of results supports the claim that Broca's aphasics have a delay in the integration of lexical information into the preceding sentence context.

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2. Semantic Deficits in Right Hemisphere Patients

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It is by now fairly well established that the right hemisphere plays a role in some aspects of language comprehension (see for an overview, Joanette, Goulet, & Hannequin, 1990). Lexical–semantic processing is one of these aspects. One kind of evidence for the involvement of the right hemisphere in lexical–semantic processing comes from patients with right hemisphere brain damage. These patients are reported to be impaired in retrieving or using lexical–semantic information (e.g., Gainotti, Caltagirone, Miceli, & Masulo, 1981). In general, the current evidence suggests that the left and right hemisphere might be differentially sensitive to specific types of semantic relations (Beeman, Friedman, Grafman, Perez, Diamond, & Lindsay, 1994; Chiarello, Burgess, Richards, & Pollock, 1990; Drews, 1987; Rodel, Cook, Regard, & Landis, 1992). Several studies have observed a stronger right hemisphere effect for word pairs that were semantically but not associatively related (Chiarello et al., 1990; Rodel et al., 1992).

In our study we investigated lexical-semantic processing in 8 right hemisphere patients by recording event-related brain potentials (ERPs). We asked subjects to listen attentively to word pairs. The words in these pairs were either unrelated or related in meaning. Related word pairs consisted either of words that were *associatively* related (e.g., *bread–butter*) or of words

that were only *semantically* but not associatively related (e.g., *church–villa*). Purely semantic pairs consisted of prototypical members of the same semantic category.

The most relevant ERP-component for this study is the N400, a negative peak in the waveform that is sensitive to the semantic relation between primes and targets (see Kutas & Van Petten, 1994). The N400 amplitude is reduced to words that are preceded by related words compared to targets preceded by an unrelated prime. This difference in the N400 amplitude is referred to as the N400-effect.

In addition to the patients with a right hemisphere lesion, we tested 12 control subjects matched in age and education with the RH patients, and 20 aphasic patients with a left hemisphere lesion.

The right hemisphere patients were the only subjects who showed a dissociation between associative and semantic word pairs. That is, the elderly controls and the aphasics with a mild comprehension deficit showed N400 effects of equal size for both associatively and semantically related word pairs. The aphasics with more severe comprehension deficit showed a reduction of N400 effects, but to the same degree for the two types of word pairs. In contrast, the right hemisphere patients showed a normal N400-effect for the associatively related word pairs, but no N400-effect for the semantically related word pairs.

In a follow-up study we presented right hemisphere patients with sentences spoken at a normal rate. Half of these sentences ended with a semantically anomalous word (e.g., "*The dangerous animals are sitting in a priest.*"), the other half of the sentences had a semantically congruous ending (e.g., "*The little boys are playing with a ball.*"). Normally the semantically anomalous ending results in a large N400 compared to the semantically congruous ending (Kutas & Hillyard, 1980).

In this experiment, we tested 6 patients with a right hemisphere lesion, 12 elderly controls and 14 aphasic patients with a left hemisphere lesion (7 high comprehenders and 7 low comprehenders).

All subject groups showed significant N400-effects. However, compared to the elderly controls and the high comprehenders, the size of the effect was reduced in both low comprehenders and right hemisphere patients. Most interestingly, the N400-effect was delayed by about 100 ms in the low comprehenders, but not in the patients with a right hemisphere lesion.

According to their results on a clinical aphasia test battery (i.e., the Aachen Aphasia Test), none of the right hemisphere patients was aphasic. Nevertheless, the results of two ERP studies showed subtle semantic deficits in these patients. The first study suggested a selective impairment in the processing of words that were purely semantically (but not associatively) related. The second study indicated that the right hemisphere patients were also slightly impaired in matching the semantic specifications of a lexical item against the semantics of the sentence context. However, insofar as these patients are

able to integrate lexical meaning into the sentence context, the finding that the latency of the N400 effect does not differ from that of the normal controls suggests that they do so at a normal rate.

A comparison between the results of the aphasic patients and the right hemisphere patients suggests that both hemispheres are involved in lexical-semantic processing, but in a qualitatively different way. The left hemisphere is crucial for the computation of semantic overlap, independent of strength or distance of the semantic relations. A lesion in the left hemisphere therefore equally affects the processing of different types of semantic relations. The right hemisphere becomes increasingly relevant to establishing coherence between elements with diminishing semantic overlap. A lesion in this hemisphere therefore more strongly affects meaning relations which are less direct than associatives, and might also impair the computation of an overall interpretation at sentence and discourse levels. This difference is compatible with the notion that semantic information is more coarsely coded in the right hemisphere than in the left hemisphere (Beeman et al., 1994).

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3. When Leopards Lose Their Spots: Knowledge of Perceptual Properties in Category-Specific Deficits for Living Things

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There have been several reports of patients who have selective deficits for the semantics of living things. Category-specific semantic impairments are