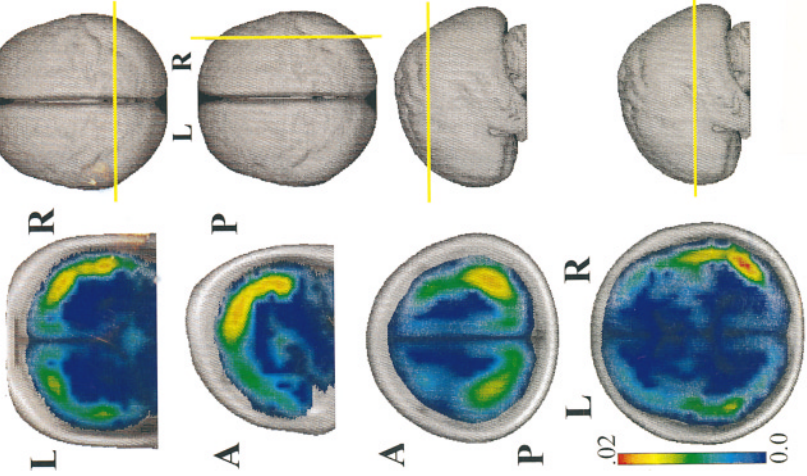
lobe injury (Milner, 1963). Deficits include a failure to switch appropriately resulting in perseverative errors, and an inability to maintain set causing the subject to respond inconsistently. This study uses ERPs to identify the cerebral processes that occur when an individual switches between 1 of 2 task-sets (Meiran, 1996).

### Method

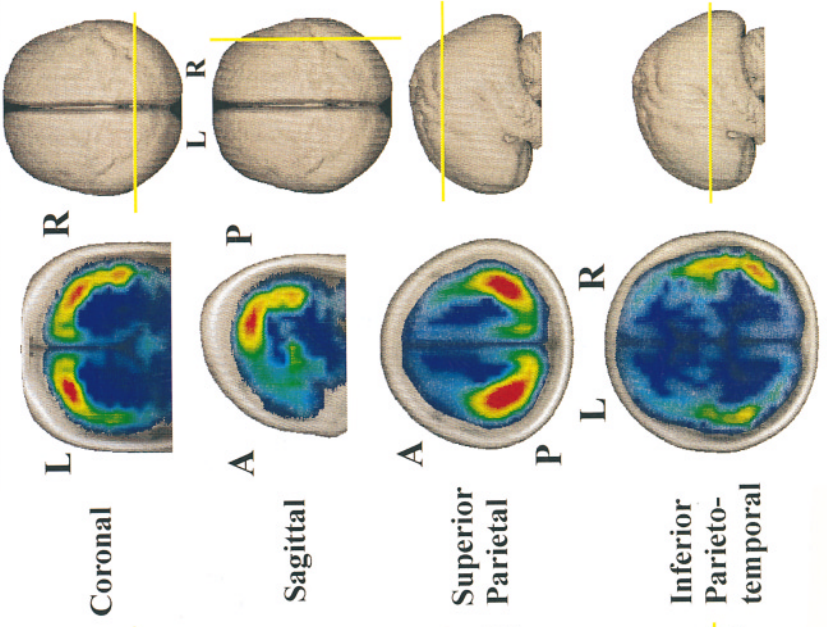
*Participants.* Participants were eight healthy right-handed male subjects (mean age of 34 years).

*Paradigm.* Subjects completed 1000 trials. Each trial consisted of a cue, a target, and a response. The target was a circle occurring in one of four grid quadrants. The left hand task involved deciding whether the circle was in the left or right half of the  $2 \times 2$  grid and pressing a button with the index or middle finger of the left hand. The right hand task involved deciding whether the circle was in the top or bottom half of the grid and responding with the right hand. Cue arrows designating the task were located either to the left and right (left hand task) or on the top and bottom (right hand task) of the grid. Cues preceded the target by 1200 msec. Task sequencing was random so that on each trial the subject either repeated the task from the previous trial or switched to the other task. The inter-trial interval was 1500 msec.

REPEAT LEFT HAND TASK



SWITCH TO LEFT HAND TASK



*Electrophysiological methods.* EEG signals were recorded from 32 scalp locations using a 0.1–50 Hz bandpass and an average reference. Ocular source components were used to remove ocular artifacts from each subject's averaged data (Lins et al., 1993).

