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**Comprehension of word meaning in sentences by fluent and
nonfluent aphasics**

Jensen, Lise R., Ph.D.

City University of New York, 1991

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**COMPREHENSION OF WORD MEANING IN SENTENCES
BY FLUENT AND NONFLUENT APHASICS**

by
Lise R. Jensen

**A dissertation submitted to the Graduate Faculty in
Speech and Hearing Sciences in partial fulfillment
of the requirements for the degree of Doctor of
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Abstract

COMPREHENSION OF WORD MEANING IN SENTENCES

BY FLUENT AND NONFLUENT APHASICS

by

Lise R. Jensen

Adviser : Professor Michael Studdert-Kennedy

The focus of the research presented is on the preservation of integration, i.e. contextual encoding of word meaning in aphasics. Based on recent research in the language processing deficits in aphasia, posterior aphasics were expected to have difficulties at the integrational level of comprehension. A set of Danish norms for semantic properties of word meaning was collected for sixty common Danish words. Based on these norms a memory probe task was constructed where the encoding of high and low dominant semantic properties of word meaning was examined in different sentence contexts. Sentences and probes were presented visually, and key-press response latencies and errors were recorded for subjects' decision as to whether or not a word occurred in a preceding sentence. An experiment with normal Danish subjects was carried out and compared to an experiment with fluent and nonfluent aphasics. The results confirmed the general finding of contextual encoding of word meaning in normal subjects, but unlike other studies the integration effect was observed for both high and low dominant properties of word meaning. Fluent aphasics showed an abnormal effect of property dominance which may indicate a disorganization within the lexical-semantic system. Both fluent and nonfluent aphasics showed integration only of low dominant properties. When regrouped according to level of single word comprehension on the Boston Diagnostic Aphasia Examination, high comprehenders conformed to normal subjects in their response latencies, whereas low comprehenders failed to show integration of high dominant properties and made more errors on the task than high comprehenders. The results are taken to suggest that low comprehenders have difficulty with some aspects of integration of word meaning involving selective deactivation of dominant properties, and that they may require more time for contextual encoding of these properties than normal subjects and high comprehenders.

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1. DISTURBANCES OF COMPREHENSION IN APHASIA

1.1 Introduction

Brain damage may disrupt the comprehension process at many theoretical levels, and presumably more than one level may be affected in a given patient. At the most fundamental level brain damage may cause cortical deafness resulting in an inability to understand language in its spoken form. Many patients with left hemisphere damage, however, who have not suffered any significant loss in auditory sensitivity have difficulties with auditory comprehension of language. In other cases such difficulties are associated with general problems in discrimination of pitch, intensity and duration of acoustic stimuli; in yet others, difficulties with verbal comprehension cooccur with an inability to identify and associate nonverbal sounds with meaning (Ellis and Young, 1988). A small subgroup of patients is diagnosed as suffering from pure word deafness (Goldstein, 1948). Patients with pure word deafness cannot comprehend speech, although their reading comprehension and auditory perception of nonverbal speech sounds are unaffected. In its pure form, i.e. when it occurs without general auditory agnosia affecting the perception of nonspeech sounds or without other aphasic symptoms, the disorder is very rare (Metz-Lutz and Dahl, 1984).

More commonly, defects in the perception of speech sounds cooccur with comprehension problems which cannot be completely compensated for through reading and which are often accompanied by certain expressive difficulties such as word finding problems, paraphasias and paragrammatic but fluent speech. This larger group of patients with so-called impressive aphasia may constitute a very heterogeneous population (Franklin, 1988). Nevertheless, neurolinguistic theory and studies have tended to group patients with this diagnosis together in studies testing impairments at different levels of the comprehension process, often in search of a unitary explanation of their comprehension problems.

The studies have involved patients selected according to site of lesion (anterior versus posterior) or aphasic syndrome (Broca's versus Wernicke's

aphasia), or they have been based on specific symptoms such as fluent versus nonfluent speech production, or good versus poor comprehension as measured on standard aphasia tests like the Boston Diagnostic Aphasia Examination or the Token Test (Goodglass and Kaplan, 1972; De Renzi and Vignolo, 1962). In the following sections a survey of some of these studies will be presented organized according to the linguistic level in the comprehension process that they aim to address. The focus is primarily on studies addressing disturbances of comprehension in aphasics with symptoms suggesting posterior brain lesions, i.e. patients diagnosed as Wernicke's aphasics, fluent aphasics, or aphasics with comprehension difficulties. For convenience's sake, the term 'posterior aphasics' will be used when referring to patients from all of these categories, without implying any known or specific site of lesion.

1.2 Disturbances of speech perception

A large group of studies has examined impairments in the basic ability of aphasic patients to perceive human speech sounds. In general, disturbances in speech perception affect segmental rather than prosodic information. Thus, Blumstein and Goodglass (1972) tested the ability of fluent aphasics (Wernicke's, Conduction and Anomic aphasics) and nonfluent Broca's aphasics, as well as of non-braindamaged controls to appreciate stress contrasts in a task where stress carried lexical distinctions. Although aphasics as a group made more errors on the overall task than normal controls there was no difference in the proportion of stress-determined errors between normals and aphasics or between aphasic subgroups. The conclusion was that the perception of stress is a remarkably robust linguistic feature and that it appears to be preserved in aphasia.

At the segmental level of speech perception most aphasics show some degree of deficit, and one issue concerns whether this might be the consequence of a general auditory processing deficit. It has been suggested that left hemisphere brain damage is associated with an impairment of temporal processing (Efron, 1963) and that this defect includes difficulties with

perceiving the fast transitions identifying stop consonants (Tallal and Newcombe, 1978). Although the role of time in phoneme identification and the extent to which aphasic difficulties in speech perception arise at a 'pre-phonetic' level have been addressed in several studies (e.g. Blumstein, Katz, Goodglass, Shrier, and Dworetzky, 1985; Riedel and Studdert-Kennedy, 1985), the issue will not be considered here. The primary focus of what follows is on language comprehension defects and the possible contribution of speech perception problems to these.

Different authors have put forth the view that comprehension deficits in aphasia can be attributed to and have as their underlying cause a basic impairment in speech perception. Thus, Luria (1970) suggested that the primary underlying disturbance in Wernicke's (or acoustic-gnostic) aphasia is a disturbance of 'phonemic hearing' associated with temporal lobe damage. In accordance with this hypothesis several studies have investigated the speech perception skills of different subgroups of aphasics.

Basso, Casati, and Vignolo (1977) used a so-called categorical perception task to test phoneme identification with synthetic stop consonants differing on a voice onset time (VOT) continuum. Research with normal subjects has shown that such stimuli are identified as belonging to discrete phonemic categories with sharp category boundaries (Lieberman, Harris, Hoffman, and Griffin, 1957). Basso et al. examined this phenomenon in aphasic subjects. The participants were brain damaged and normal subjects. Aphasic subjects with left hemisphere damage were divided into four diagnostic groups based on fluency and level of comprehension (as measured on the Token Test). Right hemisphere patients and left hemisphere patients without aphasia had no difficulty in classifying members of the acoustic continuum as belonging to one or the other phonemic category. Aphasic subjects differed in their performance. Based on the presence or absence of a clear boundary between phonemic categories aphasic patients were assigned to three levels of severity: mild, severe, and very severe phoneme identification deficit. There was a significant correlation between degree of phoneme identification deficit and performance on the Token test. However, the authors point out

that the correlation cannot be due to a simple cause-effect relationship between phoneme identification skills and language comprehension. Thus, practically all Broca's aphasics with good comprehension showed some degree of phoneme identification deficit, and one third of the Wernicke group who had poor comprehension showed no phoneme identification deficit. The authors find that the evidence is inconclusive as to which dimensions of aphasia are associated with phoneme identification deficits, but they suggest that nonfluency is a relevant candidate for consideration.

Other studies have explored in more detail the nature of the phoneme identification deficit in aphasia. As mentioned above, normal subjects identify certain continuously varying synthetic speech stimuli as belonging to discrete phonemic categories. More interestingly, discrimination between items along such an acoustic continuum is only reliable for items that belong to different categories. In other words, the same acoustic difference is only perceived as a difference by normal subjects when it coincides with a phoneme boundary (Liberman et al., 1957). This relationship between phonetic discrimination and phoneme identification was examined in aphasic subjects by Blumstein and her colleagues (Blumstein, Cooper, Zurif, and Caramazza, 1977; Blumstein, Tartter, Nigro, and Statlender, 1984). Results in both studies showed that certain aphasics whose discrimination was in accordance with the normal boundaries between phoneme categories, could not identify the stimuli reliably. However, the reverse did not occur. One group of aphasics consisting of one Broca's, one Conduction and one Mixed nonfluent aphasic was impaired in both discrimination and identification. Wernicke's aphasics did not have discrimination problems; yet, three out of four of these patients were unable to identify the phonemic category of the stimuli. It appears, then, that labeling or identification presupposes correct discrimination, but also poses further cognitive or linguistic demands such as the ability to maintain a stable configuration or category label or making linguistic use of the perceived contrast. The results also showed that phonetic discrimination scores were not correlated with overall auditory language comprehension ability as measured by the Boston Diagnostic Aphasia Examination, whereas phoneme identification scores showed a

significant correlation. These findings suggest that the comprehension difficulties of fluent aphasics do not arise due to lack of sensitivity to particular acoustic dimensions but may be associated with problems in the encoding or classification of phonetic percepts onto linguistically relevant categories.

Blumstein, Baker, and Goodglass (1977) tested different subgroups of aphasics with a task requiring the patients to make same-different judgments about pairs of auditorily presented stimuli differing in initial phoneme or in phoneme sequence. The stimuli were either words or phonologically acceptable nonwords. Aphasics with posterior lesions were classified as Wernicke's aphasics based on their fluent speech and poor comprehension. Patients with anterior lesions, nonfluent speech and good comprehension were classified as Broca's aphasics. The authors found that all aphasics showed discrimination impairment, especially with nonword stimuli. Interestingly, their subjects with Wernicke's aphasia who had the lowest comprehension scores on the Boston Diagnostic Aphasia Examination, were not the most impaired. A group of mixed posterior aphasics comprising patients classified as Conduction, Transcortical Sensory, and Anomic aphasics did worse on the discrimination test although their comprehension scores were better than the group of Wernicke's aphasics. Thus, the extent of the phonemic discrimination problem did not match the extent of the comprehension defect in any direct way.

Miceli, Gainotti, Caltagirone, and Masullo (1980) reached a similar conclusion after testing a large group of unclassified patients with left hemisphere damage on a task requiring the subjects to make same-different judgments about two auditorily presented nonwords differing in initial consonant. The patients were also tested with a word-picture matching test with both phonemic and semantic foils and a sentence comprehension test requiring the execution of simple verbal commands. The results showed a significant correlation for the large patient group as a whole between the ability to make same-different judgments on nonwords and performance on the word-picture matching and sentence comprehension tests. However, many

patients who did poorly on same-different judgments showed no impairment in word and sentence comprehension and the reverse pattern was also observed, suggesting an incomplete relation between general comprehension ability and speech perception skills as they were tested in this study.

The research discussed above serves to point out the necessity of paying due consideration to how speech perception skills are measured in brain-damaged subjects, especially concerning the cognitive, memory and linguistic demands posed by different types of tasks. Measuring speech perception in the context of language comprehension also raises two related issues. Tasks involving real word stimuli and requiring picture matching may provide additional cues for establishing phonological structure and thus cover up deficits in phonetic perception. Conversely a semantic disturbance or a disturbance involving the connection between sound and meaning may make such a task more complicated for the patient than warranted by his abilities in phonetic discrimination.

A second set of studies has thrown further light on the nature of the comprehension deficit in Wernicke's aphasia by demonstrating that if the semantic load increases, the patients' ability to discriminate between phonemically similar words decreases further than in other aphasic groups. Baker, Blumstein, and Goodglass (1981) showed that whereas Broca's aphasics do well on word-picture matching, Wernicke's aphasics show a marked decrease in performance when semantic foils are introduced, indicating a trade-off between phonological and semantic processing such that when the load in one increases, performance in the other suffers. Also Gainotti, Miceli, Silveri, and Villa (1982) found a greater impairment on semantic discrimination in Global, Wernicke's and Anomic aphasics than in Broca's aphasics in a similar task. Analysis of the effect of site of lesion on number of semantic errors showed that lesions involving the temporal lobe were associated with significantly more errors than lesions not involving this lobe. Thus, based on these word-picture matching tasks it seems that the comprehension problems of Wernicke's aphasics may involve a semantic component.

In conclusion, most aphasics have difficulties in speech perception at the segmental level, whereas prosodic information is better preserved. These deficits at the segmental level are not directly correlated with global measures of comprehension. A closer analysis of their nature indicates that a distinction must be made between basic phonetic discrimination and the ability to use the percept in a linguistically relevant way. The former is prerequisite to the latter and may be intact while the patient is still unable to do the latter. Empirical research with groups of Wernicke's aphasics suggests that these patients discriminate in a normal fashion and their difficulty is not in sensitivity to a particular acoustic dimension but in the encoding or classification of the dimension onto a linguistically relevant category. Patients with comprehension difficulties seem to have their major problems in the latter phase. Thus, their impairment is more marked in tasks assessing the ability to establish phonological form or attach meaning to it rather than in phonetic discrimination. Accordingly, the comprehension deficit of this group cannot be explained as a general auditory ('pre-phonetic') or phonetic discrimination problem, but seems to involve deficits at the level of word form or word meaning.

1.3 Disturbances of lexical-semantic structure

1.3.1 Impairment of lexical-semantic knowledge in aphasics with posterior syndromes.

The preceding section concluded that a comprehension deficit was not necessarily associated with an impairment in perceptual analysis at the acoustic or phonetic levels. Rather, the research indicated that aphasics may have problems with comprehension independently of their basic speech perception skills. More specifically, the problems seem to include a deficient ability to establish a phonological form based on the phonetic percept or difficulties in associating it with or retrieving a specific word meaning. This characterization implies difficulties at the level of word form or word meaning.

Lesser (1978) suggests three levels of description for the word. At one level the word constitutes a phonological or orthographic form. At another level, it constitutes a grammatical unit in sentence structure. Thirdly, words have meaning, i.e. have an associated lexical-semantic structure. A fourth possible level arises if one attempts to distinguish between a general cognitive system of concepts and relations and the lexical-semantic system of word meanings. Neurolinguistic research in disturbances of word recognition has mostly focussed on disturbances at grammatical and lexical-semantic levels, and this section contains a review of studies in these areas. More recently, studies have addressed impairments at the level of accessing the phonological form or of associating it with meaning. This research will be reviewed in section 1.4.

A large number of studies has been concerned with disturbances of word meaning in patients with comprehension difficulties and Wernicke-like aphasia profiles. One aspect of this research has focussed on differences in preserved word recognition skills relating to the grammatical status of the word as a unit of analysis in sentences. A distinction between so-called function and content words has been found highly relevant to describe aphasic impairments (Goodglass, 1968). Function words have primarily a grammatical or relational meaning and have little or no inherent semantic content. Function words are also sometimes referred to as closed class words, reflecting the fact that this class of words includes mostly pronouns, prepositions and conjunctions, i.e. sets of words forming a closed system that does not accept new members. Function or closed class words are distinguished in both of these characteristics from content or open class words. As the name implies, content words have an inherent meaning and constitute the lexical-semantic system. Content words include the major word classes of nouns, verbs, adjectives and adverbs, all of which are open word classes in the sense that new members can be added or assimilated within each class.

The distinction between content and function words has been shown to be of importance in aphasia because these word classes are differentially affected

in different subgroups of aphasics. There appears to be a double dissociation between the preservation of function and content words in aphasics with anterior and posterior syndromes (Bradley, Garret, and Zurif, 1980; Friederici and Schöenle, 1980). Anterior aphasics appear to deviate from normals in the recognition processes involving function words, whereas posterior aphasics treat function words in a normal fashion. Concerning content words, however, several studies have found that posterior aphasics with fluent speech and comprehension defects are more impaired than anterior aphasics in both recognition and production of this class of words.

As mentioned in the previous section, Baker et al. (1981) and Gainotti et al. (1982) found greater problems in Wernicke's aphasics than in Broca's aphasics in tasks assessing auditory recognition of content words and lexical-semantic knowledge. Other studies have addressed lexical-semantic knowledge in tasks independently of auditory perception using written materials and have also demonstrated differences in preservation of lexical-semantic knowledge between different subgroups of aphasics. In such a task Zurif, Caramazza, Myerson, and Galvin (1974) found that patients with posterior lesions and Wernicke-like aphasia did worse than patients with anterior brain damage and Broca's aphasia, who behaved more like normal controls. Gardner, Silverman, Wapner, and Zurif (1978) found that Wernicke's aphasics were sensitive to nonlinguistic antonymic relations but seemed to have lost their appreciation of linguistic antonymic relations. Broca's aphasics, conversely, performed near normally on both. The results were interpreted as suggesting a lexical impairment in Wernicke's aphasics. Grober, Perecman, Keller, and Brown (1980) and Grossman (1981) showed that patients with fluent speech and presumed posterior brain damage did worse than patients with nonfluent speech and presumed anterior brain damage. Caramazza, Berndt, and Brownell (1982) formed subgroups were formed based on performance on the experimental task and found that patients in the subgroup who performed poorly on the task predominantly included aphasics with fluent speech, moderate to severe comprehension difficulties and assumed posterior lesions.

There seems then to be some support for the view that posterior brain damage and Wernicke-like symptoms such as fluent speech and comprehension difficulties cooccur more frequently with an impairment in lexical-semantic tasks than do anterior brain damage and Broca-like symptoms such as nonfluent speech and relatively well-preserved comprehension.

Concerning localization, however, the issues are very complicated. The above-mentioned studies of patients with focal lesions suggest that posterior brain damage is associated with lexical-semantic impairment. In accordance with this, Albert, Goodglass, Helms, Rubens, and Alexander (1981) argue that impairments in cross-modal associations and disruptions of lexical elements in comprehension are found with large lesions of the left temporo-parieto-occipital junction. In contrast to the above-mentioned studies, however, Lesser (1978) has argued that lexical semantic knowledge is supported by diffuse brain tissue and that the left hemisphere is specialized for transforming this diffusely represented knowledge into its formal shape as uttered words and sentences. This is borne out by studies of patients with diffuse brain damage, e.g. senile dementia, who may be impaired in lexical-semantic knowledge while other aspects of language such as syntax and phonology are relatively well preserved (Berndt, Caramazza, and Zurif, 1985). These views, however, may not be incompatible. Thus, different etiologies and variations in the focal extension of the disease may be responsible for variations in the linguistic defects of demented patients (Bayles and Kazniak, 1987).

1.3.2 The relationship of lexical-semantic problems in comprehension to naming and conceptual knowledge

A major issue concerning lexical-semantic problems in aphasia is the question of whether lexical-semantic knowledge itself is disturbed or whether the impairment arises in its realization as speech or word recognition. According to Lesser (1978) one should expect the same errors in both production and comprehension if the impairment involves a central

lexicon in the strongest sense of the hypothesis, namely that the representations of word meanings themselves are affected. Most aphasics do show reduced performance on naming, but the problems differ for different groups of aphasics and may have different underlying causes. The spontaneous utterances of Broca's aphasics are characterized by the absence or very low occurrence of function words compared with content words. Wernicke's aphasics, on the other hand, typically have problems with content words and produce incorrect items that may be phonologically or semantically related to the target word (literal or semantic paraphasias) or may be totally unrecognizable (neologisms). So-called Anomic aphasics, who usually have posterior lesions, may have other linguistic abilities well preserved but show a deficit in word finding in spontaneous production and in confrontation naming. A major issue is whether or not there is an association between the purported break-down of lexical semantics in the comprehension of posterior aphasics and their word finding difficulties or paraphasic errors in speech production.

Many researchers have been concerned with this question because the demonstration of a relationship between production and comprehension of words would characterize the disturbance as a 'central' one affecting the storage of word meanings rather than a 'peripheral' impairment in access processes (Caramazza and Berndt, 1978). Alajouanine, Lhermitte, Ledoux, Renaud, and Vignolo (1964) and Gainotti, Caltagirone, and Ibba (1975) found a relationship between semantic paraphasias in speech production and the number of errors on a word-picture matching test with lexical-semantic foils. Gainotti et al. (1975) also showed that the correlation between semantic errors in naming and word recognition was independent of the overall level of severity of aphasia. Other authors have found a similar relationship between the ability to make lexical-semantic relatedness judgments and naming (Goodglass and Baker, 1976; Lhermitte, Derouesne, and Lecours, 1971).

Thus, there is some evidence in favour of a central semantic deficit in posterior aphasia common to production and comprehension. In Goodglass

and Baker's study aphasics were shown to make more errors on those items they failed to name. This might indicate support for the strong version of the hypothesis about a break-down of underlying lexical-semantic representations common to production and comprehension. However, other studies have not shown a similar close relationship for individual items (Butterworth, Howard, and McLoughlin, 1984). Evidence against the strong claim concerning loss of specific lexical-semantic representations also comes from the general clinical impressions that aphasics show great variability with respect to the items they master on different occasions, and that aphasia therapy generalizes beyond the specific items practiced (Gainotti, 1982).

Another indication that the lexical-semantic deficit in aphasics is central might be a demonstration that nonverbal conceptual categories also tend to be disturbed in these patients. The question of a disturbance of conceptual thinking in aphasia is an issue of debate. It should be clear, however, that a conceptual impairment is not synonymous with a generalized intellectual reduction since other important aspects of intelligent behavior such as the ability to form intentions and act in accordance with plans are thought to depend on frontal areas of the brain and therefore may be unaffected in posterior aphasics (Luria, 1970). The hypothesis of a relation between language disturbances and conceptual impairment has been most clearly stated by Goldstein, who argued that disturbances in naming and word recognition are associated with a defect in categorical thinking or 'loss of abstract attitude' (Goldstein, 1948). It is difficult, however, to assess disturbances of nonverbal concepts and lexical-semantic meanings independently. Gainotti (1982) suggests the following operational definitions : a conceptual disturbance is a 'disorganization of the nonverbal representations of entities existing in the external world', whereas a lexical-semantic disturbance is an 'incapacity to correctly appreciate the relationships between words and objects to which they refer' (Gainotti, 1982, p. 282).

In order to test the relationship between conceptual and lexical-semantic

disorders Gainotti, Miceli, and Caltagirone (1979) used a nonverbal picture sorting task involving common objects. The task was followed by a 'verbal sound and meaning discrimination test', i.e. a word-picture matching test with phonemic and semantic foils. The subjects were large groups of aphasics, non-aphasic patients with left brain damage, patients with right brain damage, and normal controls. The results showed marked differences on the nonverbal picture sorting task between aphasic patients and all other groups. Importantly, within the aphasic group no differences were found relating to severity of aphasia but aphasics who made many semantic errors on the verbal sound and meaning discrimination test did significantly worse on the nonverbal picture sorting task. These results can be interpreted as supporting the existence of a relationship between impairments at the lexical-semantic level in aphasia and conceptual impairment, although they do not clarify the nature of the relation.

According to Gainotti, the data showing correspondences between problems in lexical-semantic tasks, naming problems and nonverbal conceptual impairment do not point to a loss of individual lexical items but suggest 'a disruption of conceptual information associated with each lexical item' (Gainotti, 1982, p. 292). Thus, lexical disruptions are rarely total because the patients usually retain some aspects of a word's meaning although they are not able to grasp the full meaning of the word. This is apparent in their difficulties with selecting the correct item from semantically similar alternatives and the impairment has a parallel in production and naming errors which tend to be semantically related to the target.

1.3.3 Nature of the lexical-semantic deficit

One can assume that conceptual knowledge of objects entails both perceptual and functional information about the objects as well as knowledge of their relations to other objects. Lexical items corresponding to conceptual representations reflect this information in terms of the semantic relations of a given word to other words in the mental lexicon (McCleary, 1988).

Some studies have contributed more specific information concerning the way

in which word meanings are disturbed in posterior aphasics. In order to examine and characterize disturbances of specific aspects of word meaning, researchers have resorted to different psycholinguistic theories of word meaning including network theory (Collins and Quillian, 1969), semantic feature theory (Smith, Shoben, and Rips, 1974), and prototypicality theory (Rosch, 1975). Besides these differences in descriptive framework, there are differences in the cognitive or linguistic demands of the tasks used. This makes it difficult to compare the results and make generalizations about the nature of the preserved and impaired aspects of word meaning in posterior aphasics.

Zurif et al. (1974) used a relatedness judgment task to examine the sensitivity to semantic features in Broca's and Wernicke's aphasics and normal controls. Subjects were asked to indicate which two words out of three went best together. The words were chosen so that pairs were related based on semantic features like +/-human, +/-animate, +/-reptile, etc.. Results showed that normal subjects do not always sort consistently with semantic features. Aphasic subjects deviated from normals. Wernicke's aphasics did not produce judgments which had any hierarchical structure in terms of semantic features. Instead they seemed to put words together which might be syntagmatically associated in the sense of being able to constitute the elements of a sentence. Broca's aphasics did not violate semantic features to the same extent, but in some instances they tended to sort based on emotional or connotative meaning rather than categorical relationship.

Goodglass and Baker (1976) tested the ability of normal subjects and aphasics to judge semantic relatedness between words. Subjects were shown a printed target word which remained within view while they received an auditory presentation of fourteen words. The task consisted in pressing a button after each word to indicate whether or not the item presented was related to the printed target word. Related words belonged to specific associative categories of word meaning such as superordinate, attribute, coordinate, functional associate, and functional context. On the whole,

aphasics with high comprehension scores on the Boston Diagnostic Aphasia Examination did better than subjects with low comprehension scores. More interestingly, low comprehenders did comparatively well on judging superordinate and attribute terms but were slow and made errors on related words from the categories functional context (e.g. 'drum': 'band') and functional associate (e.g. 'drum': 'beat'). This was interpreted as indicating weakening of the semantic field of the target words, especially related to these aspects of meaning.

In the study by Grober et al. (1980), posterior and anterior aphasics were presented with a category name which remained in their view while they had to decide whether or not each of 16 test items presented one at a time was a member of the category. Exemplars varied in the degree to which they were typical members of the category. The results showed no difference between anterior and posterior aphasics in the ability to categorize typical members. However, posterior aphasics showed a dramatic decline in the classification of atypical members, which they tended not to accept.

A similar problem with boundary exemplars of semantic categories has been demonstrated in a naming study by Grossman (1981). Fluent and nonfluent aphasics were asked to name as many exemplars as possible of a given category in one minute. Nonfluent aphasics tended to provide very central members, i.e. members with high prototypicality scores (cf. Rosch, 1975). Fluents aphasics with posterior brain damage stood out as a group compared to nonfluents and normals in that they provided more out-of-set responses and in general produced many peripheral members interspersed with more prototypical ones. Grossman concluded that the fluent group showed a weaker appreciation of semantic fields in keeping with the production of semantic paraphasias common in this group.