*Analysis.* ERPs for correct-response trials were analyzed at the electrodes where they were maximally recorded using an ANOVA with independent variables of sequence (switch v. repeat), task-hand (left hand v. right hand task) and hemisphere (left v. right). The recordings were also analyzed in VARETA (Variable Resolution Electromagnetic Tomography) (Valdes, 1996) which uses average brain measurements (Evans et al., 1993) to constrain a distributed source analysis procedure (Pascual-Marqui, 1994).

## Results

*ERPs. N200, P390, Mid-frontal N430:* Figure 17 shows the main ERP switch effects. The occipital N200 to cue (N200) stimuli was larger for switch than repeat trials ( $F(1, 7) = 44.2, p < .001$ ), and exhibited a bi-occipital scalp distribution. The parietal P390 was also larger for switch than repeat trials ( $F(1, 7) = 16.49, p < .01$ ) and was maximally recorded over the right (P4) hemisphere ( $F(1, 7) = 17.52, p < .01$ ). The P390 was followed during switch trials by an enhanced negativity (N430) at the mid-frontal site ( $F(1, 7) = 9.82, p = .01$ ) with a peak latency that was significantly later (40 ms) than that of the P390 ( $F(1, 7) = 5.77, p < .05$ ).

The source analysis (Figure 18) showed both a bilateral superior parietal (mainly right) and a right inferior temporo-parietal generator for the scalp P390.

## Discussion

These data suggest that bi-occipital, parietal, and frontal brain regions are involved in visually triggered shifts in task-set. The parietal and frontal switch ERPs may correspond to goal shifting and response rule selection, respectively.

The hypothesis that the attention switching system is configured in two separate stages is consistent with clinical findings. While performing a sorting task that requires a switch between sorting principles, some frontal patients continue to make perseverative errors even while verbalizing the correct strategy or identifying a response error (Luria, 1973)—they have switched goals, but failed in response execution. This interpretation fits with

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**FIG. 18.** VARETA at the latency of the P390 wave. Yellow lines represent the level of each tomogram. The two transverse tomograms show the two active areas. The scale is adjusted to span from 0 to the maximum current density in the analysis. Multiplying the scale value by 1.5 will give an approximate estimate of the current density in milliamperes/cm<sup>2</sup>.

recent neurocognitive theories that have differentiated anterior and posterior attentional systems (Posner & Raichle, 1994; Stuss et al., 1995).

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## W-20. Do Developmental Dyslexic Subtypes Exist? The Answer Lies in Statistical Methods

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Cognitive neuropsychological research with brain-injured adults over the past few decades suggests that at least two types of dyslexics exist: Those which we call phonological dyslexics and those which we call surface dyslexics.

Pure phonological dyslexics are thought to have normal whole word orthographic recognition of words with deficient knowledge of grapheme-phoneme relationships, and pure surface dyslexics show the opposite pattern with normal sounding-out strategies and deficient whole word orthographic

and/or 'sight' reading. Such distinctions are now being picked up via the use of nonwords and irregular words. Because nonword reading (e.g., 'borp') requires sounding-out in order to read the word correctly, and irregular word reading (e.g. 'yacht') can not be read via sounding-out strategies, but is thought to require a different form of processing involving whole word orthographic/ sight recognition, deficits in reading these types of words pick up on phonological versus surface dyslexic patterns, respectively.

Several authors claim to have found the pure surface dyslexic pattern in young children with no history of brain damage (Castles & Coltheart, 1993; Manis et al. 1996). These studies used inappropriate means of word/nonword analysis, however, which is why the data is re-examined here. Do developmental pure surface dyslexics exist or not?

Castles and Coltheart (1993) and Manis et al. (1996) found high degrees of pure surface dyslexics in their developmental dyslexic populations (19% and 20%, respectively). These high percentages are a result of inappropriate statistical methods used for comparing normal control and poor reader scores, as well as the lack of regular word comparisons in these studies. A reanalysis of Castles & Coltheart (1993) using different statistical methods suggests they had 6% surface dyslexics. It is imperative that researchers in this line of research keep their methods for analysing word/nonword data consistent using a different method of analysis.