Some studies have contributed information regarding the preservation or disturbance of both verbal and nonverbal information. Thus, Wayland and Taplan (1982) found that fluent aphasics showed a deficit in a nonverbal

categorization task compared to non-fluents and non-aphasics. Errors indicated a problem in abstracting the prototype of a given category and sorting members in accordance with this. For fluent aphasics, naming ability correlated with performance on the categorization task.

Caramazza, Berndt, and Brownell (1982) constructed a nonverbal similarity rating task and a lexical classification task using line drawings varying continuously along a cup-bowl dimension in their diameter to height ratio and with the presence or absence of a perceptual feature, viz. a handle. In the similarity rating task subjects had to rate the similarity of random pairs of these items on a scale from one to seven. This nonverbal task was followed by a verbal classification task where subjects were asked to label the same stimuli as either 'cup' or 'bowl'. Besides the +/- handle feature an additional condition, +/- functional context, was introduced by including (or not including) a cereal box in the line drawings. Results on the similarity rating task separated aphasics into fourteen patients who scored highly on the test and six who did not. The six patients who failed tended to rely only on the +/- handle feature and were inconsistent in their appreciation of the diameter to height ratio. The results from the verbal labelling task showed a clear relation to performance on the similarity rating task. Patients who scored highly on similarity rating showed an appropriate integration of the +/- handle feature and the +/- functional context feature with diameter to height ratio. On the other hand, patients who were only sensitive to the +/- handle feature in their similarity judgments also tended to ignore diameter to height ratio and the functional context feature in their labelling. Correlational analysis with lesion and syndrome found that the second and most impaired group consisted predominantly of patients with posterior lesions and Wernicke-like symptoms. The study also replicated in part an earlier study by Whitehouse, Caramazza, and Zurif (1978) showing a relation between naming and preservation of conceptual information, including appreciation and proper integration of perceptual and functional attributes.

Only some tentative conclusions can be drawn. Zurif et al.'s study seems to

question the preservation of general semantic field information in posterior aphasics, because these patients violated even gross category differences when deciding which two out of three words went best together. The violations of category boundaries was also found in Grossman's naming study, where posterior aphasics provided some within-category responses, but also transgressed category boundaries. Similarly, in the study by Grober et al., the posterior aphasics failed to recognize category boundaries for atypical members. The results converge on indicating a weakening of category structure in the mental lexicon, especially for more atypical or peripheral members. The results of Goodglass and Baker point to difficulties in posterior aphasics with retrieving the full range of meanings associated with a given lexical item, especially as regards the function or situational context associated with a word. The study of Caramazza et al. has similar implications by showing difficulties in a group of posterior aphasics with the appreciation and proper integration of perceptual and functional properties of meaning.

In conclusion, several metalinguistic tasks in which subjects are required to make judgments about the relations among words have found posterior aphasics deficient when compared to aphasics with anterior syndromes. Furthermore, the research indicates that problems at the lexical-semantic level in word recognition have a parallel in naming and may also involve a conceptual impairment. Accordingly, the problem is characterized as a deficit in semantic memory. Studies of the nature of the preserved and disturbed aspects of word meaning have been based on different descriptive frameworks and have used different testing methods, which only allows for tentative comparisons and conclusions. However, it seems that posterior aphasics have difficulties in appreciating the precise hierarchical relationship between words and in identifying or retrieving the full range of semantic properties associated with a word.

1.4 Focus on lexical access and processing disturbances

In a series of studies Blumstein and her colleagues have provided some interesting data about posterior aphasics which appear to bring the

preceding hypothesis about a central impairment in lexical-semantics into doubt. Milberg and Blumstein (1981) and Blumstein, Milberg, and Shrier (1982) found evidence of normal semantic processing in posterior patients in a visual and in an auditory lexical decision task, in spite of the fact that the patients failed on semantic relatedness judgment tasks of the kind that have formed the empirical background for the hypothesized central deficit in lexical-semantics.

In a lexical decision task subjects have to decide whether or not the stimulus presented is a real word in English. Research with normal subjects has shown that if subjects are presented with pairs of words appearing with a short inter-stimulus interval and have to make a lexical decision about the second member of the pair, the meaning of the first word (the prime) has a small but robust effect on the reaction time to the following target word. If the prime and target are related in meaning reaction times are faster than if the prime is neutral or unrelated to the target word (Meyer and Schvaneveldt, 1971). This semantic facilitation (or priming) effect is generally thought to reflect the organization of the lexical-semantic system. Thus, normal subjects show facilitation not only between words which are highly associated but also between words which are semantically related without being frequently associated in their occurrence or in word association tasks (Fischler, 1977).

Milberg and Blumstein (1981) and Blumstein et al. (1982) found a consistent facilitation effect in Wernicke's aphasics in both experiments. This was all the more noteworthy since these patients performed quite poorly when asked to judge the relatedness of the same word pairs. Broca's aphasics showed nearly the reverse pattern. They did well on relatedness judgments, but only showed a significant facilitation effect in one of the two experiments. Since the priming effect is held to reflect the organization of semantic memory for words, the demonstration of a normal effect in Wernicke's aphasics suggests that some level of semantic organization may be preserved. The results have recently been partially replicated by Chenery, Ingram, and Murdoch (1990) who showed that semantic priming

occurred in low comprehending aphasics in spite of their inability to name the prime and targets or to judge their relatedness correctly. Furthermore, semantic priming effects in posterior aphasics have also been demonstrated for both meanings of ambiguous words, irrespective of the dominance or strength of association of each meaning (Milberg, Blumstein, and Dworetzky, 1987).

Based on these data Blumstein and her colleagues have argued against a loss of semantic knowledge in Wernicke's aphasia. The demonstration of semantic priming effects in these patients similar to normal subjects suggests that they have a problem with accessing linguistic information rather than a 'central' deficit in lexical semantics. More specifically, Wernicke's aphasics are said to be impaired in controlled modes of accessing linguistic information, i.e. in processes which require conscious retrieval and manipulation of linguistic knowledge. This account would explain their failure to make appropriate judgments of the relatedness of the same word pairs which caused semantic facilitation and could account for the abnormal performance of posterior aphasics in most of the studies discussed in the preceding section, where the task consisted for example of deciding which words went best together (Zurif et al., 1974), whether or not a word was a member of a given category (Grober et al., 1980), or which of the words in a list was related to a target word (Goodglass and Baker, 1976).

The performance of the Broca's aphasics who did well on relatedness judgment but failed to show priming, is also explained by reference to a disturbance of access processes rather than underlying information. Thus, Broca's aphasics are said to suffer from an impairment in automatic access but to preserve controlled modes of retrieving and manipulating information. In a summary of this research, Blumstein and Milberg (1983) have suggested that there is a double dissociation in Broca's and Wernicke's aphasia between automatic and controlled modes of information processing.

The distinction between automatic and controlled processes has long been of interest to psychologists. The automaticity concept has an obvious intuitive

validity when applied to the study of complex skilled behavior such as speed typing or tennis playing. What seems to characterize skilled or automatic performance is the speed and inflexibility with which the behavior occurs, and the small amount of conscious attention which the performer need pay to the actual execution of the task (Shiffrin and Schneider, 1977). Thus, the development of automaticity in a certain behavior affects the manner in which cognitive resources are engaged during performance and implies the possibility of corresponding differences in the neural representation of automatic and controlled aspects of behavior. However, the distinction between automatic and controlled processes suffers from lack of clear operational definitions of the concepts.

Shiffrin and Schneider (Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977; Shiffrin and Schneider, 1984) have characterized the processes as follows: Automatic processes occur at very early stages in the perception of a stimulus; they are involuntary and resist attempts at conscious control; their internal structure and operation cannot be modified by for example, the context, or other factors affecting the immediate relevance of their outcome to the overall perceptual task. Controlled processes, on the other hand, occur at a later stage in stimulus perception. They are subject to the influence of consciousness and are probably less fixed in their operation so that they can be modified to suit the demands of the particular perceptual context. Unlike automatic processes, controlled processes require attention and are capacity-limited.

Semantic facilitation effects in language comprehension are generally held to occur in both automatic and controlled modes of processing, whereas inhibitory effects are said to be restricted to controlled processes (Posner and Snyder, 1975; LaBerge, 1981). Psycholinguistic studies of word recognition in normals have shown that automatic priming effects can occur at very short prime-target intervals (cf. Fischler and Bloom, 1980). However, Neely (1977) found that when more than 250 milliseconds elapses between prime and target, the facilitation effect no longer has the characteristics of an automatic process, but becomes susceptible to the expectations of the

conscious mind. Neely also found evidence for inhibition effects at prime-target intervals of more than 250 milliseconds, which in Posner and Snyder's attentional theory is characteristic only of controlled processing (Posner and Snyder, 1975).

One problem with Blumstein and Milberg's use of the distinction between automatic and controlled processing is that in the studies by Milberg and Blumstein (1981) and Blumstein et al. (1982) rather long prime-target intervals were used (500 milliseconds for the visual and 2 seconds for the auditory study). According to Neely's research the prime has reached a more conscious stage in processing at prime-target intervals of this length allowing for controlled facilitation effects in the recognition of the target word. Thus, one cannot be sure that the tasks were tapping an automatic process. A more serious criticism applies to the study with ambiguous words by Milberg, Blumstein, and Dworetzky (1987). In fact, the results of this study showed that both normals and Wernicke's aphasics had the shortest reaction times when the ambiguous word was preceded by the neutral prime as in 'xxxx-bank-money'. Neither group showed semantic facilitation vis-a-vis this baseline when a concordant word preceded the ambiguous word as in 'coin-bank-money'. Both groups, however, showed slower reaction times relative to the neutral baseline, i.e. an inhibition effect, when the first word was discordant as in 'river-bank-money'. Since inhibitory processes are assumed within Posner and Snyder's theory to be associated only with controlled access to linguistic knowledge, the results do not support a breakdown of controlled processes in Wernicke's aphasia as these processes are usually defined.

What then is the functional significance of the semantic processing abilities in Wernicke's aphasia demonstrated by the priming research? The most obvious answer is that the facilitation effect represents a retained aspect of a normal functional system, although its exact role in the process of understanding is unclear. This is underlined by the fact that Broca's aphasics seem to comprehend very well without this ability. Some studies suggest that semantic facilitation may play a larger role in Wernicke's

aphasics than in normals. An abnormal size of priming effects was found by Grober (1985) who showed very large context effects in fluent aphasics compared to other aphasics and normal controls. An abnormal occurrence of automatic facilitation was found by Milberg, Blumstein, and Dworetzky (1988) in a study of priming effects with phonologically distorted primes.

In the study by Milberg et al. (1988) aphasic subjects were given an auditory lexical decision task. The target of the lexical decision was the second member of a pair of words where the preceding word was either a semantically unrelated (neutral) word (e.g. 'nurse-dog') or a related word (e.g. 'cat-dog'). The related primes were either phonologically undistorted as in 'cat-dog' or distorted by one or more phonetic features, which in effect changed the prime into a nonword (e.g. 'gat-dog', 'wat-dog'). A previous study with normal subjects had demonstrated that nonword primes received a lexical interpretation and gave rise to semantic facilitation effects if they shared a sufficient number of phonetic features with a real word. Thus, normal subjects showed a monotonically decreasing degree of semantic facilitation as a function of phonological distortion. For the aphasic subjects there were differences with respect to the effect of the nonword prime between subgroups when grouping was based on fluency. For nonfluent patients only real words without phonological distortions had a facilitation effect on a semantically related target. For fluent patients, however, phonologically distorted words (whether by one feature or two) seemed to evoke a semantic content to the same extent as real words. Neither of these patterns conforms with the performance of the normal subjects.

The results are especially interesting in the light of an additional test included in the study where the aphasics were asked to make a lexical decision about the words and nonwords which had served as primes. Fluent and nonfluent patients made very few errors on this task and performed similarly by rejecting nonwords better which deviated in two or more phonetic features. This indicates that there were no differences in the basic perceptual skills between the groups but that the process of lexical access was somehow different. Milberg et al. propose that lexical access is based on

two dissociable systems : one where lexical items are directly or consciously addressable and one which is automatic and not under conscious control (cf. Milberg, 1988). In nonfluent aphasics automatic access is disturbed; in fluent aphasics controlled modes of access are disturbed. In conclusion, the results are interpreted in favor of the hypothesis that the problem of fluent aphasics lies neither in phonological or semantic processing alone, but in the interaction between these processes.

The preceding study by Milberg et al. (1988) raises several issues. If semantic facilitation processes in fluent aphasics are indeed abnormal in their magnitude or pattern of occurrence, the question arises - as with any neuropsychological symptom - whether this constitutes a primary defect arising directly from organic brain damage or whether it is a compensatory mechanism arising from reorganizations or adjustments within the processing system in the attempt to compensate for some other underlying disturbance. The interpretation offered by Milberg et al. is that lexical-semantic structure as well as automatic access processes are intact in fluent aphasics. Only explicit metalinguistic manipulation is difficult. It is a fact, however, that posterior aphasics have problems with comprehension which are not restricted to metalinguistic tasks but are also observed in natural communicative settings when the patients cannot resort to situational or other cues. Secondly, there is reason to believe that semantic facilitation may occur even if the precise meaning of words is unclear. Normal subjects show facilitation effects from words presented at subliminal exposure times in spite of not being above chance level in determining whether or not a word in fact has occurred and being unable to identify the word (Marcel, 1983). It is clear that some form of lexical access must have taken place, but quite likely only partial information has been retrieved. The precise meaning of the word shown may remain unclear and inaccessible under these conditions.

A recent carefully designed study of performance on lexical-semantic knowledge across several different tasks in patients with Alzheimer's disease supports the view that large semantic facilitation effects may be

associated with disturbances in underlying semantic knowledge. Chertkow, Bub, and Seidenberg (1989) showed that the lexical items which an Alzheimer's patient failed to name also caused difficulty for the patient in a comprehension test requiring word-picture matching with semantic foils. Similarly, when asked probe questions about the same lexical items regarding superordinate category or perceptual and functional properties of meaning, the patients were more impaired on items they had failed to name. The results support the hypothesis about a 'central' or 'storage' deficit in the lexical-semantic knowledge of this group. Chertkow et al.'s study has an important bearing on the issues regarding the different results for aphasic patients on relatedness judgments and on tests showing semantic facilitation, since these two types of tasks were also given to the Alzheimer's patients and led to rather surprising results.

On relatedness judgments (e.g. 'LEMON : Is it more like a lime or like a plum?') the Alzheimer's patients performed at chance level, regardless of whether the lexical item being questioned was one they had been successful in naming. According to Chertkow et al., this suggests that relatedness judgments pose demands on cognitive processes which may not allow a clear picture of the status of lexical-semantic knowledge, since patients demonstrated considerable knowledge in other tasks about the words for which they were unable to make relatedness judgments. On the lexical decision task used to examine semantic facilitation effects, both the Alzheimer's patients and normal age-matched controls showed semantic facilitation effects. However, the size of the effect relative to subjects' reaction time in the neutral condition was significantly larger for the Alzheimer group. More interestingly, the size of the priming effect was significantly larger for lexical items which had caused difficulty on the earlier measures of lexical-semantic knowledge. Chertkow et al. conclude that priming in brain-damaged patients is not simply absent or present but may be pathologically increased. The functional significance of this 'hyperpriming' is not clear.

Although results relating to patients with diffuse brain damage cannot

simply be extended to patients with aphasia and focal brain damage, the comparison of lexical-semantic deficits across different tasks by Chertkow et al. contributes to solving the apparent paradox posed by the preservation of semantic facilitation in posterior aphasics vis-à-vis these patients' failure on relatedness judgments. It would appear that relatedness judgments demonstrate deficits of lexical-semantic knowledge which are in fact attributable to general processing demands of the task. As regards semantic facilitation effects, these cannot be taken as evidence of intact lexical-semantic knowledge but may in fact be pathological and associated with defects in underlying knowledge.

In conclusion, the demonstration of semantic facilitation effects in posterior patients may seem difficult to reconcile with an underlying lexical-semantic deficit in these patients as indicated by the metalinguistic studies discussed in the preceding section. To account for the different results, Blumstein and her colleagues have suggested that posterior aphasics have a deficit in controlled operations, including more conscious forms of accessing lexical-semantic knowledge. However, the interpretability of existing data is hampered by incomplete control of task parameters generally held to influence automatic and controlled processing and by the fact that the application of the distinction does not conform to standard definitions. Secondly, a priming task with phonologically distorted primes suggests that the semantic facilitation effect in posterior aphasics may be abnormal in its pattern of occurrence. Finally, recent research with patients suffering from Alzheimer's disease also indicates that an abnormal size of priming effects may be associated with defects in underlying lexical-semantic knowledge. The presence of semantic facilitation in posterior aphasics therefore cannot simply be taken as evidence that lexical-semantic knowledge is intact. It also appears from the research with Alzheimer's patients that semantic relatedness judgments may overestimate the extent of the semantic disturbance. Accordingly, patients' performance on these tasks needs to be compared to other measures of lexical-semantic abilities and placed in the larger theoretical context of preserved and disturbed comprehension abilities above the level of the individual word. There are indications of a dissociation

between automatic and more voluntary modes of accessing information, but the precise characterization of this distinction and the functional significance of these types of processes at different levels in comprehension and in different experimental tasks needs further elucidation.

1.5 Disturbances of higher levels

1.5.1 Relation between deficits at lower and higher levels of comprehension

An inherent difficulty in answering questions about preserved knowledge at one specific level of comprehension is that the processes at one level may not be entirely independent of other levels. This is an important issue in psycholinguistic theories of comprehension. In some views normal information flow in comprehension proceeds in a predominantly bottom-up fashion from the lower levels of phonetic perception and lexical access through lexical-semantic retrieval to the higher levels of sentential and textual understanding (e.g. Cairns, 1983; Fodor, 1983). In other views comprehension processes may occur in parallel or cascade (McClelland, 1979), or they may be guided at lower levels in a top-down fashion by knowledge and processes at higher levels (e.g. Marslen-Wilson and Tyler, 1980).

The possible interdependence between different levels in the comprehension process presents a methodological challenge in aphasia research. It places great demands on experimental studies of comprehension problems which aim to provide evidence about problems or preserved abilities at a specific linguistic level. For example, aphasics who do not understand syntax may be able to compensate by guessing at the most likely relations among the word meanings of a sentence. Only if they are deprived of these clues, does one get a measure of syntactic knowledge. The problem also presents itself from the opposite direction when one attempts to examine the ability of posterior aphasics to understand linguistic information above the level of the individual word, i.e. the ability to appreciate grammatical relations, to integrate the meaning of individual words into a conceptual whole, to

understand reference and anaphora within and across sentence boundaries, to be sensitive to the micro- and macrostructure of larger textual units, and to grasp the pragmatic implications of utterances. The difficulty is in assessing these levels independently of the patients' possible defects in speech perception and lexical- semantics. However, given the poor correlations between some of the lower level skills and overall performance scores on clinical tests of comprehension, it cannot be ruled out that posterior patients experience difficulties at higher levels of understanding additional to and perhaps independently of their lower level problems. Research in these higher aspects of the comprehension process will be considered in the following sections.

1.5.2 The sentence level : syntax

One very influential hypothesis in neurolinguistic research is that syntactic abilities are intact in Wernicke's aphasics such that there is a double dissociation between syntax and lexical- semantics in Broca's and Wernicke's aphasia (Berndt, Caramazza, and Zurif, 1983). Many studies have demonstrated problems with the comprehension of syntax in Broca's aphasia (for a review, see Berndt and Caramazza, 1980). Only a few studies have attempted to test syntactic abilities in Wernicke's aphasics, and the results are not always consistent with intact syntactic knowledge in this group.

In a sentence ordering task in German, where the correct order was signalled by case inflections and definite articles, fluent Wernicke's aphasics showed sensitivity to syntax even when the resulting sentence meaning violated semantic expectancies (Von Stockert and Bader, 1976). On the contrary, Broca's aphasics ignored case inflections and chose the most likely word order based on the major lexical items in the sentence. The results suggested that Wernicke's aphasics are more sensitive to syntax than Broca's aphasics and that Broca's aphasics are more sensitive to lexical meaning than Wernicke's aphasics, thus providing support in favor of the double dissociation hypothesis. However, Heilman and Scholes (1976), found that Wernicke's aphasics were not only inferior in lexical- semantics to Broca's

aphasics, but also made significantly more syntactic errors than either Broca's aphasics or Conduction aphasics.

Several studies of syntax and comprehension have found no difference between aphasic subgroups (Parisi and Pizzamiglio, 1970; Grober and Kellar, 1981), or poor and uninterpretable performance on syntactic comprehension in fluent aphasics (Caramazza and Zurif, 1976). Thus, evidence of agrammatic comprehension in fluent aphasics with posterior brain damage has frequently been demonstrated for Wernicke's, Anomic, and Conduction aphasics (Caramazza and Zurif, 1976; Goodglass and Menn, 1985; Bates, Friederici, and Wulfeck, 1987; Smith and Bates, 1987; Peach, Canter, and Gallaher, 1988), although the source of the difficulties for Conduction aphasics is usually attributed to limitations in working memory, which prevent an appreciation of syntactic structures (Caramazza, Basili, Koller, and Berndt, 1981).

An alternative hypothesis is that both Wernicke's aphasics and Broca's aphasics have difficulties with syntax, but that there are qualitative differences between the groups. Some researchers have been inspired by Jakobson's (1971) theory and Luria's (1975) hypothesis about breakdown of syntagmatic structure in anterior aphasia and of paradigmatic structure in posterior aphasia. Applied to syntactic surface structure the distinction has been interpreted as predicting difficulties with word order in anterior aphasics and with morphological inflections in posterior aphasics (but see section 1.5.3).

Jakobson's theory derives support from a study showing difficulties in appreciating morphological information in Anomic aphasics with posterior lesions and fluent speech (Smith and Bates, 1987), and from the demonstration of word order problems in Broca's aphasia (Schwartz, Saffran, and Marin, 1980). However, Bates et al. (1987) found Wernicke's, Anomic, and Broca's aphasics to be equally impaired on grammatical morphology, whereas word order appeared to be relatively well preserved in all groups. Based on these results Bates et al. conclude that grammatical

morphology is more vulnerable than word order.

The demonstration of syntactic comprehension problems in posterior aphasics would seem to be consistent with the tendency of this group to produce so-called paragrammatic constructions in their speech. Unlike anterior aphasics they do not omit closed class words, but often make paraphasic substitutions involving this class of words. Studies of normal subjects suggest that recognition and production of closed class words may depend on different mental processes than open class words (Bradley, 1978; Drewnowski and Healy, 1980; Garret, 1982). Studies of aphasic subjects have found differences in the preservation of sensitivity to closed class words in Broca's and Wernicke's aphasics. In accordance with their omission of closed class words in speech, Broca's aphasics seem to have lost their special sensitivity to this class of words in recognition (e.g. Andreewski and Seron, 1975; Friederici and Schoenle, 1980; Swinney, Zurif, and Cutler, 1980), and agrammatic comprehension in Broca's aphasia has been attributed to this disturbance, since closed class words may carry important structural information necessary for the decoding of surface structure (Bradley, Garret, and Zurif, 1980).

In contrast, Wernicke's aphasics appear to retain a special sensitivity to closed class words. Friederici and Schoenle (1980) compared the ability of a fluent Wernicke's aphasic and a nonfluent Broca-like patient to read aloud open and closed class words. They found that the Wernicke patient was much better on closed class words than on open class words, whereas the nonfluent patient performed similarly on both. Rosenberg, Zurif, Brownell, Garret, and Bradley (1985) found the same behavior in normal subjects and Wernicke's aphasics in a letter detection task involving open and closed class words in meaningful prose texts. Wernicke's aphasics and normal subjects showed the expected difference between letter detection accuracy in the two word classes, but Broca's aphasics failed to show any difference. But whereas normal subjects showed only a very small difference in scrambled prose, Wernicke's aphasics showed a large difference between the two word classes just as in their performance on meaningful prose. The authors argue

that closed class access and parsing mechanisms seem to some extent to be dislodged from interpretive systems in Wernicke's aphasics; i.e. they may be able to construct phrasal constituents by means of the preserved sensitivity to closed class words, 'but these constructions cannot then be normally mapped onto semantically interpretable structural levels' (Rosenberg et al., 1985, p. 301).

These results suggest that while some aspects of structural information are available to Wernicke's aphasics, they may not be able to put the information into its full normal range of use. Further support of such a view is presented by Milberg (1988), who reports evidence from a study in progress showing facilitation of reaction time in normals and in Wernicke's aphasics in lexical decisions to words preceded by a syntactically appropriate item. Broca's aphasics, however, did not show any facilitation effects. Yet, in grammaticality judgments on the same word combinations, Broca's aphasics showed nearly normal performance, whereas Wernicke's aphasics did poorly.

In his discussion Milberg interprets the results in terms of the theory of a double dissociation between automatic and controlled processing in Broca's and Wernicke's aphasia (cf. section 1.4). The results suggest that in normal on-line comprehension the listener or reader automatically recovers the grammatical structure of incoming utterances. This automatic recovery of syntax is spared in Wernicke's aphasia but absent in Broca's. According to Blumstein and Milberg (1983) the important variable is not syntax or type of linguistic knowledge but rather task requirements as to how linguistic knowledge must be accessed and manipulated in order to accomplish the task.

In conclusion, studies of syntactic abilities in Wernicke's and other aphasics with posterior syndromes illustrate the difficulty of devising experimental tests at one level which are independent of skills at other levels. The hypothesis of a double dissociation between syntactic and lexical-semantic knowledge in Broca's and Wernicke's aphasia is not consistently supported

by experimental research, since Wernicke patients do have problems in comprehending syntactic constructions. Their problems, however, may differ qualitatively from those of Broca's aphasics. A simple dissociation between word order and morphology is not borne out by experimental studies. Research indicates that knowledge of the structural information signalled by closed class words is available to the posterior aphasic for automatic access and superficial parsing routines. However, the structural representations constructed by the patients may somehow not allow the semantic interpretation necessary for comprehension or the explicit inspection required in grammaticality judgments.

1.5.3 The sentence level : semantics

Understanding the meaning of a sentence is necessarily different from understanding individual words, since a sentence meaning is a novel construction. To understand a sentence, the listener must understand the meaning of the individual lexical items, decode the relations among them indicated by the syntactic structure and combine the separate elements into an integrated semantic-conceptual representation which reflects the logical relationships between the words.

Disturbances in semantic processes in sentence comprehension have not been the subject of systematic study as often as disturbances in phonology and syntax. An exception is Luria's theory of semantic aphasia (Luria, 1970), which is concerned with the semantic operations or combinatorial processes whereby several types of information are integrated into a unified whole. According to Luria (1975) and Jakobson (1971) qualitative differences in the ability to comprehend different forms of grammatical constructions in aphasia correspond to differences in expressive language skills. Luria suggests that aphasics with anterior brain damage are disturbed in the syntagmatic connections underlying fluent speech, but preserve logical-semantic structure. Aphasics with posterior brain damage have difficulties with the logical or paradigmatic aspects of linguistic coding, but the syntagmatic dimension underlying fluent speech is preserved.