Both Castles and Coltheart (1993) and Manis et al. (1996) analysed their data in a similar fashion. They performed simple regression analyses of irregular words, and then nonwords, as a function of age for normal controls (regular words were not examined). These scores were then compared to poor readers scores which were examined in the same manner. What the authors did next, was something entirely different to other authors (Coltheart & Leahy 1996). They examined the difference between regular and irregular word reading, regular and nonword reading, and also the difference between irregular and nonword reading of these normal controls. The differences in scores were used to compare with poor readers score differences in order to determine surface or phonological subtypes. Poor readers which fell outside of the normal 90% confidence intervals of these score differences were said to have a significant difference in reading the word types.

What Coltheart and Leahy (1996) did differently, was they collected 420 normal readers' scores for each of regular, irregular and nonwords, and determined confidence levels for each of these word types by age. They then offered these norms by ranges for # correct words recalled out of 30 for each word type and age between 7-12. To determine dyslexic subtypes, researchers simply refer to these norms and ensure that their poor readers fall in the normal range for regular words, and outside of the normal range on either irregular or nonwords for surface or phonological classifications respectively.

Using this method to determine subtypes, we get a completely different picture than the one painted when comparing controls and poor readers on the difference between word type scores.

When the same analytical procedures from Coltheart and Leahy (1996) are used on the good reader raw data in Castles & Coltheart (1993), 48/53 of their poor readers had regular word scores well below the normal reader floor (outside of a 90% confidence interval). Dual-route theorists diagnose poor readers into pure surface or phonological subtypes based on normal regular word reading with either poor irregular or nonword reading, respectively. Based on this means of diagnosing subtypes, only 5 of the poor readers in Castles and Coltheart should have been examined (they examined 18). A re-examination of these 5 normal regular word readers shows that 3 fit the surface dyslexic pattern, 2 were mixed with both low irregular and nonword scores, and there were no phonological dyslexics (despite claims of 15%). As such, Castles and Coltheart could claim that 6% of their poor readers fit the pure surface dyslexic subtype; norms based on a larger group of subjects may have dropped this figure even more.

The empirical question is, which way of analysing word/nonword scores of good and poor readers is correct for determining subtypes?

The obvious means of evaluating surface and phonological dyslexic subtypes is to first determine if regular word reading is normal or not, and then go on to determine where poor readers' scores fall in comparison to the norms on irregular and nonwords as well. To examine the difference between poor readers' word type reading and compare these to good readers' differences while ignoring whether their actual scores on the individual word lists fall in the normal range or not (particularly for regular words), blinds researchers to viewing other possible dyslexic subtypes. This does not offer directional information of the data, but instead is a purely quantitative measure. Readers must presume that differences in scores involving regular-irregular or regular-nonword score differences, are always reflecting a sum generated from higher regular word scores when this may not have been the case. By examining the difference between good and poor readers on each of the word types in isolation, particularly regular word scores, deviations from dual-route theory and/or qualitatively different patterns from good readers can be recognised.

In future, it is suggested that researchers of developmental reading deficits use the same statistical methods as Coltheart and Leahy (1996), or when appropriate, use Coltheart & Leahy's norms themselves in accordance with the Castles Word/Nonword Test (in the Appendix of Coltheart and Leahy (1996)) for diagnosing subtypes. Manis et al. (1996) and other authors may wish to reanalyse their data using methods outlined here. Based on the reanalysis of data from Castles and Coltheart (1993), the authors can safely assume that pure forms of developmental surface dyslexia exist. This reanalysis has raised a new question, however, do pure forms of phonological dyslexia exist?

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## W-21. Developmental Surface Dyslexia and Other Interesting Reading Patterns: New Challenges for Theorists

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Current understandings of surface dyslexia, being normal knowledge of g-p relationships (nonlexical) with poor whole-word orthographic (lexical) knowledge, evolved from studies using adults with brain injuries (Behrmann & Bubb, 1992; Patterson, Marshall, & Coltheart, 1985). Some authors (Castles & Coltheart, 1993, 1996; Manis et al., 1996) now claim to have found the reading pattern in children with no history of brain damage. Observing this same pattern in both acquired and developmental dyslexic populations has interesting implications for how the brain may process words; e.g. researchers can begin to examine cognitive/sensory system deficiencies (often associated with developmental disorders) and/or modular deficits (often associated with acquired disorders) in an attempt to discover formulae capable of explaining both forms of the subtype.