Luria's hypothesis about a syntagmatic and paradigmatic breakdown in comprehension is not concerned with the assignment of surface syntactic structure but with a higher level in the comprehension process. Thus, in spite of the fact that Luria's theory has inspired research in dissociations between word order and morphology, Luria's focus is on the nature of the logical-semantic content of the sentence rather than the means whereby this content is expressed in surface structure. Luria distinguishes between sentences expressing 'communication of events' and sentences expressing 'communication of relations', arguing that irrespective of similarities in syntactic coding, they differ in the nature of the semantic representations which must be constructed in order to map major lexical items and syntactic structure onto a logical-semantic representation. In sentences expressing 'communication of events' a mental scheme must be constructed which depends on syntagmatic schemata. In sentences expressing 'communication of relations' a scheme must be constructed which depends on a capacity for simultaneous representation of the paradigmatic and logical relations among the individual elements.

Luria reports an investigation of the comprehension of these two types of sentences by aphasic patients. Patients with anterior damage and syntagmatic speech disturbances were compared to patients with posterior brain damage and paradigmatic errors in their speech. The results showed disturbances in comprehension corresponding to the difficulties in expressive language. Thus, posterior patients were unable to grasp the meaning of constructions like 'father's brother' vs. 'brother's father' or 'circle above square' vs. 'square above circle'. According to Luria the patients understand the meaning of the individual words quite well but cannot decode the relationship between them because of an inability to construct 'inner schemes' which unite separate elements into a simultaneous representation.

Luria's hypothesis receives support from a study by Berndt and Caramazza (1980). They showed that in a group of unclassified aphasics a subgroup of the patients had great difficulty comprehending sentences requiring the combination of negation and comparison, in a task where they had to

answer questions like 'Pat is not younger than Meg. Who is Pat?' by pointing to a picture. The same patients, however, understood both negation and comparison when they occurred in separate sentences. To examine Luria's hypothesis about difficulties with the simultaneous combination of semantic elements the patients were also given the 'cup-bowl' similarity rating task described in Caramazza, Berndt, and Brownell (1982, cf. section 1.3) where successful performance required the integration of two separate perceptual cues, diameter-to-height ratio and presence/absence of a handle. Analyses showed that patients who were unable to integrate these perceptual cues in their similarity rating also performed at chance level in the sentence comprehension task on items requiring the combination of negation and comparison. Although the patients were unclassified, Berndt and Caramazza note that the individuals who failed on combination of semantic information all had signs of posterior brain damage (fluency, paraphasic speech, and/or relatively poor comprehension). However, among the patients who did well on both tasks were also some who had posterior symptoms. This, however, might still be accounted for within Luria's theory, since he distinguishes between two categories of fluent speech corresponding to two different forms of aphasia, which are affected in different ways by paradigmatic impairment. In patients with temporal lobe damage and so-called acoustic-gnostic aphasia the paradigmatic disturbance affects 'the classification processes of the phonemic and lexical elements of speech' (Luria, 1975, p. 45). In patients with parietal or parieto-occipital damage and so-called semantic aphasia, the paradigmatic disturbance affects operations involving complicated logical-grammatical relationships, but may leave lexical elements undisturbed.

The results of the studies by Luria and Caramazza and Berndt indicate that some posterior aphasics have difficulties with semantic operations at higher levels. A study by Shapiro and Levine (1990) throws further light on this issue. The study examined the retrieval of predicate-argument structure in aphasics classified as Broca's aphasics with agrammatic comprehension and fluent aphasics. Predicate-argument structure refers to the combinatorial properties of verbs at a level of description which is relevant to both syntax

and semantics. The predicate-argument structure of a verb is constituted by the number and type of complements it may take and their thematic roles. Research with normals has shown that the number of different argument structures a verb may enter into affects the processing load associated with comprehending the verb in a given sentence context (Shapiro, Zurif, and Grimshaw, 1987). In other words, normal subjects are sensitive to the number of possibilities for assigning thematic roles to constituent phrases associated with the verb.

In Shapiro and Levine's study with aphasic subjects, agrammatic Broca's aphasics showed a normal sensitivity to predicate-argument structure complexity, whereas fluent aphasics failed to show any effect. The results for Broca's aphasics are interpreted as evidence that knowledge of the predicate-argument structure of verbs may be intact, whereas the actual use of this knowledge to assign thematic roles to phrasal constituents is disturbed. Concerning the fluent aphasics, Shapiro and Levine suggest that these patients have a semantic-like sentence processing deficit attributable to problems with activating those properties of verbs which allow an interpretation of the thematic roles of the phrases associated with the verb.

In conclusion, it appears that some posterior aphasics may have difficulties with semantic operations at the sentence level, involving the retrieval of predicate-argument structure of verbs, the mapping of lexical items onto syntactic structures, or the simultaneous combination of separate elements to form an integrated conceptual representation. However, more studies are needed to clarify the possible interrelation of these impairments, their association with problems in expressive language and the localization of brain damage.

1.5.4 Discourse and pragmatic levels of comprehension

The process of comprehending multiple sentence messages poses additional and perhaps different demands than the comprehension of single sentences. What do we know about the effect of brain damage on specific factors

operative in normal discourse comprehension, such as appreciation of cohesion and coherence (Van Dijk, 1977), understanding the semantic macrostructure of a text (Halliday and Hasan, 1976), or extracting linguistic meaning and organizing it in memory in terms of script knowledge (Schank, 1980)? Besides discourse factors, pragmatic abilities also constitute a level in comprehension (Bates, 1976). The questions here are concerned with whether aphasics are able to appreciate the speech act value or functional meaning of utterances, e.g. if they can comprehend indirect requests and metaphors. In the literature these are sometimes referred to as 'nonlinguistic' levels in contrast to phonology, lexical-semantics, and syntax, which are considered 'linguistic' levels. An increasing number of studies are addressing these aspects of comprehension and the question of how they are affected in brain damage. The 'nonlinguistic' skills of posterior patients have not been specifically addressed, but the general bearing of the research is that most aphasics do well at discourse and pragmatic levels of comprehension.

Huber and Gleber (1982) examined a specific aspect of discourse comprehension, the appreciation of macrostructure, by asking aphasics to order a set of pictures of a story. The patients did well on this task but had more difficulty on a sentence ordering task, suggesting the preservation of macrostructure, but an impairment at the linguistic level of the sentence. Several studies with aphasic subjects confirm that the comprehension of discourse is better preserved than would be expected based on the patients' comprehension of isolated sentences (Brookshire and Nicholas, 1984; Nicholas and Brookshire, 1986; Stachowiak, Huber, Poeck, and Kerschenstaeiner, 1977; Wegner, Brookshire, and Nicholas, 1984). To some extent this may be due to an increased redundancy of information, but another important factor may be a preserved ability to exploit script knowledge. Scripts are cognitive structures or schemata representing real-world knowledge of the kind of events which are likely to occur in a given situation, e.g. in a restaurant, and include knowledge of the centrality of different events and their most likely sequence. In a study of script knowledge in aphasic subjects, Armus, Brookshire, and Nicholas (1989) found well preserved knowledge of common scripts in patients with mild and moderate aphasia. According to Armus et

al. this is consistent with the fact that aphasics generally know how to behave appropriately in daily settings despite their language handicap.

Some higher level abilities especially relating to pragmatic meaning are thought to be more affected by right brain damage than left brain damage. One aspect of comprehension which lends itself to a comparison of 'pragmatic' and 'linguistic' skills is the comprehension of indirect requests. Indirect requests such as 'It is very hot in here' have a literal or 'linguistic' as well as a 'pragmatic' meaning. Depending on the context the most appropriate response to such a construction may be an answer reflecting the semantic and syntactic meaning of the sentence, e.g. 'Yes, it is 78 degrees Fahrenheit', or an action such as opening a window (Foldi, 1987). Hirst, Deloche, and Stein (1984) showed that Broca's aphasics were sensitive to the pragmatic meaning of indirect requests, whereas right hemisphere patients had problems discriminating when an action was appropriate or not. This result has been replicated in a similar study by Foldi (1987). In Foldi's study left hemisphere patients and normal subjects preferred action responses to indirect requests, but patients with right hemisphere damage inappropriately chose literal answers. Foldi concluded that the research with right-hemisphere patients and aphasics has shown that 'brain damage can lead to selective impairment of 'pragmatic' vs. 'linguistic' aspects of communication (Foldi, 1987, p. 102).

It seems then, that most left hemisphere patients preserve the ability to grasp pragmatic meaning and in fact may capitalize upon this ability to make up for deficits in perceiving and understanding the phonetic, lexical or syntactic aspects of the utterance (cf. the following section). To the extent that pragmatic information is signalled through specific lexical items or syntactic structure, one may perhaps expect aphasics to encounter problems in the sense that the nature of the information to be processed may prevent the aphasic patient from understanding the pragmatic implications. The research does not suggest, however, that these patients cannot construct representations at the pragmatic level per se.

1.5.5 Context effects in comprehension

One of the principal goals of much neurolinguistic research in comprehension is to uncover a basic defect or set of delimitable defects which might explain the low overall comprehension scores of patients on global clinical measures of comprehension such as the Boston Diagnostic Aphasia Examination or the Token Test. Clinical aphasia tests frequently reveal a more severe disturbance of language understanding than one would assume based on informal conversation with the patient. Relatives are often reported to be unaware of any comprehension deficit, because the patient may be quite adept at extracting information from extralinguistic and situational cues. A general clinical experience is also that many posterior patients understand sentence material and material presented with situational support much better than isolated words. However, the clinical test results are corroborated by the patient's marked failure in situations where these cues are less accessible to him, e.g. when attempting to follow conversations in groups, to understand what is spoken over the phone or to follow radio and even television programs. Context thus appears to play an important role for these aphasics and a number of studies has addressed this aspect of the comprehension process.

Research has demonstrated context effects in the perception of sounds and the recognition of word meaning in aphasia. For example, Gardner, Albert, and Weintraub (1975) showed that the comprehension of a target word was facilitated by including a semantically supportive word in the context. Similarly, the studies of priming in aphasics by Blumstein and her colleagues indicate that word recognition can be facilitated by a preceding related word (cf. section 1.4). Other studies have demonstrated context effects at higher levels of comprehension, as in the decoding of agent-patient relations in reversible passive sentences (Pierce and Beekman, 1985), in the comprehension of noncohesive paragraphs (Waller and Darley, 1978), and in the appreciation of the metaphoric meaning of idiomatic expressions (Stachowiak et al., 1977).

The facilitating effect also occurs if the context is nonlinguistic (Wilcox,

Davis, and Leonard, 1978; Pierce and Beekman, 1985). Thus, context effects in natural communication are presumably complex in their origin.

Nonlinguistic or paralinguistic information such as situational or pictorial context, intonation, facial expression, and gesture may allow patients to draw on well-preserved abilities for information processing. Concerning linguistic context, some minimal receptive language skills must presumably be preserved for aphasics to be able to benefit from it.

A study by Beck (1984) addressed the relationship between speech perception, the ability to make use of semantic context, and general level of comprehension as measured on the Token Test. The study was designed to allow an assessment of the relative contribution to comprehension of phonetic information and semantic context and of their interaction. Aphasic subjects with high scores on the Token Test showed evidence of relying on context in solving the task, as did normal and non-aphasic brain-damaged controls. Aphasics with low comprehension scores, however, showed no differences due to context. Finally, the results revealed a high correlation between Token Test scores and the ability to discriminate target words correctly in a neutral context as well as the ability to exploit the semantic information contained in the context. Beck suggests that high-comprehenders are especially good at exploiting semantic information in compensation for possible sound processing defects, while low-comprehenders have impairments in the processing of both sound and meaning.

Other authors have found contradictory results concerning the ability of good and poor comprehending aphasics to exploit contextual information. Pierce and Beekman (1985) found that aphasics with high scores on the Boston Diagnostic Aphasia Examination did not benefit from contextual cues in understanding reversible passive sentences, whereas low comprehenders did. Other studies have failed to show any correlation between context effects and overall level of comprehension. Blumstein, Milberg, and Shrier (1982) found no correlation between consistency of lexical priming effects and overall scores on the comprehension subtest of the Boston Diagnostic Aphasia Examination (cf. section 1.4). Hough, Pierce, and Cannito (1989)

similarly found no correlation between contextual benefit in comprehending reversible passives and scores on the Boston test. These discrepancies may in part be due to floor and ceiling effects. Clearly, some minimal sound perception and word recognition ability must be preserved for the aphasic to be able to exploit contextual information when this information has a purely linguistic form (i.e. is constituted by words) as in Beck's study. Conversely, aphasics with a near-normal comprehension ability would be expected to do well without resorting to contextual cues.

Concerning the locus and pattern of occurrence of context effects in aphasia, a study reflecting on these issues was carried out by Swinney, Zurif, and Nicol (1989). They provide data from the recognition of ambiguous words, showing that initial access of lexical meaning is not abnormally influenced by context in aphasia. The study was modeled on previous research with normal subjects showing that initial retrieval of lexical meaning is autonomous and impenetrable with respect to sentential context (Onifer and Swinney, 1981). Results showed that Wernicke's aphasics, like normal subjects, initially retrieved both meanings of ambiguous words regardless of sentence bias. Broca's aphasics, however, only retrieved the most frequent meaning of the ambiguous word, irrespective of sentence bias. Apparently, the impenetrability of initial lexical access to sentence context is not disrupted by brain damage. The results of Swinney et al. also suggest that context exerts its influence at a post-perceptual level in word recognition in both normals and aphasic patients.

1.5.6 Processing perspectives at higher levels

The preceding review indicates that studies of comprehension have not found any clear relation between aphasia type or level of comprehension on clinical tests, and defects in speech sound identification, syntactic knowledge or pragmatic skills. Studies of lexical-semantic knowledge have reported poorer performance in aphasics with posterior syndromes or low comprehension scores on the Boston Diagnostic Aphasia Examination. However, this result contrasts with the demonstration of semantic facilitation in the same

patients (section 1.4) and suggests that the nature of the processing demands in a given task may be the crucial factor rather than which aspects of linguistic knowledge are being tested. A similar observation can be made regarding deficits in syntax and sentence level semantics of posterior aphasics based on recent studies of so-called on-line language processing in these patients. Inspired by psycholinguistic theories about information flow and modularity in language comprehension (e.g. Forster, 1979; Cairns, 1983; Fodor, 1983), these studies have examined the distinction between real-time or on-line processing as opposed to metalinguistic or off-line processing during sentence comprehension. An on-line task requires a speedy response, but does not demand a direct evaluation of the stimulus. A metalinguistic or off-line task allows the subject time to reflect and requires an explicit evaluation of the stimulus.

One on-line study was carried out by Friederici (1983). The purpose of the study was to examine appreciation of sentence level semantics in a word monitoring task where subjects had to press a button to indicate that a previously presented word occurred in an auditorily presented sentence. Subjects included six Wernicke's and six Broca's aphasics and twelve normal controls. Target words occurred in the second of two sentences where the first sentence formed either an appropriate or neutral context. Analyses of reaction times showed that context had an effect for all three subject groups, and based on this, Friederici concluded that Wernicke's aphasics are capable of processing semantic information during sentence perception. However, it seems that one cannot really know whether the contextual effects on word monitoring indicate that Wernicke's aphasics are sensitive to sentence level syntax and semantics. The reason for this is that many of the context sentences may have contained lexical items semantically related to the target word so that contextual effects may be due to lexical level priming rather than to the successful processing and representation of the sentential meaning as a whole. Therefore, the study does not allow for any conclusions concerning whether the context effect in Wernicke's aphasics or any of the other groups is due to a genuine appreciation of overall sentence meaning.

Tyler (1988) presents an interesting case study of preserved and disturbed abilities at several linguistic levels and across tasks that differ in processing demands. The purpose of the study was to tease apart different sources of the comprehension difficulties of a fluent aphasic named RH with severe comprehension problems on the Boston Diagnostic Aphasia Examination and the Token Test. Tyler's study addressed three levels of comprehension : lexical access, phrase level syntax and semantics, sentence level syntax and semantics. The method was to investigate the patient's ability to construct representations at these levels in an on-line task, and to compare the results with the patient's ability to manipulate these representations explicitly in a metalinguistic judgment task. A group of normal subjects served as controls.

In the on-line tasks, the patient, RH, did not show any marked impairment compared to the normal controls. Thus, RH showed no deficit in the identification and initial access of words, nor did he have problems with retrieving the semantic information of words in on-line processing at phrase and sentence levels. RH's ability to construct syntactic on-line representations of the speech input appeared to be unimpaired in almost all respects except for his preferential sensitivity to syntactic subcategorization information as compared to (semantic) selectional restrictions. The patient had no apparent problems in constructing a normal on-line representation of the stimuli. However, he failed on the tasks where he had to make metalinguistic judgments of the same stimuli, experiencing difficulties once the task demanded off-line and conscious manipulation of the stimuli. The results replicate the dissociation reported by Blumstein and her colleagues between preserved sensitivity to lexical-semantic and syntactic relations as measured in on-line processing and the inability to judge these same relations correctly (cf. section 1.4).

Tyler concludes that on-line tasks demonstrate preserved abilities in posterior patients which otherwise go unnoticed. She suggests that there are some important differences between on-line and off-line processing. In off-line processing, the task requires the listener to access representations

in order to make some explicit judgment about them. Thus, in order to make metalinguistic decisions, the listener needs to become aware of the output of the language processing system or specific aspects of it depending on whether he has to judge grammaticality or perform a sentence-picture matching task. Based on his performance in these two types of tasks, Tyler concludes that the patient RH suffers a deficit in consciously accessing and manipulating the output of the language processing system.

In view of the fact that RH had severe comprehension problems on the Boston Diagnostic Aphasia Examination, one might suspect that it is possible for a patient to show sensitivity to syntactic or semantic violations in an on-line task without being able to construct a complete and full-fledged syntactic/semantic representation. Violations of syntax might be perceived as somehow deviant or unexpected at a superficial level of perception even though a genuine decoding of the syntactic relationships between the words in terms of their logical role in the sentence is not possible for the patient.

The studies by Tyler and Friederici raise some interesting questions. Why do metalinguistic judgment tasks correlate better with clinical aphasia tests than so-called on-line tasks? In what sense are these standard comprehension tests like off-line comprehension tasks? It seems that the issue is both what is being tested in clinical aphasia batteries and what is being tested in on-line comprehension tasks. Apparently, it is not 'comprehension' in the sense of understanding, but rather some other aspect of the activation of the language processing system that is tested in on-line tasks. The automatic processes which are retained in fluent aphasics are not a sufficient prerequisite for understanding, because this group of patients often fails to understand. Nor can these automatic processes be a mere epiphenomenon of understanding because Broca's aphasics often fail to show them, yet have little trouble comprehending. Their role in comprehension remains unexplained. The preservation of this kind of processing in fluent aphasics is interesting in so far as it demonstrates clear traces of structural knowledge which neurolinguists have thought to be destroyed. But just as clearly, it may have little to do with functional understanding.

Metalinguistic tasks by definition demand language processing outside a natural communicative context. It is not clear what it is about the quality of language processing in metalinguistic tasks or outside a natural context that causes difficulty for the posterior aphasics. One possibility is that this group of patients has specific difficulties in objectifying language. This view was proposed by R. Jakobson in his hypothesis that the patients are impaired in 'decontextualized' language processing (Jakobson, 1971). The difficulties may arise as a consequence of a general cognitive 'loss of abstract attitude' (cf. Goldstein, 1948). Another possibility is that metalinguistic tasks cause problems to the extent that they involve particular types of cognitive operations that are inaccessible to posterior patients, such as problems with controlled processing as has been suggested by Blumstein and her colleagues (cf. section 1.4).

From the perspective of deficits at specific linguistic levels, it remains possible that posterior aphasics have a lexical-semantic disturbance, since the priming data is not evidence that the full range of meanings of a word can be retrieved or is intact. Furthermore, the data showing problems with semantic operations at the sentence level is not convincingly contradicted by Friederici's demonstration of contextual effects in word monitoring or Tyler's data showing on-line sensitivity to syntactic structure.

From a processing perspective, the demonstration of preserved sensitivity to lexical-semantic and syntactic structure in posterior aphasics when tested with on-line tasks serves an important purpose in directing research in the comprehension problems of these patients to higher levels of processing. The failure of the patients to handle the same stimuli in metalinguistic tasks inspires an exploration of possible shared aspects of natural language comprehension and metalinguistic operations. Little is known about the functional significance of priming and on-line sensitivity to syntactic deviations. In normal subjects, these phenomena may be an important outcome of recognition processes which serve as the prerequisite input to further operations of the comprehension system. It is also possible that these phenomena reflect a general pattern recognition capacity in the linguistic

domain, which bears no important relation to how we actually understand language.

The answers to these questions are not known, but the evidence does suggest that disturbances affecting the comprehension of posterior aphasics occur at levels beyond the recognition of lexical forms and initial activation of word meaning. The disturbances also seem to leave intact a sensitivity of the perceptual system to the acoustic dimensions of speech and to regularities of syntactic patterns. In studying the deficits in posterior aphasics, it therefore seems appropriate to focus on psycholinguistic processes which take place after initial lexical access and after initial recognition of syntactic constructions. Rather than metalinguistic operations, which are known to be difficult for posterior aphasics, it is of interest to examine processes in normal comprehension such as coding operations, where semantic and syntactic information is integrated into a conceptual representation, and where the linguistic meaning of the utterance becomes associable with the comprehender's general store of information about the world. Unlike metalinguistic tasks, which may require explicit and conscious manipulation of isolated bits of information, the formation of a conceptual representation during normal comprehension may occur without conscious contribution on the part of the listener and is not easily open to introspection or conscious direction, except perhaps in cases where an unusual message requires special effort on the part of the comprehender in order to make sense.

Neurolinguistic studies have not systematically addressed the ability of the posterior patients to construct sentence representations at a conceptual level. Traditional tasks used to measure comprehension in aphasic patients such as sentence-picture matching do not fully probe the integrity of representations at this level. Psycholinguistic studies with normal subjects have yielded information about the qualitative characteristics of such representations, as well as some of the operations involved in their formation. Some of this research will be reviewed in the following chapter, because in the light of the studies of comprehension problems in posterior aphasics discussed in this chapter, this seems to be a highly relevant level of inquiry.

2. INTEGRATIVE PROCESSES IN NORMAL COMPREHENSION

2.1 Integration of word meaning

The focus of this chapter is on processes in normal comprehension at semantic and conceptual levels. It is generally accepted in psycholinguistic theories of normal comprehension, that the output of the entire comprehension process is a nonlinguistic conceptual representation (Forster, 1979; Cairns, 1983). At this level, the content of the linguistic message becomes accessible to the conscious mind, makes contact with relevant parts of the listener's stored knowledge about the world, and becomes capable of influencing his actions. The formation of the conceptual representation has also been referred to as the 'click of comprehension' (Bransford and McCarrel, 1974).

According to Cairns (1983) the interpretative processes involved in constructing a conceptual representation destroy some of the information resulting from the linguistic processing of the sentence and add other types of information. The lexical forms which occurred in the sentence become less accessible, the syntactic structure is not preserved, and the pragmatic entailments, rather than the literal meaning of the sentence is recalled. The crucial processes at this level are integration and inference. Inferences are made about the spatial relations between the referents of a sentence, about the objects or instruments used to carry out actions expressed in the sentence, and about the consequence of events described (Bransford and McCarrel, 1974). Ambiguous words are integrated in the sentence and given a specific interpretation, unambiguous lexical items are enriched in the interpretative process, and their salience in the conceptual representation is inversely related to the ease with which they could be integrated in the sentence (Cairns, Cowart, and Jablon, 1981).

The formation of conceptual representations affects not only the individual sentence, but also sets of sentences which form larger conceptual units characterized in terms of cohesiveness, micro- and macro-structure (Kintsch and VanDijk, 1978). Research in pragmatic skills in aphasia have

not specifically addressed the abilities of posterior aphasics in this domain. It has been demonstrated, however, that sensitivity to macrostructure, script knowledge, and comprehension of pragmatic implications are relatively well preserved in aphasic patients as compared to the 'linguistic skills' of the same patients or as compared to patients with right hemisphere damage. Thus, pragmatic and general cognitive structures may be preserved in posterior aphasics. Yet, in the light of the review in chapter one, it is possible that these aphasics have difficulties with interpretative processes closer to language, which operate at the interface between language and cognition, and serve, for example, to produce a semantic-conceptual representation of the individual sentence.

According to Cairns (1983, p. 18), the conceptual representation of a sentence constitutes 'an integration of information associated with individual lexical items - an integration governed both by the grammatical relations specified by the syntactic organization of the sentence, and by the non-linguistic plausibility relations that unite them. Each lexical item, then, can be said to be integrated into the final conceptual representation. In fact, the act of integration can be characterized as the goal of the sentence comprehension process.' The integration process thus seems to represent a level of interaction between linguistic knowledge and more general knowledge of the world. This process is of interest in posterior aphasics, who have difficulties with semantic operations at the sentence level (cf. section 1.5.3) as well as with some aspects of lexical-semantic processing (cf. section 1.3 and 1.4).

The interpretative processes involved in integration have access to the full range of the comprehender's knowledge about the world. This is apparent from the fact that the interpretations and precise meaning assigned to words depend on knowledge of constraints on entities which may enter into events. For example, the sentence 'He put the airplane in the envelope' affords the interpretation of 'airplane' as a toy airplane (Bransford and McCarrel, 1974). As pointed out by Barclay, Bransford, Franks, McCarrel, and Nitch (1974), constraints of this kind depend on knowledge of the objects mentioned and of the dynamics of their possible interactions and cannot be accounted for

within traditional approaches to meaning. However, it also appears even in the above example, that semantic knowledge about the usual properties of airplanes and envelopes play a role and are a necessary prerequisite for making the correct inference about a 'toy airplane'. Thus, according to Barclay et al. (1974, p. 479) 'the way in which an unambiguous noun is psychologically instantiated is governed by the relevance of each of its semantic properties to the event described by the sentence as a whole'. As a result of integration, the contextually determined relevance of each of a word's semantic properties is indicated in the encoded representation of that word in the conceptual representation of the sentence.

Integration of word meaning has most frequently been demonstrated in sentence recall studies where contextually determined differences in the encoded representation of a word are inferred from the relative effectiveness of different recall cues. This is in accordance with the encoding specificity hypothesis (Tulving and Thomson, 1973) according to which the effectiveness of a recall cue is a consequence of the overlap between the memory trace formed by the cue and by the sentence to be remembered. In their original study, Barclay et al, 1974 used the cued sentence recall method to examine the semantic encoding of concrete referential nouns as a function of sentence context. The cues were semantically-conceptually related to the words serving as objects in the sentences. In the appropriate condition, the sentence emphasized the same aspect of meaning of the object which was represented by the recall cue (e.g. 'The man lifted the piano' - 'heavy'). In the inappropriate condition, the sentence emphasized a different aspect of meaning, which was irrelevant in regard to the recall cue (e.g. 'The man tuned the piano' - 'heavy'). The control condition involved cues which were unrelated to the object words (e.g. 'The man lifted the infant' - 'heavy'). Results showed that recall cues for sentences ending in a related object words led to better performance, and furthermore, that cues which were appropriate in relation to the sentence context led to better performance than inappropriate cues. The authors conclude that the object words of the sentences are semantically encoded in a way that reflects not only their own intrinsic meaning and systemic relations to other words in the lexicon,

but also reflects the meaning conferred upon the word by the context in which it occurs.