Before delving into theories to explain surface dyslexia (or any subtype of dyslexia), however, we must address the issue as to whether the subtype exists or not. It's existence has been called into question (Cestnick, 1997; unpublished manuscript) based on researchers' inappropriate means for determining dyslexic subtypes (statistical methods), as well as inappropriate subject selection and sample size. It is therefore the intent of the present study to determine if developmental surface dyslexia exists by using statistical methods appropriate to determining dyslexic subtypes (outlined in Coltheart & Leahy, 1996), children from reading rehabilitation programs and a large sample size. The statistical means of analysing word/nonword data will also bring to light several presently inexplicable qualitatively different reading patterns in poor readers when compared to good readers.

### *Method*

*Subjects and Materials.* Ninety children with reading difficulties and normal IQ (TOMAL) between the ages of 7–12, from 8 schools within Sydney, Australia, participated. The children were referred by principals/teachers of

the schools from their reading rehabilitation programs. All children were administered the Castles Word/Nonword Test which is comprised of 30 regular words, 30 irregular words, and 30 nonwords all matched on word frequency, imageability, grammatical class, syllable and letter length. Each word was typed onto a separate 5" × 3" flash card using Geneva, 14 point.

*Procedure.* Each child was administered the Castles Word/Nonword Test individually in a quiet room while sitting opposite the experimenter. The children were asked to read each word or fake word aloud and cards were presented one at a time until all of them were read. All incorrect word pronunciations were recorded in detail. Cards were shuffled for the next child to randomise the word order presentation.

Total correct scores out of 30 were calculated for each of the regular, irregular and nonwords. Individual scores for each of these word-types were compared with the 420 good reader normative data from Coltheart and Leahy (1996). These norms dictate a minimal normal score, below average (Band B) and significantly below average scores (Band A) for each of the three word types, by chronological age. Band B and Band A score ranges are said to be those in which only 3.3–3.8% and 0–1% of the good readers fell in, respectively. As such, these ranges represent poor reader ranges. Surface dyslexics would be those children who achieve the minimal normal score or higher on regular words and nonwords, but in either Band B or A for irregular words. Scores were observed for other possible subtypes as well.

The Castles Word/Nonword Test was readministered to subjects to determine reliability and standard errors. No subject showed a different reading pattern on the second administration.

### *Results*

Of the ninety children, 7/90 (7.8%) showed the pure surface dyslexic pattern, and 8/90 (8.8%) showed the pure phonological dyslexic pattern. Other patterns existed as well, which were: poor regular, irregular and nonword (16/90; 17.7%); normal regular, poor irregular and nonword (4/90; 4.4%); poor regular, normal irregular and poor nonword (10/90; 11%); poor regular, poor irregular and normal nonword (3/90; 3.3%); and poor regular, normal irregular and nonword (1/90; 1.1%). The remaining 41 children all reached or surpassed the normal floor for all three word types.

Not taking the normal readers into account, these subtypes represent the following percentages of the poor reader population (Table 10).

### *Discussion*

This data confirms that developmental surface dyslexics do exist, and that children with this reading pattern are just as frequent as phonological dyslexics. Interestingly, a number of reading patterns have been exposed by this data which are currently inexplicable by existing models of reading aloud.

TABLE 10

Subtype	Regular	Irregular	Nonwords	% poor readers
General Rdg. Deficit	—	—	—	32.6
Unknown	—	+	—	20.4
Phonological Dyslexia	+	+	—	16.3
Surface Dyslexia	+	—	+	14.3
Unknown	+	—	—	8.2
Unknown	—	—	+	6.1
Unknown	—	+	+	2.0

*Note.* (+) Denotes normal; (—) denotes significantly below normal.