One aspect of integration concerns the specific and contextually determined interpretation assigned to words with a general non-specific meaning. The phenomenon is also referred to as the 'instantiation of general terms'. Anderson and Ortony (1975) demonstrated differential encoding of the word 'container' in sentences like 'The container held the apples' and 'The container held the coke' (cf. also Anderson, Pichert, Goetz, Schallert, Stevens, and Trollip, 1976). Garnham (1979) showed instantiation of verbs with a general meaning, such as 'cook'. Thus, for sentences like 'The housewife cooked the peas' and 'The housewife cooked the chips', the words 'boil' and 'fry' respectively were better recall cues than the word 'cook' which actually did occur in the sentence.

In a study of contextual coding in children with normal and poor reading comprehension Merrill, Sperber, and McCauley (1981) used a Stroop task in which subjects were asked to read aloud sentences and name the color of a target word occurring after each sentence. The relationship between target words and sentences was manipulated so that targets were related or unrelated to the object word of the sentence and the related targets were either appropriate or inappropriate with regard to the meaning emphasized by the sentence. Both normal and poor readers showed a difference between related and unrelated targets, but the appropriate-inappropriate difference was only significant for the normal readers. The mechanism accounting for the failure of the poor readers to show contextual encoding effects is not clear, including the question of whether problems with semantic integration are symptoms or causal factors in reading disability. Merrill et al. do not attempt to account for the linguistic and cognitive processes involved in the contextual integration of word meaning and it is uncertain what mental abilities must be intact for the process to succeed. However, the study raises some interesting questions concerning the dissociability of lexical-semantic or systemic aspects of meaning and contextual aspects of meaning, the nature of the processing mechanisms involved in constructing these levels of

semantic representation, and their vulnerability in various types of language disorder.

2.2 Mechanisms underlying integration

The exact mechanisms involved in integration of word meaning are not clear, but some studies reflecting on this issue will be discussed below.

One study by Tabossi (1982) addresses the question of what factors in the context contribute to the contextual encoding, i.e. what it is within the sentence that supports a specific interpretation of an unambiguous noun. A property verification task as described below by Tabossi and Johnson-Laird (1980) was used. The major question was whether a specific property of word meaning would be facilitated if supported by the selectional restrictions of the verb in the sentence (e.g. 'The fire warmed the soldiers in the winter - Is fire hot?'), as compared to a sentence where factual inference based on the sentence as a whole emphasized a specific property of meaning (e.g. 'The fire protected the soldiers in the winter - is fire hot?'). The results showed that a reliable effect of sentence context occurred both when created by selectional restrictions and by factual inference based on the sentence as a whole. Thus, selectional restrictions and factual inference did not differ in efficiency as sources of contextual emphasis. Furthermore, an additional experiment carried out by Tabossi showed that semantic biasing by both verbs and adjectives was effective in emphasizing a specific property of meaning relative to a neutral control sentence without biasing words. There was no difference in the effectiveness of verbs and adjectives, nor any additive effect of including both a biasing adjective and a biasing verb in the same sentence.

Other studies have attempted to throw more light on the psychological processes involved. In their original study, Barclay et al. (1974) left open the question concerning the mechanisms responsible for integration, proposing that the integration process might be accomplished by some weighting mechanism, or, by a mechanism which selectively activated only the

contextually relevant subset from among all of a word's semantic properties. Tabossi and Johnson-Laird (1980) addressed this issue in a property verification task. Subjects were asked to judge whether or not a given property of a word meaning was true (e.g. 'Is a diamond hard?'). The questions were presented after three types of context all of which contained the critical word: a sentence emphasizing the property in question, a sentence emphasizing another property, and a sentence emphasizing no specific property of the word. As expected in accordance with integration theory, they found that subjects were faster to judge a property as true if it had been emphasized in the preceding sentence. More interestingly, they also found a delay in the inappropriate condition compared to the neutral control condition. According to the authors, this suggests an inhibitory effect of context on irrelevant aspects of word meaning.

A set of studies has demonstrated differences in the effect of context on so-called dominant and non-dominant properties of word meaning (Ashcraft, 1976b; Barsalou, 1982; Whitney, McKay, Kellas, and Emerson, 1985; Greenspan, 1986). This seems a natural parallel to research with ambiguous words, which has focused on accessing dominant versus non-dominant meanings of ambiguous words. Indeed, many of the studies in this area have been inspired by the methods and theories applied in the study of ambiguous words, since ambiguity may be regarded as an extreme case of the semantic flexibility demonstrated in the contextual encoding of unambiguous words. Furthermore, the theoretical issues are to some extent parallel to those in ambiguity research.

Studies with ambiguous words have shown that the initial retrieval of meaning occurs independently of contextual bias. This applies to both the dominant and nondominant meaning of the word (Tanenhaus, Leiman, and Seidenberg, 1979; Onifer and Swinney, 1981), both of which are accessed in spite of a prior context biasing towards one of the meanings. It has also been shown, that the exhaustive activation of meaning is only maintained for a short period of time. Thus, when preceded by a biasing context, ambiguities appear to be resolved by the time two more syllables in the sentence have

been encountered or approximately within 500 milliseconds of retrieval (Cairns and Kameron, 1975; Onifer and Swinney, 1981).

Yates (1978) has proposed a mechanism responsible for ambiguity resolution, based on Posner and Snyder's model of automatic and attentional processes (Posner and Snyder, 1975). Yates suggested that initial access of both meanings of an ambiguous word was automatic whereas the later selection of the contextually appropriate meaning depended on a more attentional, controlled process involving inhibition of the irrelevant meaning. Yates' explanation was subsequently modified by Tanenhaus et al. (1979) who pointed out that within Posner and Snyder's model, attentional selection processes can only be engaged after 400-500 milliseconds. However, meaning selection for ambiguous words occurs in some cases within 200-300 milliseconds of word presentation, and furthermore, the listener is not consciously aware of a choice between meanings. The resolution of ambiguity may therefore depend on another mechanism in these cases than conscious limited-capacity selection, possibly a so-called 'veiled control process' (Shiffrin and Schneider, 1977) which rapidly makes use of context to suppress inappropriate meanings. The mechanisms underlying ambiguity resolution are not completely clear, but most authors agree that both dominant and nondominant meanings are initially activated and the selection of the appropriate meaning is due to post-access or integrational processes (Cairns et al., 1981).

In a study of unambiguous words, Barsalou (1982) examined context effects on properties of word meaning differing in dominance or degree of importance for understanding the meaning of a given word. Barsalou's hypothesis was that semantic properties of words might be classified a priori as 'context-independent' or 'context-dependent' based on their degree of relatedness to a given word. Furthermore, he predicted that latencies in property verification would be unaffected by context for context-independent (i.e. highly related) properties, whereas context-dependent (i.e. not highly related) properties would show a substantial influence of context. The a priori classification of properties as context-independent and

context-dependent was based on intuition and confirmed by four judges who rated the relatedness of the properties to the words on a 1-7 point scale.

A property verification task was used, where the subjects saw a sentence containing the priming word followed by a telegraphic property statement to which they had to respond. The crucial word constituted the subject of the first sentence and was followed by a predicate which either emphasized the property tested in the following statement or did not emphasize any specific property. Barsalou found that contextual emphasis in favour of a property decreased verification time relative to a neutral emphasis, but only for context-dependent properties. Context-independent properties did not shift with sentence emphasis. According to Barsalou, the results suggest that context-dependent properties are affected by the integration process and provide the source of contextual encoding variability, whereas context-independent properties represent the core meaning of words and are always activated regardless of context. Furthermore, Barsalou proposed that Posner and Snyder's (1975) model of automatic and controlled processes might account for the mechanisms underlying the processing of context-independent and context-dependent properties. Thus, the mechanism underlying the initial activation of context-independent properties is said to be automatic spreading activation, whereas context-dependent properties depend on a more conscious limited-capacity process for their activation.

Whitney, McKay, Kellas, and Emerson (1985) showed that the time course (rise time and decay) of priming differs for dominant and non-dominant properties of unambiguous words. The aim of the study was to investigate the mechanism or processes underlying integration and contextual encoding. The definition of high and low dominant properties was based on Ashcraft's (1976a) normative data on properties of word meaning. A high dominant property was a response generated by 50% or more of the subjects in Ashcraft's study. A low dominant property was generated by 25% or less of the subjects. The stimuli consisted of sentences ending in a noun and emphasizing either a high or low dominant property of that noun. The sentences were presented auditorily in a cross-modal Stroop task and

followed by a visual presentation of the high and low dominant property words for color naming. To test on-line activation of semantic properties, inter-stimulus intervals (ISI) of 0, 300, and 600 milliseconds were used. Results showed that at 0 ISI both types of properties were accessed irrespective of contextual bias relative to a neutral control sentence (a sentence containing the same subject and verb as the appropriate test sentence but with an unrelated word as object). At ISIs of 300 and 600, the dominant properties still showed activation relative to the control sentence, regardless of sentence bias, but non-dominant properties were only activated after a sentence context biased in their favour.

The authors conclude that unambiguous words behave very much like ambiguous words except that unlike the unselected dominant meaning of ambiguous words, dominant properties remain activated in spite of a context biased towards the non-dominant meaning. This does not seem surprising since the two meanings are not incompatible in the case of unambiguous words. Finally, based on the activation of both types of properties at 0 ISI irrespective of context, they argue that the contextual encoding of word meaning is due to a post-access selection process and that initial activation of meaning is context-independent.

Greenspan (1986) distinguished between 'central' and 'peripheral' properties where central properties were taken to be those included in Webster's Third International Dictionary and peripheral properties were not. The classification was verified by four judges who evaluated the semantic relatedness of the stimuli. Greenspan used a cued recall task, an association rating task, and a lexical decision task.

In the cued recall task central properties were good recall cues, for both appropriate and inappropriate contexts, whereas peripheral properties showed a great difference in their effectiveness as recall cues, depending on sentence bias. In the association rating task subjects were asked to rate the relatedness of a word to a sentence on a 1 to 7 point scale. Results showed that central properties were rated higher than neutral controls for both

appropriate and inappropriate sentence contexts. Peripheral properties were only rated higher than controls after appropriate contexts. In the lexical decision task a cross-modal procedure with an ISI of 1 second was used. Results showed that central properties were reacted to faster after both appropriate and inappropriate contexts relative to a neutral baseline, whereas peripheral properties only differed from the control condition after appropriate contexts.

The results of Greenspan's study are similar to those of Whitney et al. (1985) and Barsalou (1982), suggesting that integration does not lead to an encoding of only those aspects of word meaning which are appropriate in a given sentence context. Rather, central or highly dominant properties of word meaning are always instantiated regardless of sentence emphasis. For low-dominant or peripheral properties, the context appears to determine what is encoded. Greenspan's results, however, do show an effect of context on the integration of high dominant properties. In the association rating task Greenspan found a difference between appropriate and inappropriate contexts for central properties. In the cued recall task and the lexical decision task there was a trend in the same direction which did not reach statistical significance in all the tests. This suggests, that although high dominant properties may be encoded regardless of sentence emphasis, context does play a role in determining their relative weight or prominence in the mental representation of the comprehender.

Unlike Tabossi and Johnson-Laird (1980), Greenspan found no evidence in any of his tasks for inhibition of unselected properties. To explain this, Greenspan argues that these authors used a neutral baseline condition which contained the critical priming word and which by default may have elicited the central meaning in a more consistent manner than an inappropriate context. Greenspan concludes, that a sentence context does not facilitate or inhibit inappropriate properties. Rather, the activation of properties is automatic and related to the presence of an appropriate word in the sentence. If the sentence context as a whole is also appropriate with respect to that property, then additional activation seems to take place.

In conclusion, studies have shown that unambiguous words undergo an integration process in the final stages of comprehension, such that properties of meaning which are appropriate in the sentence are enhanced compared to properties which are inappropriate. Several studies have demonstrated that dominant properties of word meaning appear to be present in the mental representation regardless of the context in which the word occurs. This may be taken as evidence supporting the existence of a context-independent set of core meanings associated with words irrespective of whether they occur in isolation or in context. However, the weight or prominence of high dominant properties in the mental representation may reflect contextual bias. For nondominant properties the pattern of activation depends crucially on the context, so that only those properties appropriate to a given context are instantiated in the mental representation of the sentence.

Studies of the time course and mechanisms involved in assigning semantic interpretations to words during sentence processing have found several parallels between the processing of ambiguous and unambiguous words. It appears that all properties of meaning, dominant as well as nondominant, are accessed initially and that selection of the appropriate meaning is due to a post-access integrational mechanism. The nature of this mechanism and its relation to models of automatic and attentional processing is not completely clear. In one account (Barsalou, 1982) high dominant properties are accessed automatically, whereas low dominant properties require a more conscious capacity-limited mechanism for their activation. In another account all properties are activated initially, and a post-access process is responsible for the inhibition of inappropriate properties without necessarily engaging conscious or controlled processes (Whitney et al., 1985). Finally, it has been suggested that the sentence causes an increase in the activation of appropriate properties and that this may apply to high dominant properties also (Greenspan, 1986).

2.3 Integration of word meaning and aphasia

Integration and contextual encoding of word meaning has not been studied in aphasia, but seems especially pertinent in the case of patients who show comprehension difficulties for spoken or written language. Intuitively, it seems that integration of word meaning presents some demands which might prove difficult for posterior aphasics. From a processing perspective, integration of word meaning requires semantic processing at the sentence level and presumably presupposes an ability to access the full range of possible meanings associated with a word. It differs from relatedness judgments and other metalinguistic tasks in not demanding conscious access and manipulation or isolation of these semantic properties. Yet, in addition to semantic activation in the form of automatic spreading activation tested in priming studies, the integration process also depends on an ability to selectively emphasize contextually appropriate properties of meaning; possibly also the ability to inhibit irrelevant properties.

In nonfluent aphasics, comprehension is fairly well-preserved but production is slow and 'telegraphic' in style. The general view is that these patients suffer from a syntactic deficit which may encompass both productive and receptive modalities. However, they retain their lexical-semantic knowledge, and are judged capable of partially compensating for their syntactic deficit by inferring the meaning of sentences based on their recognition of individual words and their 'real-world' knowledge of the ordinary relationships between people and things (Caramazza and Zurif, 1976). One would not expect this group to show deficiencies in contextually determined encoding of word meaning insofar as lexical inferencing depends on the same cognitive processes used by an agrammatical comprehender to infer the overall meaning of a sentence.

The prevailing position concerning fluent or posterior aphasics is that these patients have a deficit in lexical-semantic abilities and semantic operations at the sentence level, while their knowledge of syntax is relatively better preserved. The data pointing to a deficit in word meaning include semantic substitution errors in production, difficulties in word sorting and word classification tasks, and semantically determined errors on tests of single

word comprehension. However, the demonstration of priming between related words in fluent aphasics, despite the inability of the same patients to appreciate these word relations in a word sorting task, suggests that some of the comprehension problems of these patients are due to deficits in the operations involved in accessing and using linguistic knowledge rather than a deficit in semantic knowledge *per se*. Thus, posterior aphasics are said to have preserved automatic processes, but have difficulties with controlled processes. From this perspective, posterior aphasics would be expected to demonstrate priming effects due to automatic spreading activation between the words of the mental lexicon. However, one would predict them to have difficulties with more controlled types of semantic processes. To the extent that the contextually determined encoding of words requires an inhibition of irrelevant meanings, a selective increase in activation of specific properties, or depends on mechanisms of inference which involve an attentional component, one might expect these aphasics to have difficulties with the integration process. This prediction is in accordance with Friederici, 1983, who has proposed that comprehension problems of posterior aphasics are at the level of higher integrational processes. Thus, the preservation of automatic activation of word meanings demonstrated in priming studies may coexist with inefficient damping of the semantic system and result in problems with integration due to failure to suppress irrelevant meanings or failure to inhibit or selectively emphasize aspects of meaning in accordance with the context.

2.4 Conclusions and overview of the empirical research.

Studies of integrative processes in normal comprehension have demonstrated that one aspect of higher level semantic processing is the contextual encoding of word meaning. Word meanings are integrated in the sentences in which they occur, such that semantic properties of word meaning which are appropriate in the context have a more prominent role in the memory representation of the sentence than do inappropriate aspects of meaning. Recent studies of contextual encoding of word meaning in normal subjects have suggested that the integration process has different consequences for highly associated and weakly associated properties of word meaning,

referred to as 'high dominant' and 'low dominant' properties. Thus, it has been proposed that semantic flexibility may manifest itself especially for low dominant, semantically more peripheral, and less strongly associated aspects of word meaning, whereas high dominant or strongly associated properties of a word are always instantiated in the mental representation after recognition regardless of the emphasis of the context. Regarding the time course and underlying mechanisms of contextual encoding, a model similar to that of ambiguous words seems to account for the data : i.e. both high and low dominant properties are accessed initially regardless of contextual bias. At a later stage in processing inappropriate properties of meaning are inhibited or deactivated, but this applies only to low dominant properties; high dominant properties remain activated but may increase in activation if appropriate. If fluent aphasics have problems with lexical-semantic operations of a more controlled kind as suggested above, integration or post-access selection processes may be impaired in this group and may contribute significantly to their comprehension problems at the sentence level.

The focus of the following research is on the preservation of integration in aphasics with fluent and nonfluent aphasia. A task is needed which is meaningful also to the aphasics, and which insures that subjects pay attention to the content of the sentences. Secondly, the task should be sensitive to a possible deficit in semantic processes in fluent aphasics as they relate to the contextual encoding of word meaning. Finally, because of the possible importance of the semantic relation between the object word and the target, the investigation must control for property dominance or degree of semantic association between the object word and its associated property. Three studies were carried out to examine the encoding of word meaning in sentences in Danish fluent and nonfluent aphasics.

Experiment no. 1.: Collection of norms for semantic properties of word meaning.

A set of Danish norms of semantic properties of word meaning were collected for sixty common unambiguous Danish nouns following a similar procedure to the one described by Ashcraft (1976b). Degree of association or

property dominance was measured in terms of the number of subjects providing a given semantic property in response to a test word.

Experiment no. 2. : Study of the integration of high and low dominant properties of word meaning in normal Danish subjects.

A set of stimuli was developed based on a subset of the words included in study no.1. The words were embedded in sentences and followed by either a high or low dominant property of the word. A probe decision task was used which required subjects to press a yes- or no-button to indicate whether a probe word had appeared in the preceding sentence. The probe word designated either a high or low dominant semantic property of the object word and was appropriate or inappropriate with respect to the meaning emphasized by the sentence. A Macintosh computer was used for stimulus presentation and response registration. Appropriately related words were expected to be rejected more slowly than inappropriately related words, at least for low dominant properties. Response latencies and errors were analysed in analyses of variance followed by orthogonal comparisons for integration and word level encoding.

Experiment no. 3. : Study of the integration of high and low dominant properties of word meaning in Danish aphasics with fluent and nonfluent forms of aphasia.

A corresponding study was carried out with aphasic participants, who were classified in terms of the Boston Diagnostic Aphasia Examination as fluent or nonfluent. As an inclusion criterion all patients had to demonstrate sufficient reading skills to perform the task in a meaningful way. The focus was on whether fluent aphasics with comprehension difficulties were capable of contextual encoding of word meaning. Response latencies and errors were analysed as for normal subjects.

3. EXPERIMENT NO. 1

3.1 Introduction

One difficulty in evaluating research in contextual encoding of dominant and non-dominant properties of word meaning is that studies have differed in how these properties are defined. Some authors have distinguished on an intuitive basis or have supplemented an intuitive distinction with relatedness ratings from a small number of judges, e.g. Barsalou's distinction between context-independent and context-dependent properties (Barsalou, 1982). Another strategy was adopted by Greenspan (1986) whose distinction between central and peripheral properties was based on the presence or absence of occurrence of a given property in Webster's Third International Dictionary. An empirical basis for the distinction such as the normative data gathered by Ashcraft (1976a) and also utilized by Whitney et al. (1985) seems preferable. From a methodological point of view quantitative operational definitions allow comparisons across studies, and from a theoretical perspective the use of empirical norms of property dominance for words presented in isolation provides a valid baseline for gathering empirical data on changes or shifts in the mental representation of properties of word meaning due to integration processes.

Studies of semantic properties of word meaning or word association norms are not available in the Danish language, except for Bredtoft (1987) which provides psychological norms for a Danish translation of the Word Association Test developed by C.G. Jung. Although norms of semantic relatedness may to some extent reflect general experience with the world and its objects, there is likely to be cultural and language-specific variation (Cramer, 1968), which makes it questionable to use a translation of American property norms, e.g. the norms of Ashcraft (1976a), in a study of integration of word meaning by Danish subjects. Consequently, experiment no. 1 was undertaken to collect semantic norms of property dominance from Danish subjects.

3.2 Method

3.2.1 Subjects

The subjects were volunteers drawn from students and secretarial staff in the Speech and Hearing and Applied Linguistics Department at the University of Copenhagen, students at a practical-technical school, and students and faculty at a high school. Altogether, one hundred questionnaires were filled out by the participating subjects, but some individuals agreed to fill out more than one. Sixty-five of the questionnaires were filled out by women and thirty-five by men. The age of the subjects ranged from 16 to 65 years of age : 16 questionnaires were filled out by subjects between 16 and 20 years of age, 28 questionnaires by subjects between 21 and 30 years of age, 34 questionnaires by subjects between 31 and 45 years of age, and 22 questionnaires by subjects above 45 years of age.

3.2.2 Stimuli

Sixty words were selected for inclusion in the experiment. All the words were common concrete unambiguous referential nouns and belonged to a variety of semantic categories including animals, natural objects (egg, teeth, tree), man-made objects (blanket, coffee, school), or places (beach, wood). The sixty words used as experimental items are shown in Appendix A.

3.2.3 Procedure

The procedure for obtaining property norms followed the principles described in Ashcraft (1976b). As in Ashcraft's study subjects were instructed to provide responses which they judged to be important for understanding the meaning of the word. The method differs from a word association task in that subjects are encouraged to produce semantically associated words rather than free-associate in responding. To emphasize this, subjects were also asked to rate each response on a scale from 1 to 3 points according to how important it was for understanding the meaning of the experimental item.

Five questionnaires were constructed each containing 12 different words. At the head of each questionnaire were written instructions to list as many

other words up to ten as one could think of which described properties of the meaning of the experimental item or were important to understanding its meaning. An example was presented with an associated set of properties and ratings. Subjects were provided with a questionnaire and the instructions were read aloud to them and explained as necessary. Ample time was allowed for the completion of the questionnaire (15 minutes to half an hour).

Each questionnaire was filled out by 20 subjects (some subjects saw only one, some saw all five). The norms were established by determining the frequency with which a given word was provided as a response across the subjects. Furthermore, the average rating it received was established. The response frequency and average rating were calculated for a given semantic morpheme, irrespective of differences in the derivational or inflectional form provided by the subject.

3.3 Results

Subjects had no difficulty in doing the task. Each subject provided an average of 7.4 properties in response to each stimulus word. Altogether, the sixty experimental items elicited 8890 semantic properties, or an average of 148 per word. For each of the sixty stimulus words, between one and eight properties were provided by 35% or more of the subjects, so that a property dominance hierarchy could be established based on response frequency across subjects. The results of the normative study are presented in Appendix B. For each experimental item is listed the total number of semantic properties across subjects which were given in response to that word. Furthermore, the table presents those properties which were given as a response by 35% or more of the subjects, their frequency in percent across subjects and average relatedness rating.

3.4 Discussion

The general outcome of the experiment is similar to the normative property study by Ashcraft (1976a). Thus, subjects of different ages with varying educational backgrounds were capable of generating semantic properties of

word meaning which allowed the formation of a property dominance hierarchy. The responses included both perceptual (e.g. 'ball-round') and functional attributes (e.g. 'ball-bounce') as well as associated concepts or objects ('ball-goal'). A preliminary inspection of the dominant properties generated by Danish subjects to words which also occurred in Ashcraft's study did not suggest a very close correspondance between the American and Danish norms. Using a set of Danish norms is therefore much to be preferred to a translation of American norms in a Danish study of contextual effects on dominant and nondominant properties of word meaning.

4. EXPERIMENT NO. 2

4.1 Introduction

Experiment no. 2 was undertaken to examine integration of word meaning in normal Danish subjects. The purpose was to replicate previous research with English-speaking subjects showing semantic integration, while developing a different methodology that could be adapted to aphasic subjects.

In order to examine integration a method is needed which is sensitive to the integrity and completeness of the mental representations being formed in the comprehension process. Several requirements must be fulfilled regarding the stimuli and the nature of the task. Success, i.e. the presence of an integration effect, should be attributable to semantic processes involving the relationship between a word and the sentence context as a whole rather than priming between individual words. Furthermore, if the capacity for integration in normal and aphasic subjects is to be compared, failure on the part of aphasics to show an integration effect should be attributable to problems in contextual encoding rather than problems with recovering grammatical structure or recognizing rare and difficult words, general memory limitations or difficulties in producing an adequate verbal response. Consequently, the stimuli developed to examine integration would have to consist of short sentences constructed from frequent words which might be expected to be well within the vocabulary range of a normal adult. All sentences should be active subject-verb-object (SVO) sentences with semantically irreversible subjects and objects, so that the sentences would be comprehensible also for agrammatic subjects incapable of using syntactic information to construct a conceptual representation (cf. section 1.5.2).

Concerning the task, several of the methods previously used to test integration in normal subjects pose demands on language or memory capacity which many aphasics may not be able to meet for reasons unrelated to any deficit in higher order comprehension processes. One example is the cued sentence recall task, where the subject is required to remember and reproduce a previously heard or read sentence. Long-term

memory disturbances, word finding difficulty, or problems with producing sentences may all interfere with the aphasics' ability to provide an adequate response.

The Stroop color naming task also presents problems because of the difficulty of some aphasics in initiating a fast oral response or in providing a correct color label without paraphasic error. The lexical decision task avoids many of these difficulties and has been used successfully with aphasics in studies of psycholinguistic processes such as priming (e.g. Blumstein, Milberg, and Shrier, 1982). However, when this method is applied to study sentential effect on word meaning, the sentence which precedes the target word has no purpose of its own in relation to the subject's task. In order to insure that subjects payed attention to the sentence, the participants in studies with normal subjects have been asked to repeat the sentence after the lexical decision. Unfortunately, this technique cannot be used with aphasics for reasons similar to those described for the cued sentence recall task.