Four different patterns observed all involved odd regular word reading scores in combination with various irregular and nonword scores. Dual-route theory states that words can be read via a lexical or nonlexical route which are picked up via the use of irregular and nonwords respectively. Irregular words (e.g. 'yacht') can not be read by applying normal sounding-out rules and are said to require whole-word orthographic/sight processes (lexical access) to be read correctly. Nonwords (e.g. 'borp') on the other hand, must be read by applying sounding-out rules (nonlexical access). Differently, regular words can be read by either the lexical or the nonlexical route, so normal irregular or nonword scores dictates normal regular word scores. Based on findings here, this claim of dual-route theory can not explain 36.7% of cases (not including the general reading deficit category) which showed low regular word scores with either normal irregular or nonword reading, as well as normal regular word scores with low irregular and nonword reading scores. As such, dual-route theory should be altered to account for these newly observed patterns, be limited to the study of surface and phonological dyslexics, or be abandoned as a theory for developmental dyslexias; albeit perhaps suitable for acquired dyslexics.

In addition, this data challenges the belief of various researchers, e.g., Bryant and Impey (1986) that most poor readers are quantitatively, but not qualitatively, different from good readers. The 'quantitatively different' perspective may account for 32.6% of the poor reader population here, but the remaining 67.3% of the poor readers demonstrated reading patterns qualitatively different from those of the good reader controls.

In terms of children participating in school reading programs in Sydney, Australia, it should be noted that 45.5% of the children referred for the study (said to be at least 2 chronological years behind in their reading by their educators) had normal word reading skills. It could be that these children had reading problems beyond the word level, were misdiagnosed or the educators have high expectations for their students. Educators should make note of this in order to re-evaluate those placed in their reading programs and/

or examine each case individually to determine individual needs which may or may not involve deficits to reading. The Coltheart and Leahy (1996) norms could be used to help guide decisions for reading program placement.

In developing new theories of processes behind reading words aloud, researchers should attempt to account for all of the above reading patterns (Table 10). At present, dual-route, parallel-distributed and multiple levels theories can not account for all of these patterns.

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### W-22. Individual Differences in the Previous Trial Effect

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and Marco Iacoboni

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Behavioral laterality effects are believed to reflect hemispheric specialization for the task and are sensitive to individual differences, including handedness, sex and menstrual stage. But the laterality effect in a behavioral experiment with discrete trials also reflects module- and hemisphere-specific momentum effects across trials. Are these previous trial effects also sensitive to individual differences? We report the results of three lateralized lexical decision experiments that manipulated the handedness, biological sex and menstrual stage. We analyzed accuracy and speed of responses on the current trial as a function of the correctness of the previous trial, the wordness of the previous target and the visual hemifield of the previous target. Sex, menstrual stage and handedness all interacted with previous trial variables. Males were more sensitive to previous trial variables than were females; females during menses were more sensitive than during the midluteal stage; right-handers were more sensitive than were left-handers. Thus, handedness, sex and menstrual stage all modulate previous trial effects but do so in different ways.

## *Introduction*

Behavioral laterality effects in the normal brain are usually obtained from tests consisting of discrete trials with lateralized targets. It is customary to regard the “snapshot” provided by each trial as an accurate measure of hemispheric specialization for the trial. But laterality effects in the current trial may be affected by performance in the previous trial and thus also reflect hemispheric “recent past” dynamics.

There is little data on hemispheric momentum across trials. Spence et al. (1990) found a selective effect of order of stimulus presentation at short ISIs on the visual field (VF) asymmetry in an emotionality judgment task of negative and neutral emotional scenes. Levy et al. (1990) found that both the lateralization and response accuracy of the previous trial affected the VF asymmetry in the current trial in a lateralized syllable identification task. Recently, Iacoboni et al. (1997) used a lateralized lexical decision task and found previous trial effects as a function of (1) the correctness of the previous trial, (2) the VF of the previous target, and (3) the wordness of the previous target.

In this paper we study individual differences in the previous trial effect in lateralized lexical decision. In Experiment 1 we analyze the effect of biological sex, male vs. female; in Experiment 2 we analyze the effects of high and low estrogen, menstrual stages in females; in Experiment 3 we analyze the combined effects of biological sex and handedness.

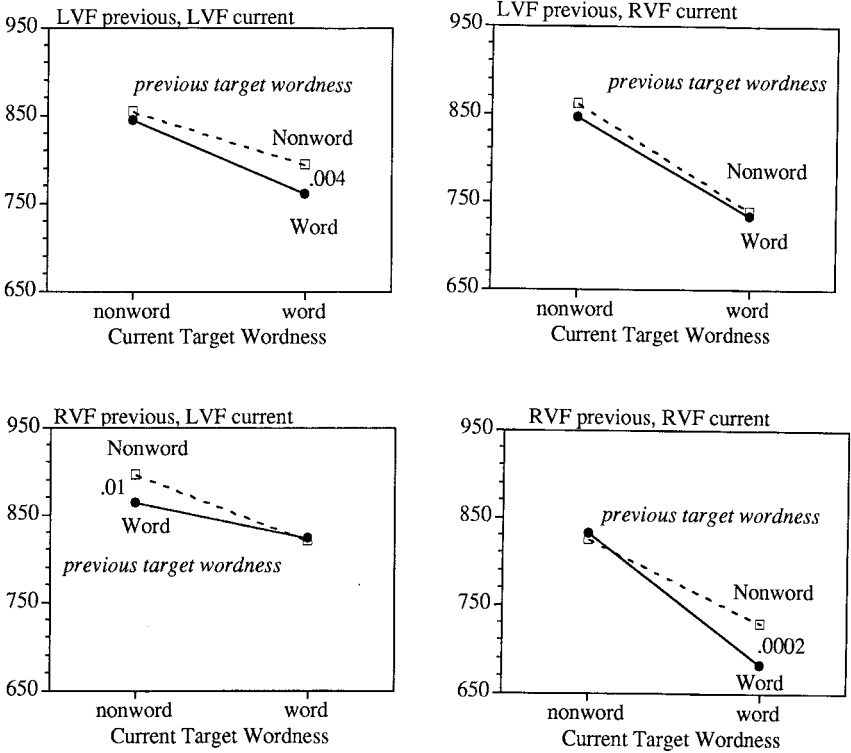
## *General Methods*

All three experiments required lexical decision of lateralized English letter strings varying in length from 3 to 6 letters. Nonwords were orthographically legal. All experiments included bilateral trials with cued word or nonword targets in one visual hemifield (VF) and word or nonword distractors in the other. Experiments 1 and 2 included unilateral trials as well. Targets were presented for 120 ms on a computer monitor and responses were made by pressing one of two buttons to indicate “word” or “nonword” targets.

Due to small cell sizes, two separate ANOVAs were run. One included correctness of the previous trial ( $C_p$ ), the visual field of the previous target ( $VF_p$ ) and the visual field of the current target ( $VF_c$ ) as independent variables. The other included the visual field ( $VF_p$ ) and wordness ( $W_p$ ) of the previous target, and the visual field ( $VF_c$ ) and wordness ( $W_c$ ) of the current target as independent variables. Each ANOVA was run with speed (RT) or accuracy (acc) as the dependent variable.

## *Meta-analysis*

The previous trial effects of the right-handed subjects in all three experiments were analyzed together regardless of individual differences. The fol-



**FIG. 19.** Lexical congruity effects as a function of the visual hemifield of the previous target and of the current target.

lowing significant effects occurred: (1)  $Cp_{(RT)}$ : Targets following correct trials were decided faster than targets following incorrect trials. (2)  $VFp \times VFc_{(RT,acc)}$ : There was a visual field congruity effect. For accuracy it was significant in the RVF, whereas for speed it was significant in the LVF. (3)  $VFp \times VFc \times Wp \times Wc_{(RT,acc)}$ : There was a lexical congruity effect for word targets when the target occurred in the same VF on the previous and current trial, but there was a lexical incongruity effect for nonword targets when the target occurred in opposite VFs on subsequent trials (Figure 19).

*Experiment 1: Biological Sex*

*Methods.* Trials in this experiment consisted of either unilateral presentations, with targets only or bilateral presentations, with a cued target in one VF and a distractor in the other VF. Twelve male and 12 female subjects, all right handed, participated.

*Results and discussion.* The following interactions of previous trial variables with sex occurred: (1) Females showed a greater effect of previous wordness than males:  $Wp \times Sex_{(RT)}$ . (2) Males showed a greater lateral differentiation as a function of previous wordness than did females:  $VFc \times Wp \times Sex_{(RT)}$ . (3) The lexical congruity effect in males, but not in females, was sensitive to the visual hemifield of the previous target:  $VFp \times Wc \times Wp \times Sex_{(acc)}$ .

Thus, males show greater lateral differentiation than females, i.e., more interactions between VF of current *or* previous trial and some other variable(s).