Another set of methods which have been used to test integration in normal subjects is relatedness judgment and property verification. Both tasks might be adapted for use with aphasic subjects but the objection can be raised that they impose additional intellectual demands compared to the normal comprehension process. Thus, the subject is required to make a conscious judgment about the semantic relationship between a sentence and a word or about the truth value of a linguistic statement. As discussed in section 1.5.6 it may be reasonable to distinguish between comprehension as an immediate post-perceptual level, where the outcome of processes is available to consciousness and metalinguistic introspection as a more complex process requiring explicit manipulation of linguistic representations.

The method developed and used in this experiment does not require subjects to make explicit evaluations of linguistic stimuli or to produce a verbal response. The probe decision method has been used in psycholinguistic research with normal subjects to provide data about the processing and

memory representation of specific elements in sentences (Cairns et al., 1981), and the research indicates that it is more sensitive to the contextually integrated representation of the sentence than to its surface structure.

The task used in this study to test integration required the subject to read a short sentence (of 3 to 4 words) following which a probe word was presented. The subject had then to decide whether or not the probe had occurred in the preceding sentence. Latencies and errors were recorded and pilot studies had shown that with an inter-stimulus-interval of 900 milliseconds between the sentence and the probe, normal subjects' probe rejection times were reliably influenced by the semantic relation between the probe and the sentence. Thus, the time taken to decide that a word did not occur in the preceding sentence was longer if the word was semantically related to the meaning of the sentence. The mechanism may be explained within the framework of Tulving's encoding specificity hypothesis (Tulving and Thomson, 1973). According to the hypothesis the efficiency of a sentence recall cue is determined by its overlap with the memory trace of the sentence to be recalled. By extension, in a probe decision task where the subject has to decide that a word did not occur in the preceding sentence, a semantic overlap between the probe and the sentence ought to slow down decision times.

The subject was seated at a computer using two fingers on the left hand for responding by pressing a yes- or no-key. The sentences were presented on the screen and remained in view for a fixed period of 7.3 seconds. When the sentence disappeared, there was a 900 millisecond interval before the probe word appeared. A visual presentation of sentence as well as probe was used. Thus, possible defects in phonemic hearing ought not to interfere with semantic processing and integration (cf. section 1.2). Differences in reading capacity, however, might be expected to influence aphasic subjects' ability to show contextual encoding. To control for this, aphasic subjects had to demonstrate adequate reading skills on a set of reading pretests before they were included in the experiment. Difficulties with short-term memory storage might be expected to lead to more errors regardless of the subjects'

capacity for contextual encoding, but ought not to affect the integration process per se, since ample time was allowed for comprehension while the sentence remained in view.

Experimental items were selected from the normative experiment. To serve as probes, a high dominant and low dominant property were selected for each item, which referred to different aspects of its meaning. Experimental items were then embedded as the final word in a pair of SVO-sentences which emphasized the different aspects of meaning expressed by the two properties. Sentence-probe combinations were constructed such that each probe occurred once preceded by the sentence context which was appropriate to its meaning and once preceded by a sentence which was inappropriate. As an unrelated control condition, a neutral sentence was constructed, in which the experimental item of the appropriate sentence was replaced by words matched in frequency and unrelated to the target. The same sentences served both as appropriate and inappropriate contexts and the verb from the appropriate context was retained in the unrelated control condition, so that complexity of verb-argument structure (or syntactic subcategorization) did not differ between conditions. Thus, type of sentence context (appropriate, inappropriate, and unrelated control) was fully crossed with degree of association of the probe word (high and low dominant property) giving six experimental conditions as illustrated in table 1.

As the example illustrates, the appropriate and inappropriate sentences both include a word, which is related to or associated with the following probe word ('window'-'glass' or 'window'-'sill'). In the unrelated conditions the sentences end in a word which is not related to the probe ('car'-'glass' or 'couch'-'sill'). In the appropriate conditions the sentence emphasizes a property of the meaning of the experimental item which is congruent with the following probe word. In the inappropriate conditions a different property is emphasized which is not congruent with the following probe word. Differences in probe decision latencies allow inferences about the specificity or level of semantic encoding of the words in the preceding context. The method is intended to assess the degree of semantic resolution

Table 1

Example of Stimuli in Experiment 2

Condition	Context	Probe
High dominant /Appropriate	Drengene smadrede vinduet <i>The boys smashed the window</i>	glasset <i>glass</i>
High dominant /Inappropriate	Kvinden sad i vinduet <i>The woman sat in the window</i>	glasset <i>glass</i>
High dominant /Unrelated	Drengene smadrede vognen <i>The boys smashed the car</i>	glasset <i>glass</i>
Low dominant/Appropriate	Kvinden sad i vinduet <i>The woman sat in the window</i>	karmen <i>window sill</i>
Low dominant/Inappropriate	Drengene smadrede vinduet <i>The boys smashed the window</i>	karmen <i>window sill</i>
Low dominant/Unrelated	Kvinden sad i sofaen <i>The woman sat in the couch</i>	karmen <i>window sill</i>

of which normal subjects and aphasics with different clinical patterns of comprehension problems are capable.

(1) integration level encoding

Integration is examined by comparing probe decision latencies or errors to the same probe words preceded by appropriate or inappropriate sentence contexts. If subjects encode words so as to reflect those implicit aspects of meaning which are emphasized in a given context, one should find that 'glass' in the appropriate condition is rejected more slowly than 'glass' in the inappropriate condition. Similarly, 'sill' should be slower after the appropriate than after the inappropriate sentence.

(2) word-level encoding

Lexical-level encoding is examined by comparing probe decision latencies or errors in the two related conditions which both end in a word associated with the following target (the appropriate and inappropriate condition) to the unrelated condition. If subjects can form mental representations of the general meaning of words but are not capable of further constraining these word meanings depending on the context, then 'glass' and 'sill' should be slower after sentences containing the word 'window' than after sentences containing the word 'car' or 'couch', irrespective of the sentence emphasis.

In order to develop a reliable test of integration for use with aphasic subjects, the experiment with normal subjects included a large set of stimuli (24 experimental sets) which were distributed among the subjects so that each subject saw a subset (16 sets) of the stimuli. A repeated measures design still applied, since a subject always saw the same word in all the experimental conditions. Based on the results, a subset of the items was retained for a version of the test to be used with aphasic subjects (experiment no. 3). The normal subjects' response latencies and errors on that subset was subsequently re-analysed for comparison with the aphasic groups.

4.2 Method

4.2.1 Subjects

Twelve normal Danish subjects participated in the experiment. The subjects were volunteers among students and faculty members from the Speech and Hearing Department and the Applied Linguistics Department at the University of Copenhagen.

4.2.2 Materials

4.2.2.1 Experimental stimuli

To serve as experimental items, 24 words were selected from the normative property experiment (see chapter 3). For each of the selected words, a high and low dominant response could be established which designated a property or attribute, or an associated concept of the experimental word.

Furthermore, the high and low dominant properties were selected so that they emphasized different aspects of the meaning of the experimental word. The 24 experimental items selected from the normative experiment and their high and low dominant properties are shown in table 2. A high dominant property occurred as a response to the experimental word in 50% or more of the subjects in the normative experiment. A low dominant property was provided as a response by 40% or less of the subjects. Mean property frequency for high dominant properties was 73.3% (range 50-95). Mean property frequency for low dominant properties was 14.6% (range 5-40). The high and low dominant properties constituted common nouns or adjectives and were selected so that they always belonged to the same grammatical category. This was done to avoid confounding grammatical class with degree of semantic association, since fluent and nonfluent aphasics may differ with respect to their ability to process certain classes of words (Miceli, Silveri, Nocentini, and Caramazza, 1988). Because frequency and size of context effects have been shown to interact (Grosjean and Itzler, 1984), the words serving as high and low dominant properties did not differ in overall length and frequency across the materials. Appendix C shows property frequency in the normative experiment as well as word length and word frequency for the high and low dominant words.

Table 2

Experimental Items with their High and Low Dominant Properties
Used in Experiment no.2 with Normal Subjects

Experimental item	High dominant property	Low dominant property
se (lake)	fiskene (fish)	sivene (reeds)
hus (house)	døren (door)	væggen (wall)
orm (worm)	slimmet (slimy)	rund (round)
kat (cat)	pelsen (fur)	kloer (claws)
rose (rose)	tornen (thorn)	stilken (stem)
bi (bee)	honning (honey)	brodden (sting)
æble (apple)	rødt (red)	sødt (sweet)
ur (watch)	klokken (time)	guld (gold)
træ (tree)	bladene (leaves)	rødder (roots)
strand (beach)	sandet (sand)	rav (amber)
ko (cow)	mælk (milk)	mule (muzzle)
seng (bed)	dynen (quilt)	ben (leg)
avis (newspaper)	nyheder (news)	papiret (paper)
frakke (coat)	varm (warm)	stor (large)
bål (bonfire)	ilden (fire)	røgen (smoke)
kirke (church)	præst (priest)	tårnet (tower)
mark (field)	kornet (grain)	hegnet (fence)
skab (closet)	tøjet (clothes)	bunden (bottom)
gade (street)	bilerne (cars)	fliserne (flagstone)
græs (grass)	grønt (green)	blødt (soft)
sol (sun)	sommer (summer)	dagen (day)
sten (stone)	hård (hard)	flad (flat)
nøgle (keys)	lås (lock)	bundt (bunch)
vindue (window)	glasset (glass)	karmen (sill)

Pairs of sentence contexts were constructed in which the experimental words occurred in final position and constituted the object of the sentence. One sentence emphasized the aspect of the meaning of the experimental word which was expressed by the high dominant property. The other sentence emphasized the meaning expressed by the low dominant property. Care was taken in the construction of the sentences not to include other words than the experimental word, which might of themselves directly activate the meaning of the associate properties. Each sentence was then combined with each of the two properties giving four conditions. In the first two conditions the sentence was followed by an appropriate or inappropriate high dominant property. In the other two conditions the sentence was followed by an appropriate or inappropriate low dominant property. Furthermore, two unrelated control conditions were added by replacing the experimental words with concrete referential nouns which were matched in length and frequency across the materials and unrelated to the following properties. The subject and verb of the appropriate conditions were retained so that relatedness effects might be attributed to the relationship between the dominant property and the sentence or the experimental word, not to intralexical relationships between the dominant property and the subject or verb.

The associated properties were to serve as probes in a task where the subject saw a sentence and subsequently had to decide whether or not the property word had occurred in the sentence. For the purpose of presentation, three experimental lists were constructed, each based on 8 experimental words with their high and low dominant probes and containing 96 experimental sentence-probe trials, where the probe did not occur in the sentence (negative probes). All sentences were active and nonreversible. Since each sentence occurred as an appropriate, an inappropriate and a neutral context, the sentences in the six conditions did not differ in overall length. Appendix D contains the experimental sentence-probe trials for each of the three lists and information about length and frequency of the experimental words and the neutral control words which occurred as objects in the unrelated conditions.

4.2.2.2 Filler stimuli

Each list also contained 96 filler trials where sentences were followed by a probe word which did occur in the sentence (positive probes). The positive probes were common content words and did not differ in overall frequency and length from the negative probes. The probe words were selected in equal numbers from the initial, middle and final part of the sentence, i.e. predominantly from subject, object, and verb position. This was done in order to prevent subjects from paying attention to only one part of the sentence. The probes in the three positions did not differ in overall length and frequency in order to enable comparisons of verification times as a function of sentence position. The filler sentences did not differ in length or grammatical structure from the experimental sentences, and experimental sentences were also used as fillers, so that each sentence occurred once followed by a positive probe. Appendix E contains the filler sentences and their probes with information about length and frequency.

4.2.3 Procedure

Each subject saw two of the three lists in the experiment, giving a total of 192 trials. The twelve subjects were assigned to the three lists so that each list was seen by eight subjects. Within each list, the sentence-probe trials occurred in a fixed randomized order with the constraint that there were no more than three 'yes' or 'no' trials in a row, no more than two appropriate, inappropriate or unrelated probes in a row of negative trials, and no more than two probes from initial, middle or final position in a row of positive trials. The list was presented in eight presentation blocks each of which was preceded by two warm-up trials.

Subjects were seated at the computer with their left index and middle fingers resting on a yes- and no-response button. On each trial subjects saw a sentence presented on the computer screen for a fixed period of 7.3 seconds. The sentence then disappeared, and after an interval of 900 msec the probe word appeared. Subjects then had to press a button to indicate whether or not the probe had occurred in the preceding sentence. The probe word stayed on the screen until the subject responded. Subjects were

instructed to read and comprehend the sentences carefully and to respond as fast as possible once the probe appeared. Before the experimental task began, subjects were familiarized with the response buttons by completing a task requiring them to press the yes- or no-button when the words 'yes' or 'no' appeared on the screen. This was followed by a practice session with ten sentence-probe trials similar to the stimuli in the experimental task.

4.2.4 Apparatus

The stimuli were shown on the screen of a Macintosh computer and the responses were registered by means of a response box connected to the serial port of the computer. Stimulus presentation and response registration was carried out by a Modula-2 program. See appendix F for details concerning the computer program.

4.3 Results

4.3.1 Negative probes

Prior to statistical analyses, subjects' reaction times were pruned of outlying values which might otherwise distort the means. Response times were identified as outliers if they fell outside two standard deviations of the subject's mean in that condition and also fell outside two standard deviations of the group mean for the specific item. Outliers were replaced by the subject's mean in that condition.

Subjects' mean correct probe rejection latencies were analysed in a 2-factor repeated measures ANOVA (type of context (appropriate, inappropriate and neutral) x property dominance (high and low)). The subject means are shown in table 3. Results showed a significant effect due to context ($F(2,22)=8.83$, $p<.002$), but neither property dominance nor the interaction were significant ($F(1,11)=.55$, $p>.47$ and $F(2,22)=1.16$, $p>.33$ respectively). The results from the analysis of variance are shown in table 4.

A priori tests were made of the appropriate and inappropriate condition using a t-statistic based on the mean square error from the analysis of variance (Kirk, 1968, section 8.7). The tests showed significant differences

for both high and low dominant properties ($t(22)=3.982$, $p<.001$ (one-tailed) and $t(22)=3.186$, $p<.005$ (one-tailed) respectively). Because of the significant integration effects, priming tests were not carried out, since a significant priming effect under these circumstances might be due to the appropriate condition alone.

Inspection of the error data showed that on the whole subjects made very few errors on the task (overall error means are presented in table 5). However, to examine the general direction of these errors, a corresponding analysis of variance was carried out followed by tests of integration (the data for the analysis and the anova table are included in appendix G and H). The effect of context was marginally significant, $F(2,22)=3.17$, $p=.061$. There was no overall effect of property dominance, $F(1,11)=.31$, $p>.58$, and the interaction was nonsignificant, $F(2,22)=.35$, $p>.70$. A priori comparisons for integration and priming showed no significant differences in the high dominant condition. For low dominant properties the integration comparison was significant ($t(22)=1.736$, $p<.05$ (one-tailed)).

Table 5

Normal Subjects : Mean Errors in Probe Rejection

	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
mean	0.33	0.17	0.42	0.42	0.0	0.25

Table 3

Normal Subjects : Mean Probe Rejection Latencies in Milliseconds

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
01	545	548	542	530	511	538
02	748	700	690	703	664	659
03	633	678	626	635	593	563
04	657	616	572	624	633	628
05	757	702	706	764	744	709
06	663	585	589	622	603	663
07	631	638	571	650	637	612
08	824	679	660	767	687	656
09	748	634	750	667	615	731
10	650	609	576	619	625	577
11	705	708	676	827	697	680
12	712	625	630	657	627	655
mean	689	644	632	672	636	639

Table 4

Normal Subjects : Anova Table from Analysis of Mean Probe Rejection Latencies

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	216469.82	11	19679.07		
Dominance	618.35	1	618.35	.55	.476
Dominance x BS	12474.49	11	1134.04		
Context	29645.03	2	14822.51	8.83	.002
Context x BS	36932.97	22	1678.77		
Domin. x Context	1779.53	2	889.76	1.16	.332
Domin. x Context x BS	16855.14	22	766.14		

It appears that probe rejection latencies are sensitive to differences in the semantic encoding of word meaning, so that normal subjects take longer to reject probes which refer to semantic properties of word meaning which were appropriate in the preceding sentence. Subjects made very few errors on the task, and this might explain why the integration effect did not quite reach statistical significance in the analysis of errors. Property dominance did not have any effect nor did this factor interact with type of context as reported in studies by Greenspan (1986) and Barsalou (1982).

4.3.2 Inspection of items and pruning of the test for use with aphasic subjects

In order to refine the test for use with aphasic subjects, the item means for high and low dominant probes were computed collapsing across the twelve subjects (see appendix I to J). In this experiment, high and low dominant properties are different sets of words, but the same words appear in all three types of context. Neither the property dominance factor nor the interaction with type of context were significant in the by-subject analyses. For the context factor, which was statistically significant by subjects, an item analysis as described by Clark (1973) is not appropriate, since the purpose of such an analysis is to partial out variance due to different stimuli appearing in the experimental conditions (cf. Greenspan, 1986, p. 542 note 3).

An inspection of the item means revealed that for most of the items the appropriate and inappropriate conditions differed in the expected direction. However, a subset of the items did not seem to work very well. The normal study was intended to lead to the construction of the best possible test of integration for use with aphasic subjects and included a larger number of sentence-probe sets than was intended for the aphasic study. Consequently, a new version of the test was constructed by removing some of those items which did not show a difference in the expected direction between the appropriate and inappropriate condition. A constraint on this pruning procedure was the requirement that length and frequency still be matched across the high and low dominant conditions. The items removed from the

test are marked in appendix I to J.

In order to allow a more direct comparison with the aphasic study, normal subjects' means on the new pruned version of the test were computed and reanalysed. Subjects' probe rejection latencies on the pruned test are given in table 6. Overall error means are presented in table 7 (the complete error data are included in appendix K).

For mean probe rejection latencies, results showed a significant effect of context ($F(2,22)=9.26$, $p<.001$) and no effect of property dominance ($F(1,11)=1.35$, $p>.27$) as in the full version of the test. However, in the pruned version, the interaction of context with property dominance reached significance, $F(2,22)=3.56$, $p<.046$. Anova tables from the analyses of the pruned test are included in appendix L and M.

To examine the interaction, post hoc tests (Scheffé's ratio) were performed on differences between means at each level of property dominance. Results showed that for both high dominant properties and low dominant probes, the appropriate condition differed from the inappropriate condition due to integration (critical $F(1,11)$ at the .05 level of significance=9.68; observed $F=13.638$ and observed $F=13.257$ respectively). There were no significant differences between the inappropriate and unrelated condition at either level of property dominance. However, for high dominant probes, the appropriate condition differed both from the inappropriate and unrelated conditions (observed $F=17.741$ for the comparison with the unrelated condition), whereas for low dominant probes the appropriate condition differed only from the inappropriate condition.

A priori tests of integration were also carried out as planned and showed significant integration for both high and low dominant properties ($t(22)=5.075$, $p<.001$ (one-tailed) and $t(22)=4.282$, $p<.001$ (one-tailed) respectively).

Table 6

Normal Subjects : Mean Probe Rejection Latencies in Milliseconds
on Subset of Items Used for the Experiment with Aphasic Subjects

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
01	551	540	533	533	505	563
02	772	700	705	704	642	655
03	655	682	613	630	593	576
04	658	584	558	622	615	638
05	763	695	710	749	718	678
06	686	602	565	655	598	671
07	641	632	553	662	638	612
08	857	669	672	812	655	656
09	719	644	773	661	571	755
10	673	609	532	614	604	592
11	730	724	685	830	680	691
12	752	614	652	645	639	662
mean	705	641	629	676	622	646

Table 7

Normal Danish Subjects : Overall Errors in Probe Rejection
on Subset of Items Used for the Experiment with Aphasic Subjects

mean	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
mean	0.25	0.0	0.33	0.17	0.0	0.25

For errors the analysis of variance showed a significant effect of context, $F(2,22)=6.22$, $p<.007$, while property dominance and the interaction remained nonsignificant ($F(1,11)=.38$, $p>.55$ and $F(2,22)=.07$, $p>.93$ respectively).

However, a priori comparison for integration and priming failed to reveal any significant differences. Only for high dominant properties was there a trend towards an integration effect ($t(22)=1.366$, $p<.10$ (one-tailed)). As in the unpruned version, the absence of integration and priming effects was presumably due to the small number of errors made by normal subjects on the test.

4.3.3 Positive probes

Inspection of the yes-responses, i.e. latencies to accept positive probes, suggested that probes from initial position were faster than probes from the middle position and these appeared to be yet faster than probes from the final position. The error data presented a corresponding picture with probes from initial position apparently leading to fewer errors than probes from middle and final position. After a procedure replacing outlying reaction times (see section 4.3.1), normal subjects' mean probe acceptance latencies and errors on words which had occurred in initial, middle, and final position of the sentence were analysed in a 1-factor ANOVA. The overall means are shown in table 8 and 9; the data for the analyses are included in appendix N and O.

Table 8

Normal Subjects : Mean Overall Probe Acceptance
Latencies by Sentence Position in Milliseconds

	SENTENCE POSITION		
	Initial	Middle	Final
mean	638	658	676

Table 9

Normal Subjects : Overall Errors in Probe
Acceptance by Sentence Position

	SENTENCE POSITION		
	Initial	Middle	Final
mean	0.67	1.33	2.17

The statistical analysis of probe acceptance latencies showed only a trend in the relationship between probe acceptance time and the position of the word in the sentence ($F(2,22)=3.05$, $p=.068$). For errors there was a significant effect of sentence position ($F(2,22)=4.90$, $p=.017$). However, post hoc analyses (Scheffé's ratio) failed to reveal significant differences between any two pair of means. (Anova tables from the analyses of the probe acceptance data are included in appendix P and Q).

4.4 Discussion

Normal subjects showed integration, i.e. significant differences between the appropriate and inappropriate condition. The result is in general agreement with other studies of the comprehension of unambiguous words in sentences in so far as the data support the hypothesis that semantic properties of concrete referential nouns are weighted in the mental representation of the comprehender in a way which reflects the meaning of the word as an integrated part of the context. The hypothesis has previously been confirmed in studies using other methods, such as cued sentence recall (Barclay et al., 1974; Anderson et al., 1976; Greenspan, 1986), property verification (Ashcraft, 1976b; Tabossi and Johnson-Laird, 1980; Tabossi, 1982; Barsalou, 1982), Stroop color naming (Merril et al., 1982; Whitney et al., 1985), cross-modal lexical decision (Greenspan, 1986), and association rating (Greenspan, 1986). The demonstration of similar findings using the probe decision method therefore lends further support to the integration hypothesis, since it seems to

represent a phenomenon which can be demonstrated across a variety of different tasks.

Some of the specific findings in experiment no. 2 concerning high and low dominant properties do not agree with previous research involving this variable. In the post hoc tests, no difference was found between the inappropriate and unrelated condition for either high dominant or low dominant properties. This result is contrary to several studies which have found activation of high dominant properties relative to a neutral (unrelated) baseline, even when they were inappropriate in the context (cf. section 2.2) The major conclusion drawn from this research has been that highly associated or central aspects of meaning are always activated in the mental representation, regardless of contextual bias. In this study, both dominant and nondominant properties were influenced by the appropriateness of the context, as evidenced by the significant integration effect in both dominance conditions. The only difference between high and low dominant properties was due to a difference between the appropriate condition and the unrelated baseline which was found only for high dominant properties.

Since large and statistically stable differences were found relating to the context factor in this study, there is no reason to suspect that the results relating to the degree of dominance factor are due to a general problem of methodology. Rather, an interpretation of the results seems warranted which considers possible differences in the stimuli or tasks of studies which have yielded different results. Concerning the stimuli, it is conceivable that high dominant properties showed contextual encoding because they were not as closely associated as high dominant properties in other studies. However, the mean frequency for high dominant properties was 73% based on the Danish normative study. In a comparable study by Whitney et al. (1985), which was also based on normative data, the average frequency of high dominant properties was 64%. Another possibility is that differences in length and frequency may have been confounded with degree of dominance in some studies, since these factors have not previously been controlled. However, a more likely source of the different results may have to do with the

processing demands of the tasks used to test integration.

One method employed in the study of integration of high and low dominant properties has been the cued sentence recall task (Greenspan, 1986). In the cued sentence recall task the subject is asked to read and remember a set of sentences. After an interval which may be filled by a distractor task intended to minimize short term memory influence on sentence recall, the subject receives a cue word for each sentence and is asked to remember and reproduce the literal form of the sentence as correctly as possible. Responses are scored as correct if they include the critical noun which is related to the cue word.

The method does not impose any on-line time limitations on integrative processes, since it is the long term memory representation which is probed. The finding that high dominant properties are more effective recall cues than unrelated cues even if they are not emphasized in the sentence is interpreted in terms of Tulving's encoding specificity hypothesis (Tulving and Thomson, 1973) to mean that high dominant properties are always present in the memory trace of the sentence irrespective of contextual bias. An alternative explanation is also possible based on the need to distinguish between the memory representation of the sentence and the lexical-semantic system which operates in recognizing the cue word. When the subject is presented with a high dominant property as a cue word, it is not unlikely that lexical retrieval processes may cause an activation of words with which the property is highly associated independently of any context. Among these words would be the related word occurring in the sentence to be remembered. When this word comes to mind, the subject may be aided in reconstructing the literal form of the sentence, irrespective of its emphasis. For low dominant properties, consistent activation of the associated word from the sentence cannot be expected in the probe recognition phase, and the subject may resort to a more semantically based strategy for solving the task which is in accordance with Tulving's account. This might account for Greenspan's (1986) finding with the cued sentence recall method that high dominant properties are always effective recall cues regardless of contextual

emphasis.

Concerning the Stroop color naming task and the cross-modal lexical decision task, these methods share the characteristic that the actual experimental task is unrelated to the preceding sentence : i.e. the task does not require an active inspection of the memory representation of the sentence or a comparison of the sentence to the word, as does the probe decision task used in experiment no. 2. The mechanism underlying the Stroop task and the lexical decision task should presumably be located in the effect of the sentences on the lexical recognition processes involving the color term or lexical decision target, and is likely to depend on a post-access checking mechanism sensitive to the semantic appropriateness of the word in the context. No direct comparison is required between the property word and the memory representation of the sentence, but an indirect effect of the encoded representation is expected.

With the Stroop color naming task, Whitney et al. (1985) found that both high and low dominant properties were initially activated regardless of contextual appropriateness. Subsequently, low dominant properties were deactivated if they were not appropriate, but high dominant properties remained activated in spite of not being appropriate in the sentence. It is puzzling that this indirect measure of integration should yield different results than the probe decision method used in experiment 2. One possible explanation may refer to differences in the temporal parameters of the two tasks. Whitney et al. used sentence-word target intervals of 0, 300, and 600 milliseconds, whereas the probe decision task had a sentence-probe interval of 900 milliseconds to which one might add the prolonged presentation (7.3 seconds) of the sentence on the screen. Although most primary processes of word recognition have taken place within 600 milliseconds of word presentation, it is still conceivable that integrational activity relating to the semantic representation of the sentence in memory may take place after 600 milliseconds. This explanation is to some extent supported by the cross-modal lexical decision study of Greenspan (1986). Like Whitney et al., Greenspan used an auditory presentation of the sentence which was then followed by a

visually presented letter string for lexical decision. The sentence-word interval was 1 second and thus closer to the inter-stimulus interval of experiment no. 2. Like Whitney et al., Greenspan found that high dominant properties were always activated irrespective of sentence emphasis. He did, however, demonstrate an influence of context on high dominant properties of meaning, i.e. a difference between the appropriate and inappropriate condition. While the latter finding suggests that processing time may be an explanatory factor in understanding the differences in the results of these studies from experiment no. 2, the former finding of a continued activation in inappropriate contexts of the high dominant property relative to a neutral base line is still contrary to the results of experiment no 2.

In conclusion, the results of experiment no. 2 provide additional support of the general finding that in normal subjects the semantic encoding of unambiguous referential nouns is influenced by the sentence context. The study does not provide any conclusive evidence regarding the underlying mechanisms of contextual encoding, but is in agreement with Greenspan's (1986) account of an increase in activation of appropriate properties due to sentence emphasis which also applies to high dominant properties of word meaning. The absence of inhibition in the inappropriate condition as compared to the unrelated control also comports with Greenspan's results. However, the finding of continued activation of high dominant properties relative to the unrelated control condition by Greenspan and other researchers was not replicated in experiment no. 2, where normal subjects showed a deactivation also of high dominant properties when these were inappropriate in the sentence.

5. EXPERIMENT NO. 3

5.1 Introduction

Experiment no. 3 was undertaken to examine integration in aphasics with fluent and nonfluent aphasia and different degrees of comprehension difficulties.

5.2 Method

5.2.1 Subjects.

Fifteen aphasic subjects were included in the experiment. All patients were right-handed and had been diagnosed as aphasic following left cerebrovascular accidents. Except for the patients JP and JA, who had suffered two strokes, all other patients were one-stroke victims at the time of testing. Information about localization of lesion was not available for all the patients since CT-scanning is not a routine procedure in every Danish hospital. Table 10 contains a summary of information about the patients including information about presence or absence of hemiplegia and visual field defects which may be informative as to the site of lesion.

A Danish translation of the Boston Diagnostic Aphasia Examination was used for the assessment and classification of type of aphasia. The subtests given were those which most clearly discriminate between different forms of aphasia : the subtests of auditory comprehension, repetition, confrontation naming, and description of the cookie theft picture (with rating of speech characteristics). The patients included could all be comfortably assigned to one of the fluent (Wernicke, Transcortical Sensory, Anomic, Conduction) or nonfluent (Broca, Transcortical Motor) categories of the Boston classification system. Patients with unclassifiable forms of language breakdown and patients with global or severe mixed nonfluent aphasia were not included in the experiment.

Fifteen patients were included : nine fluent aphasics (four Wernicke's, one Transcortical Sensory, one Anomic, and three Conduction aphasics) and six nonfluent aphasics (four Broca's and two Transcortical Motor aphasics)

Table 10

Danish Aphasics : Subjects in Experiment no. 3

Name	Age	Educ. /Job	Post onset	Radiological info	Other localising info
Nonfluent aphasics :					
RP	61	10 yrs. /TV-technician	3 yrs	large l. parietal in- farct	r. hemiparesis
MN	46	7 yrs. /cleaning ass.	6 yrs.	not available	r. hemiparesis
EH	69	7 yrs. /typesetter	7 yrs.	large l. infarct ex- tending to frontal lobe	r. hemiparesis
CC	66	9 yrs. /foreman	9 yrs	not available	r. hemiparesis
NL	27	12 yrs. /bank clerk	6 mo.	l. frontal infarct	r. hemiparesis
JL	43	10 yrs. /book keeper	6 mo	infarct of l. middle cerebral artery area	r. hemiparesis
Fluent aphasics					
JP	63	7 yrs. /saleswoman	8 yrs.	l. temporo-parietal 6 yrs. not available	no paresis
EA	73	7 yrs. /housewife	12 mo.	not available	no paresis
KB	62	9 yrs. /florist	3 yrs	not available	remitted mild r. hemiparesis
CD	61	10 yrs. /clerk	3 yrs	infarct of l. middle cerebral artery area	r. hemianopsia, no paresis
JA	67	12 yrs. /business man	2 yrs. 12 mo	not available l. hemispherical infarct	remitted mild r. hemiparesis
EJ	47	10 yrs. /secretary	18 mo	large l. temporo- parietal infarct	no paresis
EN	65	12 yrs. /housewife	7 yrs.	l. temporal infarct	no paresis
MS	52	16 yrs. /interpreter	13 mo.	l. temporal infarct	no paresis
HP	46	9 yrs. /insurance agent	16 mo.	large infarct of l middle cerebral artery area	remitted mild r hemiparesis

Tables 11A and 11B show the scores on the different subtests of the Boston Diagnostic Aphasia Examination and the aphasia classification for the subjects in the experiment.

To insure subjects had sufficient reading skills to carry out the experimental task, a further criterion for participation was an overall score of at least 70% correct on the single word reading subtests of the Boston test (visual symbol discrimination, phonetic association, and word-picture matching) as well as on a special sentence-picture matching pretest with 10 sentences taken from the experimental study. The results of the reading pretests are shown in table 12.

The use of classifiable patients ensures to some degree against muddled data due to the inclusion of patients with highly individualized or amorphous patterns of language breakdown, or cases where the compensatory strategies distort the original pattern of the disorder. For the experimental analyses, however, grouping by diagnostic category may not be relevant to the particular dimension of language which is being studied. Furthermore, such a grouping is often impracticable because the number of patients in each diagnostic category is too small. Alternatively, the fluent-nonfluent dimension has proved an important grouping criterion in studies of automatic and controlled processes in word recognition and will be used here in the statistical analyses.

5.2.2 Stimuli

A subset of 16 words was selected from the 24 experimental items used in experiment no. 2 as described in section 4.3.2. The 16 words are shown in appendix R. The experimental sentences and filler sentences were the exact same as in experiment no. 2, except for the exclusion of sentence-probe sets relating to the 8 experimental items which were not included in the aphasic version. T-tests were repeated for the new version of the test and showed no significant differences in length or frequency between high and low dominant properties, between experimental sentence objects and unrelated controls, between positive probes from initial, middle and final position of

Table 11A

Aphasics : Raw Scores on Subtests
of the Boston Diagnostic Aphasia Examination

CLASSIFIC		COMPREHENSION				REPETITION		
		sgl wo.	body part	commands	complex material	sgl wo.	hi. prob. sentences	lo. prob. sentences
MAX SCORE		72	20	15	12	10	8	8
Nonfluent aphasics :								
RP	TM	70.0	19	10	7	8	4	4
MN	Broca	69.0	14	11	7	8	1	0
EH	TM	69.5	19	13	7	9	4	2
CC	Broca	66.5	13	11	8	8	1	0
NL	Broca	72.0	19	14	12	1	0	0
JL	Broca	72.0	20	13	9	9	3	3
Fluent aphasics :								
JP	Wern.	57.5	19	7	1	8	2	0
EA	Wern.	41.5	13	1	1	6	1	0
KB	Cond.	54.5	15	13	7	8	1	1
CD	TS	56.0	18	4	7	9	8	8
JA	Wern.	68.0	15	4	3	7	2	1
BJ	Cond.	72.0	18.5	12	2	7	2	1
EN	Cond.	60.0	19	13	8	8	3	2
HS	Anomic	69.0	20	13	7	9	5	4
HP	Wern.	55.0	4	2	1	6	0	0

Table 11B
Aphasics : Raw Scores on Subtests
of the Boston Diagnostic Aphasia Examination

CLASSIFIC.	NAMING	SPEECH CHARACTERISTICS						
		mel line	phr length	artic	gram form	para- phasia	word finding	
MAX SCORE	114	7	7	7	7	7	7	
Nonfluent aphasics :								
RP	TM	66	2	1	1	1	1	
MN	Broca	47	2	2	3	1	1	
EH	TM	78	2	2	2	2	2	
CC	Broca	63	2	2	2	2	2	
NL	Broca	6	1	1	1	1	1	
JL	Broca	96	3	2	2	2	2	
Fluent aphasics :								
JP	Wern.	110	7	7	5	7	2	5
EA	Wern.	108	7	7	7	7	4	6
KB	Cond.	46	7	6	5	5	4	6
CD	TS	61	6	7	6	6	3	6
JA	Wern.	77	7	7	6	5	4	5
BJ	Cond.	108	7	7	7	6	6	6
EN	Cond.	78	6	6	4	5	4	6
HS	Anomic	104	7	7	7	7	4	5
HP	Wern.	87	7	7	7	6	5	6

TABLE 12

Danish Aphasics : Reading Pretest Scores

Subject	Boston Diagnostic Aphasis Examination Symbol discrim	Phon association	Word-picture matching	Sentence-picture matching	Percent correct
Nonfluent aphasics					
RP	10	7	9	8	89.5
MN	9	6	8	9	84.2
EH	9	8	9	8	89.5
CC	10	8	10	9	97.4
NL	10	8	10	9	97.4
JL	9	7	9	8	86.8
Fluent aphasics					
JP	10	8	10	8	94.7
EA	10	7	10	8	92.1
KB	10	6	7	8	81.6
CD	7	1	10	9	71.1
JA	10	8	10	9	97.4
BJ	10	4	10	9	86.8
EN	10	6	10	9	89.5
HS	10	8	10	10	100.0
HP	10	8	10	9	97.4

the sentence, or between negative and positive probes (see also appendix R).

5.2.3 Procedure

The experimental setup and procedure was the same as described in experiment no. 2. However, special care was taken in the instruction of the subjects. Thus, written materials were used to demonstrate the task before practice on the computer began. Computer practice with the response buttons and with the sentence-probe task was repeated if necessary to ensure that subjects were able to carry out the experiment in a meaningful manner. In order to avoid problems due to fatigue, aphasic subjects were asked to complete only four presentation blocks in one session and returned on another day to complete the last four blocks. Each session lasted approximately one hour including a break between the first and the last two presentation blocks.

5.2.4 Apparatus

The apparatus was the same as described for experiment no. 2.

5.3 Results

5.3.1 Negative probes

Reaction times for correct responses were subjected to a data comb to remove outliers (see section 4.3.1). A subsequent inspection of the raw data of the aphasic subjects suggested that there was a relationship between errors in probe rejection and response latencies. Thus, subjects who erroneously accepted a word in the appropriate condition, often managed to correctly reject the same word in the inappropriate condition, but were very slow in doing so. Since only decision latencies for correct probe rejection latencies were included in the analyses, this relationship might distort the general slowing effect of contextual relatedness on subjects' rejection latencies. In order to correct for this, a subject's mean rejection latency included only those items on which he had answered correctly in all three context conditions. Because this procedure might be suspected to off-set the word length and word frequency balance between the high and low dominant condition, these values were recomputed for each subject.

Non-repeated measures t-tests carried out on these values showed no differences between the high dominant and low dominant condition in word length or word frequency for any of the fifteen subjects.

Subjects' mean probe rejection latencies and errors were both analysed in 3 factor analyses of variance (group(2) by dominance(2) by context(3)). The probe rejection latencies for nonfluent and fluent aphasics are presented in table 13; mean overall errors in table 14 (the complete error data are shown in appendix S).

Table 13
Aphasics Grouped by Fluency : Mean Probe Rejection
Latencies in Milliseconds

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
Nonfluent aphasics :						
RP	1943	1859	1553	1864	2053	1889
MN	1392	1320	1269	1373	1226	1210
EH	1788	1500	1400	1740	1536	1887
CC	1205	1237	1507	2598	2216	1970
NL	1672	1465	1243	1749	1407	1579
JL	1387	1338	1008	1422	1195	1109
mean	1565	1453	1330	1791	1606	1607
Fluent aphasics :						
JP	1313	1336	1225	1286	1199	1265
EA	2981	3626	2121	2509	2124	1940
KB	2234	2539	2042	2095	1974	1882
CD	1543	1667	1423	1361	1263	1365
JA	1290	1069	1032	1040	1073	1116
BJ	1277	1186	1142	1205	1215	1111
EN	1272	1315	1082	1606	1209	1150
HS	2057	1861	1969	1948	1588	1402
HP	1774	1337	1146	1273	1216	1361
mean	1749	1758	1465	1591	1429	1399

Table 14

Aphasics Grouped by Fluency: Mean Overall Errors in Probe Rejection

Group	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
Nonfluent	2.00	1.50	0.50	1.17	1.17	0.50
Fluent	1.78	1.44	0.78	0.89	0.78	0.56

For probe rejection latencies, the anova showed no overall effect of group ($F(1,13)=.00, p>.97$) or property dominance ($F(1,13)=.05, p>.82$). However, the group by dominance interaction was significant ($F(1,13)=6.74, p=.022$). Furthermore, results showed a main effect of context ($F(2,26)=10.84, p<.000$), but neither the interaction between group and context, dominance and context, nor the three-way interaction were significant ($F(2,26)=.59, p>.55$; $F(2,26)=1.75, p>.19$ and $F(2,26)=.23, p>.79$ respectively) (see table 15).

Table 16

Aphasics Grouped by Fluency: Anova Table from Analysis of Mean Probe Rejection Latencies

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	1022.31	1	1022.31	.00	.975
between cells	13541946.18	13	1041688.2		
DOMINANCE	6303.75	1	6303.75	.05	.829
G. x D.	878218.02	1	878218.02	6.74	.022
within cells	1694089.81	13	130314.60		
CONTEXT	720656.07	2	360328.04	10.84	.000
G. x C.	39492.47	2	19746.24	.59	.559
within cells	864139.91	26	33236.15		
D. x C.	140155.63	2	70077.82	1.75	.193
G. x D. x C.	18637.63	2	9318.82	.23	.794
within cells	1040658.61	26	40025.33		

In order to elucidate the group by dominance interaction, scores from different levels of the context factor were collapsed and comparisons were made of latencies to reject high dominant versus low dominant properties separately for the group of fluent and nonfluent aphasics. For fluent aphasics, paired t-tests showed that these patients were slower to reject high dominant than low dominant properties ($t(8)=2.307$, $p<.05$ (two-tailed)). For nonfluent aphasics the means differed in the opposite direction, but this was not significant ($t(5)=-1.463$, N.S. (two-tailed)).

Tests of integration and priming were carried out following the model for orthogonal a priori comparisons using the mean square error from the analysis of variance as suggested by Kirk (1968). The results of these tests were as follows: For high dominant words, neither nonfluent nor fluent aphasics showed integration ($t(26)=1.533$ and $t(26)=-.0123$ respectively). For both groups, however, the comparison for priming was significant in the high dominant condition ($t(26)=2.450$, $p<.025$ and $t(26)=3.949$, $p<.001$ respectively). In the low dominant condition, both groups showed integration ($t(26)=2.533$, $p<.01$ and $t(26)=2.218$, $p<.025$ respectively).

The three-way anova on errors in probe rejection showed no effect of group ($F(1,13)=.03$, $p>.86$) or dominance ($F(1,13)=2.47$, $p>.14$) and the group by dominance interaction was nonsignificant for errors ($F(1,13)=.11$, $p>.75$). As in the latency results, however, there was a significant main effect of context ($F(2,26)=3.73$, $p<.038$). Neither group by context, dominance by context, nor the three-way interaction were significant ($F(2,26)=.25$, $p>.78$, $F(2,26)=1.06$, $p>.36$; $F(2,26)=.04$, $p>.96$ respectively). See appendix T.

A priori comparisons for integration and priming were carried out in the same manner described for the latency results. The tests for integration in the high dominant and low dominant conditions were not significant for either group. However, both nonfluent and fluent aphasics showed priming in the high dominant condition, and nonfluent aphasics showed priming in the low dominance condition as well ($t(26)=3.492$, $p<.005$, $t(26)=2.318$, $p<.025$, and $t(26)=1.872$, $p<.05$ respectively).

5.3.2 Regrouping of aphasics by level of comprehension

The question of grouping criteria in experimental studies with aphasic subjects is highly controversial and it has been argued that only case studies can be acceptable in research where one attempts to draw inferences from pathological function to the normal language processing system (Caramazza and McCloskey, 1988). Other researchers have taken the intermediate position that grouping of patients is an appropriate method in studies where one attempts to demonstrate associations between symptoms in aphasia (Newcombe and Marshall, 1988). In accordance with the latter viewpoint it is legitimate to group patients based on performance in one aspect of linguistic functioning such as fluency of speech production in order to examine whether a relationship exists to other language deficits. However, a theoretical motivation for choice of grouping criterion is required and the relevance of a given criterion with regard to the experimental variables examined in a study may be a subject of debate.

Grouping by fluency of speech production is a traditional criterion and in the case of this experiment it is theoretically motivated in the research of Blumstein and colleagues demonstrating a relationship between breakdown in automatic and controlled processes in comprehension and fluency in speech production (see section 1.4). Thus, from a processing perspective the integration of word meaning in sentences might be assumed to depend on controlled mental processes. However, from the perspective of the type of linguistic knowledge involved, the integration level in comprehension may be assumed to depend on the preservation of knowledge of word meanings. In accordance with this perspective, subjects were regrouped into high and low (single word) comprehenders according to their scores on the auditory single word comprehension score on the Boston Diagnostic Aphasia Examination, cf. table 16.

Mean probe rejection latencies for aphasics regrouped according to single word comprehension are shown in table 17. The data were resubmitted to a three-way anova as described for the fluency grouping above (see anova table in appendix U).

Table 16
Aphasics Grouped according to Level
of Single Word Comprehension

<u>Subject</u>	<u>Aphasia type</u>	<u>Sgl. Word Comp. Score</u>	<u>Group</u>
NL	Broca	72.0	High Comprehenders
JL	Broca	72.0	
BJ	Conduction	72.0	
RP	Transcortical M.	70.0	
EH	Transcortical M.	69.5	
MN	Broca	69.0	
HS	Anomic	69.0	
JA	Wernicke	68.0	
CC	Broca	66.5	Low Comprehenders
EN	Conduction	60.0	
JP	Wernicke	57.5	
CD	Trancortical S.	56.0	
HP	Wernicke	55.0	
KB	Conduction	54.5	
EA	Wernicke	41.5	

Table 17

**Aphasics Grouped by Comprehension : Mean Probe Rejection
Latencies in Milliseconds**

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
High comprehenders :						
NL	1672	1465	1243	1749	1407	1579
JL	1387	1338	1008	1422	1195	1109
BJ	1277	1106	1142	1205	1215	1111
RP	1943	1859	1553	1864	2053	1889
EH	1788	1500	1400	1740	1536	1887
MN	1392	1320	1269	1373	1226	1210
HS	2057	1861	1969	1948	1588	1402
JA	1290	1069	1032	1040	1073	1116
mean	1601	1450	1327	1543	1412	1413
Low comprehenders :						
CC	1205	1237	1507	2598	2216	1970
EN	1272	1315	1082	1606	1209	1150
JP	1313	1336	1225	1286	1199	1265
CD	1543	1557	1423	1361	1263	1365
HP	1774	1337	1146	1273	1216	1361
KB	2234	2539	2042	2095	1974	1882
EA	2981	3626	2121	2509	2124	1940
mean	1760	1850	1507	1818	1600	1562

Results showed no main effect of group, dominance or group by dominance interaction ($F(1,13)=1.19$, $p>.29$, $F(1,13)=.07$, $p>.79$, and $F(1,13)=.05$, $p>.82$). Only the context effect was significant ($F(2,26)=12.11$, $p<.001$). Neither group by context, dominance by context nor the three-way interaction were significant ($F(2,26)=1.00$, $p>.38$, $F(2,26)=2.44$, $p>.10$, $F(2,26)=1.38$, $p>.27$).

Orthogonal comparisons for integration and priming were carried out as previously described. High comprehenders showed integration for both high dominant and low dominant words ($t(26)=2.154$, $p<.025$ and $t(26)=1.869$, $p<.05$ respectively). For low comprehenders, the integration comparison for high dominant words was not significant ($t(26)=-1.284$, N.S.). In fact, for six of the seven subjects the inappropriate condition was longer than the appropriate in the high dominant condition. However, the test of priming was significant for low comprehenders in the high dominant condition ($t(26)=4.252$, $p<.001$) and low comprehenders showed integration in the low dominant condition ($t(26)=3.111$, $p<.005$).

The overall error data for aphasics grouped according to level of single word comprehension is presented in table 18. The errors were analysed in analysis of variance as previously described (see anova table in appendix V). The results showed a main effect of group ($F(1,13)=7.61$, $p<.016$) due to low comprehenders making more errors than high comprehenders. There was no main effect of degree of dominance or group by dominance interaction ($F(1,13)=3.40$, $p>.08$ and $F(1,13)=1.61$, $p>.22$ respectively). The context effect was significant ($F(2,26)=4.58$, $p<.02$) but none of the interactions involving the context factor was significant.

Table 18

Aphasics Grouped by Comprehension: Mean Overall
Errors in Probe Rejection

Group	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
High compr.	.63	.75	.38	.38	.63	.25
Low compr.	3.29	2.29	1.00	1.71	1.29	.86

A priori comparisons showed no differences between any conditions for high comprehenders, presumably due to the fact that they made comparatively few errors on the task. For low comprehenders, the test of integration was significant for high dominant probes ($t(26)=2.89$, $p<.005$, but not for low dominant probes, where they only showed priming ($t(26)=1.85$, $p<.05$).

5.3.3 Positive probes

After the removal of outliers, mean latencies in probe acceptance were analysed in a two-factor repeated measures anova (group(2) by sentence position(3)) to clarify whether the time taken to accept a word was related to its (initial, middle, or final) position in the sentence. Overall means for fluent and nonfluent aphasics are shown in table 19; the data for the analysis is included in appendix W.

Table 19

Aphasics Grouped by Fluency : Mean Overall Probe
Acceptance Latencies in Milliseconds

	SENTENCE POSITION		
	subject	verb	object
Nonfluent	1647	1697	1637
Fluent	1867	1661	1605

The latency results did not show any significant differences between groups, or due to sentence position or interaction between group and sentence ($F(1,13)=.03$, $p>.86$; $F(2,26)=.44$, $p>.64$ and $F(2,26)=.51$, $p>.60$ respectively; see anova table in appendix X).

Overall errors for fluent and nonfluent aphasics are presented in table 20. A corresponding analysis of subjects' errors (see appendix Y) showed a trend towards a difference between groups ($F(1,13)=3.55$, $p=.082$) and a marginally significant main effect of sentence position ($F(2,26)=3.32$, $p=.052$). There was no interaction effect ($F(2,26)=.52$, $p>.60$; see anova table in appendix Z). A post hoc test (Scheffe's ratio) failed to reveal any significant differences between the error means from different sentence positions.

Table 20

Aphasics Grouped by Fluency: Mean Errors in Probe Acceptance

	SENTENCE POSITION		
	subject	verb	object
Nonfluent	8.33	10.17	6.00
Fluent	4.33	5.67	3.78

5.4 Discussion

The integration process has not previously been studied with aphasic subjects. However, based on research in the linguistic deficits of posterior aphasics with comprehension difficulties, it was hypothesized that this group might have difficulties at higher integrational levels of the comprehension process, including the level of contextual encoding of word meaning. This hypothesis was only partially supported by the results since all groups of aphasics showed integration in some of the experimental conditions.

For aphasics grouped by fluency, no differences in contextual encoding were found between the fluent and nonfluent patients in the analysis of response latencies. Both groups showed integration of low dominant aspects of word meaning but not of high dominant aspects. The analysis revealed a group by dominance interaction due to fluent aphasics being slower in rejecting high dominant properties than low dominant properties. The nonfluent group showed a nonsignificant trend in the opposite direction. The analysis of the error data did not show sentence level contextual encoding in either group, but only context effects related to word level encoding.

When aphasics were regrouped according to single word comprehension, a difference became apparent in the response latency data with respect to integration of word meaning. Thus, high comprehenders showed integration for both high and low dominant aspects of word meaning whereas low

comprehenders only showed integration in the low dominant condition. The analysis of the error data showed that low comprehenders made more errors than high comprehenders in probe rejection. High comprehenders showed no context effects on errors, presumably due to their making relatively few errors altogether. Low comprehenders did show sentence level contextual encoding in the high dominant condition contrary to their response latency results.

The results of experiment no. 3 suggest that fluent aphasics succeeded in encoding some aspects of word meaning in a manner reflecting the context in which the word occurred such that properties of meaning appropriate to the context were enhanced compared to inappropriate or neutral properties. Previous studies have shown sentence context effects on word recognition for this group, but in tasks where there was no attempt to control for word-level priming (e.g. Friederici, 1983).

For the nonfluent group an integration effect was expected, because the contextual encoding process was thought to rely on the same general capacity for inference which nonfluent aphasics are claimed to use in compensating for deficits in syntactic knowledge. Since the sentences in the study were all active nonreversible SVO-sentences one would not expect agrammatic aphasics to encounter any difficulties in arriving at a correct understanding of the thematic relationships expressed. This was confirmed in so far as nonfluent aphasics did show integration in the low dominant condition.

Both groups, however, failed to show contextual encoding of high dominant aspects of word meaning. An explanation of this became apparent when the aphasics were regrouped by level of single word comprehension, which separated out those subjects who failed to show integration of dominant properties from those who did. Thus, it appears that this aspect of the comprehension process is related to single word comprehension rather than fluency and that the failure of fluent and nonfluent aphasics to show contextual encoding of high dominant properties of word meaning might be

attributed to the inclusion of low single word comprehenders in both groups. The group by dominance interaction was associated only with the fluency grouping, and was due to the fluent group being slower in rejecting dominant properties. Normal subjects did not show any effect of dominance, and therefore it seems reasonable to interpret the importance of dominance for fluent aphasics as a disturbance or imbalance of normal semantic processing relating to lexical access or lexical representation. The disturbance cannot be characterized as a loss of information, e.g. of low dominant properties of word meaning, since these properties are successfully retrieved and encoded in the mental representation when they are appropriate in the sentence. Rather, the dominance effect suggests a possible disorganization within the lexical semantic system, such that dominance or associative strength may be augmented as an organizing principle, taking precedence over a normal categorical semantic structure.

The literature provides some support for difficulty with categorical semantic structure in posterior aphasics. Grober et al. (1980) showed that these patients performed as well as anterior patients when asked to categorize typical category members, whereas they showed a dramatic decline in the classification of atypical members. Similarly, Grossman (1981) found that fluent aphasics transgressed category boundaries in a naming task where they had to provide exemplars of semantic categories. Gross violations of categorical semantic structure has also been demonstrated in the behavior of patients classified as Wernicke's aphasics on a word sorting task where the normal semantic-hierarchically based sorting patterns were replaced by syntagmatic or idiosyncratic associations in this group. While these studies support a disturbance of normal categorical semantic organization, other studies, notably the research demonstrating large and statistically reliable priming effects in posterior aphasics (e.g. Blumstein et al., 1982), may comport with an augmentation of dominance or associative strength as an organizing principle. One can perhaps also speculate that the imprecision of expression, word finding difficulty, and lack of organization of the speech output of these patients may somehow bear a relation to categorical semantic disorganization. However, the hypothesized disorganization of

lexical retrieval processes or lexical representations needs to be substantiated with further support from empirical data.