### *Experiment 2: Menstrual Stage*

*Methods.* The task was identical to Experiment 1. Subjects included 32 right-handed females, half were tested during the low estrogen stage of the menstrual cycle (menses), and half were tested during the high estrogen stage (midluteal).

The same ANOVAs were ran as in Experiment. 1, replacing Sex by Stage (menses, midluteal):  $Cp \times VFp \times VFc \times Stage$  and  $Wp \times Wc \times VFp \times VFc \times Stage$ .

*Results and discussion.* The following interaction of previous trial variables with menstrual stage occurred. Females during menses showed a greater lateral differentiation (i.e., a significant  $VFc \times VFp \times Wp$  interaction) than females in the midluteal stage:  $Wp \times VFp \times VFc \times Stage$ . Here, there was a symmetric VF congruity effect in all conditions except in the menses group following a word, where the congruity effect occurred only in the LVF. Thus, females with low estrogen appear to resemble males.

### *Experiment 3: Sex and Handedness*

*Methods.* The stimuli were the same as in Experiment 1, but there were only bilateral presentations, with an underlined target in one VF and a distractor in the other. Subjects' handedness was classified by a modified Edinburgh questionnaire. There were 18 left-handed females, 28 right-handed females, 16 left-handed males, and 20 right-handed males.

*Results and discussion.* The following interactions of previous trial variables with Sex and Handedness occurred: (1) Right- and left-handers had different sensitivity to error monitoring:  $Cp \times Handedness_{(acc)}$ . Right handers tended to be more accurate following a correct than an incorrect trial whereas left-handers tend to be more accurate following an incorrect than correct trial. (2) Males showed greater (previous trial) lateral differentiation:  $Cp \times VFp \times Sex_{(RT)}$ . Correctness of previous trial interacted with visual field of previous trial in males but not in females. (3) There was an opposite (previous trial) laterality effect in right- and left- handers:  $VFp \times Wc \times Handedness$ . In right-handers there was a greater wordness advantage when the pre-

TABLE 11  
Modulation of Previous Trial Effects by Sex, Menstrual Stage, and Handedness

	Experiment 1: Overall	Experiment 2: Sex	Experiment 3: Stage	Sex	Handedness	Sex × Handedness
Cp	+			+	+	
Wp	+	+	+		+	
VFp	+	+	+	+	+	+

*Note.* Cp, Correctness of previous trial; Wp, wordness of previous trial; Vfp, VF of previous trial.

vious target was in the RVF, whereas in left-handers there was a greater wordness advantage when the previous target was in the LVF:  $VFp \times Wc \times Handedness_{(RT)}$ . (4) There was a wordness congruity effect in right- but not left-handers:  $Wp \times Wc \times Handedness_{(RT)}$ . (5) There was (previous trial) lateral differentiation in males but not in females and it interacted with handedness:  $Wc \times VFp \times Handedness \times Sex_{(acc)}$ . Females did not show main effects or interactions of previous VF and current wordness. Right-handed males showed an interaction of previous VF and current wordness whereas left-handed males did not. (6) There was (current trial) lateral differentiation in males but not in females and it interacted with handedness:  $Wp \times VFc \times Handedness \times Sex_{(RT)}$ . Only right-handed males tended to perform better in the RVF following nonwords than words but tended to perform better in the LVF following words than nonwords. (7) Right-handed males showed greater lateralized differentiation than other groups:  $Wp \times VFp \times VFc \times Sex \times Handedness_{(RT)}$ . All Sex × Handedness groups showed a VF congruity effect except the right-handed males following nonword targets.

Thus, handedness is more sensitive than sex to previous trial variables. In general, right-handers are more sensitive to, or show opposite previous trial effects than, left-handers. Males are more sensitive to previous trial variables and show greater lateral differentiation (in either the previous or current trial) than females. Right-handed males tend to show different previous trial effects than the other Sex × Handedness groups.

Although laterality effects in general are more likely to occur in accuracy than latency, previous trial effects are more likely to occur in latency than accuracy.

### Conclusion

Previous trial effects are pervasive and some are consistent across (similar) experiments. Correctness of the previous trial, visual field of the previous target and wordness of the previous target all affect performance in the current trial. Sex, menstrual stage, and handedness all affect not only degree of lateralization but also the momentum of hemispheric-specific modules, but they do so in different ways (Table 11).

## References

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