As will be recalled, in experiment no. 2 normal subjects were slower to reject probes after appropriate than inappropriate sentences, irrespective of whether the probe was a high dominant or a low dominant property. The same result was observed for high comprehending aphasics, who all conformed to the normal pattern. However, unlike normal subjects and high comprehenders, low comprehenders showed continued activation of high dominant properties where these were inappropriate with respect to the sentence context. In fact, six of the seven low comprehenders showed a reverse pattern for high dominant probe words : they were slower to reject the probe if it was inappropriate with respect to the meaning of the sentence than if it was appropriate. In their error data, however, they did make more errors in rejecting high dominant properties after appropriate than after inappropriate contexts. Furthermore, they made more errors altogether in probe rejection than high comprehenders.

The overall larger number of errors of low comprehenders suggests that the ability of these aphasics to retain and examine a representation of a sentence in memory is reduced compared to high comprehenders. This does not seem surprising, since the group of low comprehenders were defined by their low scores on the auditory single word comprehension subtest on the Boston Diagnostic Aphasia Examination, and it is quite likely that problems with word discrimination may interfere with short term memory capacity.

The results also provide information about the qualitative nature of the mental representation of the experimental sentences in the understanding of the low comprehending aphasics. The latency results indicate that with regard to low dominant properties of word meaning, appropriate properties are activated or represented, suggesting a fairly advanced appreciation of sentence meaning. With regard to high dominant properties, however, the word level encoding effect and absence of integration indicate that these properties are present in the mental representation even when not

appropriate. This suggests that low comprehenders may have problems with some aspects of the integration of word meaning. However, the interpretation of the reaction time data must be modified by the fact that the low comprehenders did show an appropriate-inappropriate difference for high dominant properties in their error data. Furthermore, a number of studies of integration in normal subjects have also failed to demonstrate integration of high dominant properties (cf. section 4.4.). However, the method used here did demonstrate a clear integration effect for high dominant properties in both normal subjects and in high comprehending aphasics. Accordingly, a tentative interpretation should be offered of the deviant performance of low comprehenders on the test.

The general bearing of the results is that low comprehenders may have some form of difficulty with encoding properties of lexical meaning in accordance with the weight conferred on these properties by the context. Not all aspects of meaning cause difficulty. It appears that less dominant aspects of word meaning can be retrieved and encoded when appropriate in the context. This constitutes a parallel to the demonstration by Swinney et al. (1989) of a preserved ability of Wernicke's aphasics to retrieve the nondominant meaning of ambiguous words. Furthermore, the results of experiment no. 3 suggest that low dominant properties of unambiguous words do not remain activated when they are not appropriate in the context. Judging by the latency data, high dominant properties, which express the central or core meaning of the word, continue to stay activated beyond the point where normal subjects and high comprehending aphasics have deactivated inappropriate properties. It seems, however, that low comprehenders may eventually succeed in a proper weighting of high dominant properties as judged by their increased number of errors in the appropriate compared to the inappropriate condition.

In conclusion, low comprehenders seem to have difficulty with selective deactivation of properties of word meaning when these express central or core properties of the meaning of a word. It does not appear that they are unable to perform the weighting of semantic properties prerequisite for

integration of word meaning, but they may require more time than normal subjects and aphasics without problems in word recognition.

6. General summary

The preceding review of neurolinguistic theory and research in comprehension problems of aphasics with posterior syndromes can be summarized as follows.

Most aphasics have difficulties on speech perception tasks but there is no direct relation between skills at this level and more global assessments of comprehension. Aphasics with posterior syndromes do not consistently perform worse than patients with anterior syndromes and detailed testing has revealed that their problems do not arise in phonetic discrimination but in the linguistic identification or application of the phonetic percept.

Tasks that tap lexical-semantic knowledge show a closer relation to overall comprehension ability. Patients with posterior syndromes do worse than patients with anterior syndromes on word-picture matching with semantic foils, on semantic relatedness judgments and on similar tasks requiring manipulation of aspects of word meaning. The retrieval of lexical-semantic knowledge is not all-or-none, but some aspects of word meaning may be available even if the full range of semantic properties of a word cannot be retrieved. Receptive lexical-semantic skills show some correlation with performance on naming tasks, occurrence of semantic paraphasia in spontaneous speech, and conceptual disturbances but not on specific items. The data point to an impairment of lexical-semantic knowledge in posterior aphasics. However, most of the tasks used to test receptive lexical-semantic skills require metalinguistic awareness and may pose additional cognitive demands on mental processing besides preserved lexical-semantic knowledge. Accordingly, poor performance on these tasks may have other causes than disturbed lexical-semantic knowledge.

The latter view is espoused by Blumstein and her colleagues who argue that aphasia can be understood as a disturbance of the processes whereby knowledge is accessed, rather than a loss of knowledge. In their view, the

cause or underlying source of the impairments is not the destruction of a given level or type of linguistic information. Rather, brain damage affects the psychological processes involved in retrieving linguistic information, such that automatic processes are intact but controlled processes are disturbed in posterior aphasics. There are also problems with this theory, however, since the priming data that support it do not necessarily entail intact underlying lexical-semantic knowledge; the abnormal size and patterns of occurrence of priming phenomena in posterior aphasics may, in fact, be associated with a disturbance of underlying lexical-semantic knowledge.

At higher levels, syntactic knowledge is comparatively well preserved but not intact, and semantic operations at the sentence level including the recovery of logical-semantic relations appear to cause difficulties for posterior aphasics. Pragmatic and discourse levels are not easy to examine, but for most aphasics performance is generally better than would be expected based on the patients' understanding of isolated words or sentences. It seems also that most aphasics including poor comprehenders benefit from a nonlinguistic supportive context, but aphasics with few remaining receptive language skills may not be able to exploit contextual information of a purely linguistic nature.

One variable which has been shown to be of importance in recent research is the distinction between, on the one hand, the on-line perceptual-level construction of a linguistic representation involving lexical access and retrieval of semantic and syntactic information and, on the other hand, post-perceptual processes and metalinguistic tasks which require an explicit manipulation of mental representations. There is evidence that initial access and construction of a perceptual representation at different linguistic levels is preserved in posterior aphasics although the integrity of these linguistic representations has not been fully documented. Most of the problems of this group seem to be located above the immediate perceptual level. The post-perceptual level of constructing an integrated semantic-conceptual representation of a sentence is an important part of ordinary comprehension

and has not been examined in posterior aphasia. Studies with normal subjects have shown that word meanings are encoded in the conceptual representation in a manner reflecting the importance or weight conferred by the context on specific properties of their meaning. It was hypothesized that demonstrations of priming effects in posterior aphasics might coexist with disturbances of the lexical-semantic system, and that these patients in spite of showing priming might have difficulties with more selective activation of properties of word meaning such as might be required during metalinguistic processes but also during higher levels of ordinary comprehension including the integration of word meaning in sentences.

To examine this, studies were carried out investigating integration of word meaning in normal and aphasic subjects. The results confirmed some of these predictions. Some posterior aphasics with fluent speech seem to have a disorganization of the lexical-semantic system, such that associative strength is augmented as an organizing principle and may take precedence over normal categorical semantic structure. Aphasics who do poorly on auditory word recognition do seem to have difficulties with selective activation or deactivation of specific aspects of word meaning, namely deactivation of properties which are central to the meaning of words. It is possible that there may be some relationship between these patterns of disturbance, but the nature of such a relation will await further empirical investigation.

Appendix A

Experimental Items in Normative Property Experiment

No. 1	No. 2	Questionnaire		
		No. 3	No. 4	No 5
hund <i>dog</i>	bold <i>ball</i>	ko <i>cow</i>	æble <i>apple</i>	mark <i>field</i>
støvler <i>boots</i>	kat <i>cat</i>	seng <i>bed</i>	frakke <i>coat</i>	hus <i>house</i>
træ <i>tree</i>	tændstik <i>matchstick</i>	mave <i>stomach</i>	hjul <i>wheel</i>	gade <i>street</i>
baby <i>baby</i>	rose <i>rose</i>	tænder <i>teeth</i>	skov <i>wood</i>	se <i>lake</i>
strand <i>beach</i>	klaver <i>piano</i>	kaffe <i>coffee</i>	skole <i>school</i>	fugl <i>bird</i>
taske <i>bag</i>	bi <i>bee</i>	æg <i>egg</i>	lam <i>lamb</i>	mur <i>wall</i>
blomster <i>flowers</i>	vindue <i>window</i>	bil <i>car</i>	tog <i>train</i>	græs <i>grass</i>
tæppe <i>blanket</i>	kniv <i>knife</i>	billede <i>picture</i>	is <i>ice-cream</i>	kiste <i>coffin</i>
orm <i>worm</i>	barn <i>child</i>	hotel <i>hotel</i>	bål <i>bonfire</i>	trappe <i>staircase</i>
glas <i>glass</i>	sofa <i>couch</i>	avis <i>newspaper</i>	næse <i>nose</i>	sol <i>sun</i>
mønt <i>coin</i>	øm <i>nail</i>	ovn <i>oven</i>	kirke <i>church</i>	sten <i>stone</i>
skab <i>closet</i>	ur <i>watch</i>	ring <i>ring</i>	stok <i>cane</i>	nøgle <i>key</i>

Appendix B

Results from Normative Property Study

Experimental item	Total n. of responses	Semantic property	Frequency of occurrence	Mean Rating
avis (<i>newspaper</i>)	139	nyheder (<i>news</i>)	80	1.00
		papir (<i>paper</i>)	35	1.29
		billeder (<i>pictures</i>)	35	1.71
		annoncer (<i>advertisements</i>)	35	2.00
baby (<i>baby</i>)	185	ble (<i>diaper</i>)	60	2.08
		sut (<i>pacifier</i>)	35	2.00
		vugge (<i>cradle</i>)	35	2.08
barn (<i>child</i>)	139	lille (<i>small</i>)	40	1.75
		lege (<i>play</i>)	35	1.57
bi (<i>bee</i>)	149	honning (<i>honey</i>)	95	1.79
		stikke (<i>sting</i>)	80	1.94
		blomster (<i>flowers</i>)	65	2.00
		summe (<i>buzz</i>)	45	1.56
		sommer (<i>summer</i>)	45	2.56
		insekt (<i>insect</i>)	40	1.13
		vinger (<i>wings</i>)	40	1.50
bil (<i>car</i>)	150	hjul (<i>wheel</i>)	60	1.17
		køre (<i>drive</i>)	45	1.11
		køretøj (<i>vehicle</i>)	40	1.00
		fart (<i>speed</i>)	40	2.13
billede (<i>picture</i>)	139	maleri (<i>painting</i>)	65	1.31
		foto (<i>photo</i>)	60	1.08
		ramme (<i>frame</i>)	45	2.22
blomster (<i>flowers</i>)	172	duft (<i>smell</i>)	70	1.21
		farver (<i>colors</i>)	55	1.36
		sommer (<i>summer</i>)	35	1.71
bold (<i>ball</i>)	142	rund (<i>round</i>)	80	1.13
		trille (<i>roll</i>)	50	1.20
		hoppe (<i>bounce</i>)	50	1.60
		spille (<i>play</i>)	45	1.67
bål (<i>bonfire</i>)	153	ild (<i>fire</i>)	80	1.06
		varm (<i>warm</i>)	70	1.29
		træ (<i>wood</i>)	40	2.25
		flammer (<i>flames</i>)	35	1.14
		brænde (<i>firewood</i>)	35	2.00

		hygge (<i>cosiness</i>)	35	2.29
		snobrød (<i>twistbread</i>)	35	2.57
frakke (<i>coat</i>)	133	varm (<i>warm</i>)	65	1.46
		vinter (<i>winter</i>)	50	1.80
		uld (<i>wool</i>)	40	2.38
		knapper (<i>buttons</i>)	35	2.14
fugl (<i>bird</i>)	150	flyve (<i>fly</i>)	75	1.00
		sang (<i>song</i>)	75	1.67
		fjer (<i>feather</i>)	60	1.25
		vinger (<i>wings</i>)	55	1.18
		næb (<i>beak</i>)	55	1.45
		æg (<i>eggs</i>)	55	1.45
gade (<i>street</i>)	168	biler (<i>cars</i>)	80	1.88
		mennesker (<i>people</i>)	60	1.75
		fortov (<i>sidewalk</i>)	50	1.60
		trafik (<i>traffic</i>)	50	1.70
		cykler (<i>bicycles</i>)	50	2.00
		huse (<i>houses</i>)	40	1.50
		asfalt (<i>asphalt</i>)	35	1.29
glas (<i>glass</i>)	155	vin (<i>wine</i>)	55	2.09
		drikke (<i>drink</i>)	45	1.00
		øl (<i>beer</i>)	40	1.75
græs (<i>grass</i>)	151	grønt (<i>green</i>)	95	1.11
hjul (<i>wheel</i>)	143	rundt (<i>round</i>)	70	1.00
		eger (<i>spokes</i>)	55	1.73
		dæk (<i>tire</i>)	55	2.09
		bil (<i>car</i>)	50	2.30
		cykel (<i>bicycle</i>)	45	2.11
		køre (<i>drive</i>)	40	1.75
		punktere (<i>puncture</i>)	40	2.25
hotel (<i>hotel</i>)	138	ferie (<i>vacation</i>)	60	1.83
		overnatning (<i>spend the night</i>)	35	1.43
		værelse (<i>room</i>)	35	1.57
hund (<i>dog</i>)	179	gø (<i>bark</i>)	80	1.19
		bide (<i>bite</i>)	40	2.25
		pels (<i>fur</i>)	35	1.43
		kødben (<i>bone</i>)	35	1.57
hus (<i>house</i>)	172	vinduer (<i>windows</i>)	70	1.64
		tag (<i>roof</i>)	60	1.42
		dør (<i>door</i>)	50	1.70
		mursten (<i>bricks</i>)	45	1.89

		skorsten (<i>chimney</i>)	45	1.89
		have (<i>garden</i>)	40	1.88
		hjem (<i>home</i>)	35	1.14
is (<i>icecream</i>)	150	kold (<i>cold</i>)	70	1.50
		sommer (<i>summer</i>)	45	2.11
		dessert (<i>dessert</i>)	35	2.00
kaffe (<i>coffee</i>)	142	sort (<i>black</i>)	70	1.21
		drikke (<i>drink</i>)	65	1.08
		varm (<i>warm</i>)	60	1.25
		bønner (<i>beans</i>)	50	1.30
		kop (<i>cup</i>)	35	1.57
kat (<i>cat</i>)	148	pels (<i>fur</i>)	50	1.20
		blød (<i>soft</i>)	50	1.70
		spinde (<i>purr</i>)	35	1.43
		mus (<i>mouse</i>)	35	2.14
kirke (<i>church</i>)	169	præst (<i>priest</i>)	80	1.56
		bygning (<i>building</i>)	40	1.63
		bryllup (<i>wedding</i>)	40	1.88
		tårn (<i>tower</i>)	40	2.00
		Gud (<i>God</i>)	35	1.29
		klokke (<i>bell</i>)	35	1.43
kiste (<i>coffin</i>)	155	død (<i>dead</i>)	80	1.25
		begravelse (<i>funeral</i>)	45	1.78
		kirke (<i>church</i>)	40	1.75
		sorg (<i>grief</i>)	35	1.43
		lig (<i>body</i>)	35	1.57
		træ (<i>wood</i>)	35	1.86
klaver (<i>piano</i>)	131	musik (<i>music</i>)	85	1.29
		spille (<i>play</i>)	50	1.80
		tangenter (<i>keys</i>)	40	1.38
kniv (<i>knife</i>)	122	skarp (<i>sharp</i>)	70	1.14
		skære (<i>cut</i>)	45	1.11
		skaft (<i>handle</i>)	45	1.44
ko (<i>cow</i>)	162	mælk (<i>milk</i>)	85	1.12
		yver (<i>udder</i>)	65	1.23
		græs (<i>grass</i>)	65	1.92
		kalv (<i>calf</i>)	45	1.67
		kød (<i>meat</i>)	40	2.00
larn (<i>lamb</i>)	145	uld (<i>wool</i>)	70	1.50
		får (<i>sheep</i>)	65	1.62

mark (field)	178	korn (<i>grain</i>)	80	1.13
		græs (<i>grass</i>)	50	1.20
		jord (<i>soil</i>)	40	1.25
		køer (<i>cows</i>)	35	2.00
mave (stomach)	131	mad (<i>food</i>)	55	1.36
		tyk (<i>heavy</i>)	35	2.00
mur (wall)	125	sten (<i>stones</i>)	50	1.40
		mursten (<i>bricks</i>)	45	1.22
mønt (coin)	157	penge (<i>money</i>)	70	1.00
		metal (<i>metal</i>)	40	1.63
		rund (<i>round</i>)	35	1.14
		pung (<i>purse</i>)	35	2.29
næse (nose)	145	ansigt (<i>face</i>)	45	1.11
		lugt (<i>smell</i>)	40	1.25
		rød (<i>red</i>)	35	2.43
		forkølelse (<i>cold</i>)	35	2.71
nøgle (key)	137	lås (<i>lock</i>)	75	1.00
		dør (<i>door</i>)	75	1.87
		åbne (<i>open</i>)	40	1.38
orm (worm)	158	jord (<i>soil</i>)	75	1.80
		slimet (<i>slimy</i>)	60	1.50
ovn (oven)	129	varm (<i>hot</i>)	90	1.00
		bage (<i>bake</i>)	60	1.58
		mad (<i>food</i>)	50	1.60
		stege (<i>roast</i>)	35	1.71
ring (ring)	128	guld (<i>gold</i>)	75	1.60
		rund (<i>round</i>)	50	1.00
		selv (<i>silver</i>)	45	1.67
		smykke (<i>jewellery</i>)	40	1.38
		finger (<i>finger</i>)	40	1.50
rose (rose)	144	torne (<i>thorns</i>)	65	1.38
		rød (<i>red</i>)	65	2.15
		blomst (<i>flower</i>)	45	1.00
		duft (<i>smell</i>)	45	1.44
		have (<i>garden</i>)	35	2.14
seng (bed)	149	sove (<i>sleep</i>)	95	1.11
		dyne (<i>quilt</i>)	70	1.21
		madras (<i>mattress</i>)	45	1.33
		pude (<i>pillow</i>)	35	1.71
		hvile (<i>rest</i>)	35	2.00

		syg (<i>ill</i>)	35	2.43
skab (<i>closet</i>)	144	tøj (<i>clothes</i>) hylder (<i>shelves</i>) dør (<i>door</i>)	70 40 35	1.50 1.50 1.71
skole (<i>school</i>)	173	lærer (<i>teacher</i>) elev (<i>pupil</i>) børn (<i>children</i>) bøger (<i>books</i>) lektier (<i>homework</i>)	80 45 40 35 35	1.19 1.33 1.38 1.43 1.86
skov (<i>wood</i>)	163	træer (<i>trees</i>) blade (<i>leaves</i>) grøn (<i>green</i>) dyr (<i>animals</i>)	95 50 50 50	1.05 1.20 1.60 2.00
sofa (<i>couch</i>)	117	sidde (<i>sit</i>) møbel (<i>furniture</i>) ligge (<i>lie</i>) sove (<i>sleep</i>) puder (<i>pillows</i>)	50 45 45 40 35	1.90 1.11 1.67 1.63 2.43
sol (<i>sun</i>)	155	varme (<i>warmth</i>) sommer (<i>summer</i>) gul (<i>yellow</i>) lys (<i>light</i>)	100 75 45 35	1.15 1.60 1.44 1.14
sten (<i>stone</i>)	138	hård (<i>hard</i>) strand (<i>beach</i>)	55 45	1.64 2.22
stok (<i>cane</i>)	125	gammel (<i>old</i>) træ (<i>wood</i>)	50 50	1.50 1.50
strand (<i>beach</i>)	178	sand (<i>sand</i>) sol (<i>sun</i>) vand (<i>water</i>) sten (<i>stones</i>) bølger (<i>waves</i>) bade (<i>bathe</i>) sommer (<i>summer</i>) tang (<i>seaweed</i>)	90 65 60 60 45 45 45 40	1.06 1.62 1.00 1.92 1.22 2.00 2.22 2.00
støvler (<i>boots</i>)	161	varme (<i>warm</i>) sne (<i>snow</i>) skind (<i>leather</i>)	45 45 40	1.56 1.89 1.75
se (<i>lake</i>)	163	fisk (<i>fish</i>) vand (<i>water</i>) ænder (<i>ducks</i>)	90 80 60	1.67 1.00 2.17

		båd (<i>boat</i>)	50	2.30
		siv (<i>reeds</i>)	35	1.57
søm (<i>nail</i>)	110	hammer (<i>hammer</i>)	80	1.31
		spids (<i>pointed</i>)	45	1.33
		hoved (<i>head</i>)	40	1.38
		metal (<i>metal</i>)	40	1.63
taske (<i>bag</i>)	142	indkøb (<i>shopping</i>)	40	1.75
		læder (<i>leather</i>)	35	1.71
		pung (<i>purse</i>)	35	2.14
tog (<i>train</i>)	154	rejse (<i>travel</i>)	40	1.38
		skinner (<i>rails</i>)	40	1.50
		lokomotiv (<i>locomotive</i>)	35	1.43
		billet (<i>ticket</i>)	35	2.00
trappe (<i>staircase</i>)	126	trin (<i>steps</i>)	65	1.08
		gælder (<i>bannister</i>)	50	1.70
		op (<i>up</i>)	40	1.88
		træ (<i>wood</i>)	40	2.25
træ (<i>tree</i>)	182	blade (<i>leaves</i>)	75	1.26
		skov (<i>forest</i>)	50	1.80
		grene (<i>branches</i>)	45	1.22
		grønt (<i>green</i>)	40	1.25
		bark (<i>bark</i>)	40	1.38
		frugt (<i>fruit</i>)	40	1.63
		stamme (<i>trunk</i>)	35	1.25
tænder (<i>teeth</i>)	164	hvide (<i>white</i>)	70	1.43
		huller (<i>caries</i>)	65	2.31
		tygge (<i>chew</i>)	60	1.17
		bide (<i>bite</i>)	45	1.00
		tandbørste (<i>toothbrush</i>)	45	1.89
		tandlæge (<i>dentist</i>)	35	2.29
tændstik (<i>matchstick</i>)	131	træ (<i>wood</i>)	80	1.50
		ild (<i>fire</i>)	75	1.27
		svovl (<i>sulfur</i>)	65	1.15
		lys (<i>light</i>)	40	1.63
tæppe (<i>carpet</i>)	151	varmt (<i>warm</i>)	80	1.76
		gulv (<i>floor</i>)	50	1.50
		uld (<i>wool</i>)	45	1.89
		støvsuge (<i>vacuum</i>)	40	2.25
ur (<i>clock</i>)	128	tid (<i>time</i>)	75	1.13
		klokken (<i>o'clock</i>)	60	1.25
		visere (<i>hands</i>)	60	1.50

		tal (<i>numbers</i>)	35	1.43
vindue (<i>window</i>)	112	glas (<i>glass</i>)	85	1.25
		udsigt (<i>view</i>)	40	1.63
æble (<i>apple</i>)	161	træ (<i>tree</i>)	55	1.64
		rødt (<i>red</i>)	50	2.00
		frugt (<i>fruit</i>)	45	1.00
		kerner (<i>core</i>)	45	1.89
		rundt (<i>round</i>)	45	2.11
		saftigt (<i>juicy</i>)	40	1.63
		spise (<i>eat</i>)	35	1.71
æg (<i>egg</i>)	147	hvide (<i>white</i>)	60	1.33
		høns (<i>chicken</i>)	55	1.18
		skal (<i>shell</i>)	55	1.18
		blomme (<i>yolk</i>)	50	1.20

Appendix C

High and Low Dominant Properties in Experiment no.2 : Property Frequency, Length and Frequency

Exp. Word	Dominance H=High L=Low	Property	Property Freq. ^a	Length ^b	Freq. ^c
sø (lake)	H	fiskene (fish)	90	7	0
	L	sivene (reeds)	35	6	0
hus (house)	H	deren (door)	50	5	171
	L	væggen (wall)	5	6	30
orm (worm)	H	slimet (slimy)	60	6	0
	L	rund (round)	10	4	0
kat (cat)	H	pelsen (fur)	50	6	0
	L	kloer (claws)	30	5	0
rose (rose)	H	tornen (thorn)	65	6	0
	L	stilken (stem)	5	7	0
bi (bee)	H	honning (honey)	95	7	0
	L	brodden (sting)	25	7	0
æble (apple)	H	rødt (red)	50	4	16
	L	sødt (sweet)	15	4	7
ur (watch)	H	klokken (time)	60	7	55
	L	guld (gold)	5	4	8
træ (tree)	H	bladene (leaves)	75	7	7
	L	rødder (roots)	25	6	0
strand (beach)	H	sandet (sand)	90	6	6
	L	rav (amber)	5	3	0
ko (cow)	H	mælk (milk)	85	4	9
	L	mule (muzzle)	5	4	0
seng (bed)	H	dynen (quilt)	70	5	12
	L	ben (leg)	10	3	49
avis (newspaper)	H	nyheder (news)	80	7	4
	L	papiret (paper)	35	7	11

frakke (<i>coat</i>)	H	varm (<i>warm</i>)	65	4	17
	L	stor (<i>large</i>)	5	4	121
bål (<i>bonfire</i>)	H	ilden (<i>fire</i>)	80	5	10
	L	regnen (<i>smoke</i>)	20	5	11
kirke (<i>church</i>)	H	præst (<i>priest</i>)	80	5	6
	L	tårnet (<i>tower</i>)	40	6	4
mark (<i>field</i>)	H	kornet (<i>grain</i>)	80	6	5
	L	hegnet (<i>fence</i>)	15	6	7
skab (<i>closet</i>)	H	tøjet (<i>clothes</i>)	70	5	18
	L	bunden (<i>bottom</i>)	10	6	14
gade (<i>street</i>)	H	bilerne (<i>cars</i>)	80	7	0
	L	fliserne (<i>flagstone</i>)	5	8	0
græs (<i>grass</i>)	H	grønt (<i>green</i>)	95	5	6
	L	blødt (<i>soft</i>)	10	5	9
sol (<i>sun</i>)	H	sommer (<i>summer</i>)	75	6	29
	L	dagen (<i>day</i>)	10	5	55
sten (<i>stone</i>)	H	hård (<i>hard</i>)	55	4	5
	L	flad (<i>flat</i>)	10	4	0
nøgler (<i>keys</i>)	H	lås (<i>lock</i>)	75	3	4
	L	bundt (<i>bunch</i>)	10	5	6
vindue (<i>window</i>)	H	glasset (<i>glass</i>)	85	7	14
	L	karmen (<i>sill</i>)	5	6	0

^a Property frequency was measured as number of occurrences in response to the experimental words in the property experiment (see Appendix B).

^b Length was measured in number of letters for the given form. A t-test (at the .05 level of significance) showed no significant differences between length of high dominant properties (mean=5.58) and low dominant properties (mean=5.25), $t(46)=0.899$.

^c Frequency was measured for the given form of the word as number of occurrences in 250.000 words in Maegaard and Ruus (1981). A t-test (at the .05 level of significance) showed no significant differences in frequency between high dominant properties (mean=16.42) and low dominant properties (mean=13.83), $t(46)=0.287$.

Appendix D

Experimental Sentences and
Probes in Experiment no.2

Sentence	Object		Probe
	frequency ^a	length ^b	
Drengen kastede nettet ud i søen	11	4	fiskene
Pigen samlede planter ved søen	11	4	fiskene
Drengen kastede nettet ud på banen	6	5	fiskene
Pigen samlede planter ved søen	11	4	sivene
Drengen kastede nettet ud i søen	11	4	sivene
Pigen samlede planter på bjerget	6	7	sivene
Drengene gik ind i huset	90	5	døren
Konen malede huset	90	5	døren
Drengene gik ind i byen	79	4	døren
Konen malede huset	90	5	væggen
Drengene gik ind i huset	90	5	væggen
Konen malede hånden	80	6	væggen
Drengen rørte ved ormen	0	5	slimet
Pigerne tegnede ormen	0	5	slimet
Drengen rørte ved trøjen	0	6	slimet
Pigerne tegnede ormen	0	5	rund
Drengen rørte ved ormen	0	5	rund
Pigerne tegnede flaget	0	6	rund
Pigen kærtegnede katten	15	6	pelsen
Drengen sloges med katten	15	6	pelsen
Pigen kærtegnede sin søster	15	6	pelsen
Drengen sloges med katten	15	6	klør
Pigen kærtegnede katten	15	6	klør
Drengen sloges med sin bror	15	4	klør
Hendes søn rev sig på rosen	0	6	tornen
Kvinden klippede lidt af rosen	0	5	tornen
Hendes søn rev sig på sømmet	0	6	tornen
Kvinden klippede lidt af rosen	0	5	stilken
Hendes søn rev sig på rosen	0	5	stilken
Kvinden klippede lidt af stoffet	6	7	stilken
Manden passede bierne	0	6	honning

Barnet blev stukket af bierne	0	6	honning
Manden passede planterne	0	9	honning
Barnet blev stukket af bierne	0	6	brodden
Manden passede bierne	0	6	brodden
Barnet blev stukket af myg	0	3	brodden
Moderen gned på æblet	0	5	rødt
Sønnen smagte på æblet	0	5	rødt
Moderen gned på skeen	0	5	rødt
Sønnen smagte på æblet	0	5	sødt
Moderen gned på æblet	0	5	sødt
Sønnen smagte på bøffen	0	6	sødt
Læreren stillede urene	0	5	klokken
Tyven stjal urene	0	5	klokken
Læreren stillede tasken	0	6	klokken
Tyven stjal urene	0	5	guld
Læreren stillede urene	0	5	guld
Tyven stjal cigarer	0	7	guld

List 2

Sentence	frequency	Object	
		length	Probe
Manden fejede under træet	5	5	bladene
Mændene ville flytte træet	5	5	bladene
Manden fejede under sædet	8	5	bladene
Mændene ville flytte træet	5	5	rødder
Manden fejede under træet	5	5	rødder
Mændene ville flytte disken	5	6	rødder
Familien satte sig på stranden	16	8	sandet
Pigerne samlede sten på stranden	16	8	sandet
Familien satte sig i toget	15	5	sandet
Pigerne samlede sten på stranden	16	8	rav
Familien satte sig på stranden	16	8	rav
Pigerne samlede sten på pladsen	11	7	rav
Pigen satte en spand under koen	0	4	mælk
Barnet rakte noget hø til koen	0	4	mælk
Pigen satte en spand under pumpen	0	6	mælk
Barnet rakte noget hø til koen	0	4	mule
Pigen satte en spand under koen	0	4	mule
Barnet rakte noget hø til soen	0	4	mule
Kvinderne ordnede sengen	48	6	dynen

Drengen stødte sig på sengen	48	6	dynen
Kvinderne ordnede stuen	52	5	dynen
Drengen stødte sig på sengen	48	6	ben
Kvinderne ordnede sengen	48	6	ben
Drengen stødte sig på ryggen	51	6	ben
Hans bror læste ivrigt sin avis	12	4	nyheder
Gæsten satte skoene på en avis	12	4	nyheder
Hans bror læste ivrigt bogen	14	5	nyheder
Gæsten satte skoene på en avis	12	4	papiret
Hans bror læste ivrigt sin avis	12	4	papiret
Gæsten satte skoene på bænken	12	6	papiret
Manden åbnede sin frakke	13	6	varm
Pigen lånte sin fars frakke	13	6	varm
Manden åbnede sine breve	12	5	varm
Pigen lånte sin fars frakke	13	6	stor
Manden åbnede sin frakke	13	6	stor
Pigen lånte sin fars hammer	12	6	stor
Kvinden var nervøs over bålet	0	5	ilden
Naboen var generet af bålet	0	5	ilden
Kvinden var nervøs over prøven	0	6	ilden
Naboen var generet af bålet	0	5	regnen
Kvinden var nervøs over bålet	0	5	regnen
Naboen var generet af larmen	5	6	regnen
Kvinden hørte efter i kirken	14	6	præst
Børnene fik øje på kirken	14	6	præst
Kvinden hørte efter sin radio	11	5	præst
Børnene fik øje på kirken	14	6	tårnet
Kvinden hørte efter i kirken	14	6	tårnet
Børnene fik øje på porten	15	6	tårnet

List 3

Sentence	Object		Probe
	frequency	length	
Mændene havde travlt i marken	11	6	kornet
Pigerne gik langs med marken	11	6	kornet
Mændene havde travlt i parken	11	6	kornet
Pigerne gik langs med marken	11	6	hegnet
Mændene havde travlt i marken	11	6	hegnet
Pigerne gik langs med åen	5	3	hegnet
Kvinden hængte tingene op i et skab	0	4	tøjet
Manden vaskede under sit skab	0	4	tøjet

Kvinden hængte tingene op i et skur	0	4	tøjet
Manden vaskede under sit skab	0	4	bunden
Kvinden hængte tingene op i et skab	0	4	bunden
Manden vaskede under en rist	0	4	bunden
Børnene skulle over gaden	27	5	bilerne
Damen faldt på gaden	27	5	bilerne
Børnene skulle over gangen	28	6	bilerne
Damen faldt på gaden	27	5	fliserne
Børnene skulle over gaden	27	5	fliserne
Damen faldt på værelset	33	8	fliserne
Ejeren så stolt på græsset	8	7	grønt
Spejderne lagde sig i græsset	8	7	grønt
Ejeren så stolt på slottet	7	7	grønt
Spejderne lagde sig i græsset	8	7	blødt
Ejeren så stolt på græsset	8	7	blødt
Spejderne lagde sig i stalden	8	7	blødt
Pigen gik ud i solen	47	5	sommer
Manden stod op med solen	47	5	sommer
Pigen gik ud i køkkenet	43	8	sommer
Manden stod op med solen	47	5	dagen
Pigen gik ud i solen	47	5	dagen
Manden stod op med børnene	32	7	dagen
Drengen ridsede med stenen	4	6	hård
Pigen slog smut med stenen	4	6	hård
Drengen ridsede med sin finger	12	6	hård
Pigen slog smut med stenen	4	6	flad
Drengen ridsede med stenen	4	6	flad
Pigen slog smut med øjnene	121	6	flad
Manden kom ind med sine nøgler	4	6	lås
Kvinden raslede med sine nøgler	4	6	lås
Manden kom ind med sine træsko	4	6	lås
Kvinden raslede med sine nøgler	4	6	bundt
Manden kom ind med sine nøgler	4	6	bundt
Kvinden raslede med sine smykker	4	7	bundt
Nogle drenge smadrede et vindue	15	6	glasset
Konen satte sig i et vindue	15	6	glasset
Nogle drenge smadrede en taxa	13	4	glasset
Konen satte sig i et vindue	15	6	karmen
Nogle drenge smadrede et vindue	15	6	karmen
Konen satte sig i sofaen	15	6	karmen

^a Frequency was measured in number of occurrences in 250.000 words for the given form as listed in Maegaard and Ruus (1981). t-tests (at the .05

level of significance) showed no significant differences in frequency between experimental objects (mean=14.17) and control objects : in high dominant control condition (mean=13.75), $t(46)=0.072$; and in low dominant control condition (mean=18.17), $t(46)=0.549$.

^a Length was measured in number of letters for the given form. t-tests (at the .05 level of significance) showed no significant differences between length of experimental objects (mean=5.42) and control objects : for high dominant control condition (mean=5.67), $t(46)=0.806$; and for low dominant control condition (mean=5.88), $t(46)=1.369$.

Appendix E

Filler Sentences^a and Probes in Experiment no. 2

Sentence	Probe	Category ^b	Freq.	Length
<u>Filler Sentences Derived From List 1 :</u>				
Drengen kastede nettet ud i søen	drengen	4	38	7
Konen malede huset	konen	4	16	5
Hendes søn rev sig på rosen	søn	4	37	3
Barnet blev stukket af bierne	barnet	4	27	6
Drengen rørte ved ormen	rørte	5	14	5
Drengen sloges med katten	sloges	5	5	6
Moderen gned på æblet	gned	5	10	4
Tyven stjal urene	stjal	5	0	5
Pigen samlede planter ved søen	søen	6	11	4
Drengene gik ind i huset	huset	6	90	5
Pigerne tegnede ormen	ormen	6	0	5
Pigen kærtegnede katten	katten	6	15	6
Kvinden klippede lidt af rosen	rosen	6	0	5
Manden passede bierne	bierne	6	0	6
Sønnen smagte på æblet	æblet	6	0	5
Læreren kiggede på urene	urene	6	0	5
<u>Filler Sentences Derived From List 2 :</u>				
Manden fejede under træet	manden	4	66	6
Pigerne samlede sten på stranden	pigerne	4	22	7
Hans bror læste ivrigt sin avis	bror	4	15	4
Pigen lånte sin fars frakke	pigen	4	22	5
Pigen satte en spand under koen	spand	5	0	5
Drengen stødte sig på sengen	stødte	5	6	6
Kvinden var nervøs over bålet	nervøs	5	15	5
Børnene fik øje på kirken	øje	5	40	3
Mændene ville flytte træet	træet	6	5	5
Familien satte sig på stranden	stranden	6	16	8
Barnet rakte noget hø til koen	koen	6	0	4
Kvinderne ordnede sengen	sengen	6	48	6
Gæsten satte skoene på en avis	avis	6	12	4
Manden åbnede sin frakke	frakke	6	13	6
Naboen var generet af bålet	bålet	6	0	6
Kvinden hørte efter i kirken	kirken	6	14	6
<u>Filler Sentences Derived From List 3 :</u>				
Manden vaskede under sit skab	manden	4	66	6
Damen faldt på gaden	damen	4	14	5
Pigen gik ud i solen	pigen	4	22	5

Nogle drenge smadrede et vindue	drenge	4	29	6
Mændene havde travlt i marken	travlt	5	31	6
Ejeren så stolt på græsset	stolt	5	13	5
Pigen slog smut med stenen	smut	5	0	4
Kvinden raslede med sine nøgler	raslede	5	5	7
Konen satte sig i et vindue	vindue	6	15	6
Pigerne gik langs med marken	marken	6	11	6
Kvinden hængte tingene op i et skab	skab	6	0	4
Børnene skulle over gaden	gaden	6	27	5
Spejderne lagde sig i græsset	græsset	6	8	7
Manden stod op med solen	solen	6	47	5
Drengen ridsede med stenen	stenen	6	4	6
Manden kom ind med sine nøgler	nøgler	6	4	6

Original Filler Sentences

Hendes bror børstede sine tænder	bror	4	15	4
Deres chef havde ferie	chef	4	9	4
Barnet havde ondt i maven	barnet	4	27	6
Pigen spiste ægget	pigen	4	22	5
En røver truede med en kniv	røver	4	0	5
Lægen undersøgte blodet	lægen	4	16	5
Den gamle bonde dyrkede selv tomater	bonde	4	5	5
Fyren bar på stigen	fyren	4	10	5
Vennen brækkede sin arm	vennen	4	0	6
Konen fodrede hønsene	konen	4	16	5
Karlen arbejdede på gården	karlen	4	0	6
Bruden syede selv sin kjole	bruden	4	0	6
Barnet samlede på mønter	barnet	4	27	6
Babyen opdagede hunden	babyen	4	0	6
Enken valgte en hvid kiste	enken	4	0	5
Pigen tabte sine støvler	pigen	4	22	5
Værten fejdede nede i gården	værten	4	5	6
Et kor underholdt ved festen	kor	4	0	3
Damen gik over broen	damen	4	14	5
Sønnen kom for sent i skole	sønnen	4	8	6
Kokken tændte for ovnen	kokken	4	0	6
En soldat ladede geværet	soldat	4	11	6
En fange stak af fra fængslet	fange	4	10	5
Løberen nåede frem til målet	løberen	4	0	6
Manden flyttede klaveret	flyttede	5	20	8
Datteren var ansat på kontoret	ansat	5	6	5
Jægeren skød efter ræven	skød	5	27	4
Manden bad om en tændstik	bad	5	46	3
Børnene legede oppe på loftet	legede	5	10	6
Veninden pakkede sin kuffert	pakkede	5	0	7
Drengen slugte bolsjerne	slugte	5	0	6
Manden fik solgt et billede	solgt	5	10	5
Barnet gemte sig i kælderens	gemte	5	9	5
Manden smurte brødet	smurte	5	0	6

Børnene drak af saften	drak	5	42	4
Drankeren betalte for flasken	betalte	5	4	7
Manden red på hesten	red	5	10	3
Tjeneren snød med regningen	snød	5	0	4
Studenten var flov over fejlen	flov	5	8	5
Manden ville købe en ring	købe	5	31	4
Mekanikeren skiftede hjulet	skiftede	5	11	8
Moderen lappede bukserne	lappede	5	0	7
Pigen gik en tur i regnen	tur	5	27	3
Skuespilleren glemte sin rolle	glemte	5	17	6
Eleverne steg ud af bussen	steg	5	22	4
Pigen skubbede til bordet	skubbede	5	11	8
Betjenten sprang over muren	sprang	5	38	6
Soldaterne spærrede vejen	spærrede	5	0	8
Pigen ringede til politiet	politiet	6	30	8
Kvinden pudsede spejlet	spejlet	6	19	7
Drengen greb efter bolden	bolden	6	0	6
Kvinden fik en ny taske	taske	6	15	5
Pigerne lyttede til en sang	sang	6	35	4
Kvinden serverede fra en gryde	gryde	6	0	5
Pigen sang for sin dukke	dukke	6	9	5
Drengen pustede til støvet	støvet	6	11	6
Pigen kælkede ned ad bakken	bakken	6	10	6
Kvinden gik ned ad trappen	trappen	6	35	7
Drengene skræmte fuglen	fuglen	6	0	6
Kvinden stillede sig på vægten	vægten	6	0	6
Drengen pudsede næsen	næsen	6	21	5
Manden havde lige lavet kaffe	kaffe	6	35	5
Kvinden sov på kroen	kroen	6	7	5
Manden støttede sig til en stok	stok	6	7	4

^a The filler sentences for a given subject consisted of the original set of filler sentences plus the filler sentences derived from those two of the three lists which the subject saw. t-tests were carried out for all combinations of the three lists and showed no significant differences in length and frequency between positive probes from initial, middle, and final position. Nor were there any significant differences between the overall length and frequency of negative probes (cf. Appendix D) and positive probes (word categories 4 to 6 above).

^b Probe in Initial Position : category=4
 Probe in Middle Position : category=5
 Probe in Final Position : category=6

Appendix F

Explanation of Modula 2 Program Used for Stimulus Presentation and Response Registration

The Modula-2 program used for stimulus presentation and response registration was developed by Bo Holst-Christensen (it is not included for reasons of space limitations). The program was designed specifically with a view to solve any issues of variability in stimulus presentation and response registration. The program completely bypassed (turned off) the Macintosh user interface and made use of the hardware on a specific Macintosh model.

1. Variability in the duration of counter cycles

Measurement of reaction time was effected by a loop which incremented a counter by one after checking the serial port of the computer which was connected to a response box. All other interrupts except for the reset button were disabled (busy waiting) in order to avoid sources of variability due to Macintosh "housekeeping routines". Counting cycles were calculated to be approximately 0.158 milliseconds.

2. Variability in response registration in relation to stimulus presentation

A problem affecting studies using computers for stimulus presentation and response registration is the fact that a computer screen under normal circumstances shows 60.25 screen images pr. second, i.e. a given dot on the screen can only be updated at fixed intervals of 16.59 milliseconds. This introduces variability both in stimulus presentation length, interstimulus intervals, and measurement of response times relative to stimulus presentation. While the two former variables may be of great importance in studies of automatic psychological processes, they are likely to be of little or no significance under conditions allowing ample time for controlled modes of processing such as this study. However, the registration of response times relative to stimulus presentation is necessarily important. Due to the fixed screen refresh rate a message to print a word on the screen may be effected with a delay of up to 16.59 milliseconds. In the meantime, however, programming continues and reaction time measurements are started. Assuming a normal distribution this results in an average variability of 8.29 milliseconds in response registration relative to stimulus presentation affecting all trials. The problem can only be solved with special hardware or programming modifications as described below.

The Modula-2 program synchronized the initiation of the counter loop to the appearance of stimuli on the screen by a loop which checked a byte that turned high when the update cycle reaches the lowest right dot on the screen (the vertical interrupt flag). To avoid problems with variable writing time due to differences in sentence or word length the ordinary process for output to the screen was bypassed. A part of RAM (32 000 bytes) was reserved for a bit-map, representing an alternate screen image. The

width of the bit map was equal to the width of the screen and the height was approximately one third of the screen which was sufficient to show sentences and words in font size 24. The program wrote the sentence or word to the alternate screen map. When the stimulus was to appear on the screen, the alternate screen area was copied onto the actual screen map. This copying process was measured to take approximately 6.23 milliseconds. Since the area to be copied always had the same size, copying time was the same irrespective of stimulus length. Copying was started when the screen update process reached the lower right dot on the screen and copying was completed before the screen update process reached the area (about the middle of the screen) where the stimuli appeared.

Appendix G

Normal Subjects : Errors in Probe Rejection

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
01	0	0	0	0	0	1
02	0	0	0	1	0	0
03	1	0	0	0	0	1
04	0	0	0	0	0	1
05	0	0	0	1	0	0
06	1	0	1	0	0	0
07	0	0	1	0	0	0
08	0	0	0	0	0	0
09	0	0	1	3	0	0
10	1	0	0	0	0	0
11	1	1	1	0	0	0
12	0	1	1	0	0	0
mean	0.33	0.17	0.42	0.42	0.0	0.25

Appendix H

Normal Subjects : Anova Table from Analysis of
Errors in Probe Rejection

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	2.15	11	.20		
Dominance	.13	1	.13	.31	.586
Dominance x BS	4.38	11	.40		
Context	1.19	2	.60	3.17	.061
Context x BS	4.14	22	.19		
Domin. x Context	.25	2	.12	.35	.705
Domin. x Context x BS	7.75	22	.35		

Appendix I

Normal Subjects : Mean High Dominant Item
Latencies in Milliseconds

Item	CONTEXT		
	Appropriate	Inappropriate	Unrelated
fiskene	738	658	596
døren	636	576	616
slimet ^a	629	632	633
pelsen	735	668	646
tornen	783	668	656
honning ^a	589	638	589
rødt	639	582	565
klokken	728	641	605
bladene ^a	714	677	643
vandet	675	650	610
mælk ^a	657	596	668
dynen	597	573	558
nyheder	656	586	609
varm	567	606	558
ilden ^a	721	658	662
præst	702	719	603
kornet ^a	633	604	599
tøjet	872	701	704
bilerne	700	677	644
grønt	920	715	604
sommer ^a	722	721	604
hård	649	631	732
lås ^a	622	670	723
glasset	683	603	725
mean	690	644	631

^aMarked items were left out in the pruned version of the test

Appendix J

Normal Subjects : Mean Low Dominant Item
Latencies in Milliseconds

Item	CONTEXT		
	Appropriate	Inappropriate	Unrelated
sivene	731	638	692
væggen	597	609	648
rund ^a	596	623	609
klæer	629	563	600
stilken	715	705	621
brodden ^a	735	643	641
sødt	804	636	682
guld	709	654	611
rødder ^a	585	595	556
rav	558	570	664
mule ^a	609	646	652
ben	697	605	623
papiret	700	637	648
stor	688	565	673
røgen ^a	641	648	612
tårnet	675	597	626
hegnet ^a	696	741	649
bunden	742	672	683
fliserne	617	614	687
blødt	666	645	601
dagen ^a	665	686	650
flad	582	589	657
bundt ^a	787	735	650
karmen	701	655	645
mean	672	636	641

^aMarked items were left out in the pruned version of the test

Appendix K

Normal Subjects : Errors in Probe Rejection on
Subset of Items Used in Experiment with Aphasic Subjects

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
01	0	0	0	0	0	1
02	0	0	0	0	0	0
03	1	0	0	0	0	1
04	0	0	0	0	0	1
05	0	0	0	1	0	0
06	1	0	1	0	0	0
07	0	0	1	0	0	0
08	0	0	0	0	0	0
09	0	0	1	1	0	0
10	0	0	0	0	0	0
11	1	0	0	0	0	0
12	0	0	1	0	0	0
mean	0.25	0.0	0.33	0.17	0.0	0.25

Appendix L

Normal Subjects : Anova Table from Analysis
of Probe Rejection Latencies on Pruned Test

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	219137.49	11	19921.59		
Dominance	1995.01	1	1995.01	1.35	.270
Dominance x BS	16299.49	11	1481.77		
Context	50887.86	2	25443.93	9.26	.001
Context x BS	60480.47	22	2749.11		
Domin. x Context	6795.53	2	3397.76	3.56	.046
Domin. x Context x BS	20997.47	22	954.43		

Appendix M

Normal Subjects : Anova Table from Analysis
of Probe Rejection Errors on Pruned Test

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	1.00	11	.09		
Dominance	.06	1	.06	.38	.551
Dominance x BS	1.61	11	.15		
Context	1.08	2	.54	6.22	.007
Context x BS	1.92	22	.09		
Domin. x Context	.03	2	.01	.07	.932
Domin. x Context x BS	4.31	22	.20		

Appendix N

Normal Subjects : Mean Probe Acceptance Latencies
by Sentence Position in Milliseconds

Subject	SENTENCE POSITION		
	Initial	Middle	Final
01	603	613	520
02	624	624	639
03	613	617	626
04	641	650	688
05	724	795	863
06	634	571	747
07	602	637	618
08	628	669	668
09	629	679	706
10	563	589	591
11	686	717	686
12	710	734	757
mean	638	658	676

Appendix O

Normal Subjects : Errors in Probe Acceptance
by Sentence Position

Subject	SENTENCE POSITION		
	Initial	Middle	Final
01	4	4	2
02	0	0	3
03	1	3	2
04	0	1	6
05	0	0	2
06	1	1	2
07	0	1	2
08	0	1	2
09	0	1	2
10	2	2	2
11	0	0	1
12	0	2	0
mean	0.67	1.33	2.17

Appendix P

Normal Subjects : Anova Table from Analysis
of Probe Acceptance Latencies

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	126178.08	11	11470.73		
Position	8520.67	2	4260.33	3.05	.068
Position x BS	30736.00	22	1397.09		

Appendix Q

Normal Subjects : Anova Table from Analysis
of Probe Acceptance Errors

Source	Sum of squares	df	Mean square	F	Signif. of F
Between Subjects	24.56	11	2.23		
Position	13.56	2	6.78	4.90	.017
Position x BS	30.44	22	1.38		

Appendix R

High and Low Dominant Words in Experiment no.3 : Property Frequency, Length and Frequency

Exp. Word	Dominance H=High L=Low	Property	Property Freq. ^a	Length ^b	Freq. ^c
sø (lake)	H	fiskene (fish)	90	7	0
	L	sivene (reeds)	35	6	0
hus (house)	H	døren (door)	50	5	171
	L	væggen (wall)	5	6	30
kat (cat)	H	pelsen (fur)	50	6	0
	L	kløer (claws)	30	5	0
rose (rose)	H	tornen (thorn)	65	6	0
	L	stilken (stem)	5	7	0
æble (apple)	H	rødt (red)	50	4	16
	L	sødt (sweet)	15	4	7
ur (watch)	H	klokken (time)	60	7	55
	L	guld (gold)	5	4	8
strand (beach)	H	sandet (sand)	90	6	6
	L	rav (amber)	5	3	0
seng (bed)	H	dynen (quilt)	70	5	12
	L	ben (leg)	10	3	49
avis (newspaper)	H	nyheder (news)	80	7	4
	L	papiret (paper)	35	7	11
frakke (coat)	H	varm (warm)	65	4	17
	L	stor (large)	5	4	121
kirke (church)	H	præst (priest)	80	5	6
	L	tårnet (tower)	40	6	4
skab (closet)	H	tøjet (clothes)	70	5	18
	L	bunden (bottom)	10	6	14
gade (street)	H	bilerne (cars)	80	7	0
	L	fliserne (flagstone)	5	8	0

græs	H	grønt (<i>green</i>)	95	5	6
(<i>grass</i>)	L	blødt (<i>soft</i>)	10	5	9
sten	H	hård (<i>hard</i>)	55	4	5
(<i>stone</i>)	L	flad (<i>flat</i>)	10	4	0
vindue	H	glasset (<i>glass</i>)	85	7	14
(<i>window</i>)	L	karmen (<i>sill</i>)	5	6	0

Experimental items

Experimental items and their high and low dominant properties consisted of 16 of the 24 sets included in study no. 3. t-tests on length and frequency of high and low dominant properties were repeated for the new version of the test.

^a Property frequency was measured as number of occurrences in response to the experimental words in the property study (see Appendix 6.B). Mean property frequency for high dominant properties was 70.9% (range 50-95). Mean property frequency for low dominant properties was 14.4% (range 5-40).

^b Length was measured in number of letters for the given form. A t-test (at the .05 level of significance) showed no significant differences between length of high dominant properties (mean=5.63) and low dominant properties (mean=5.25), $t(30) < 1$.

^c Frequency was measured as number of occurrences in 250,000 words for the given form as listed in Maegaard and Ruus (1981). A t-test (at the .05 level of significance) showed no significant differences in frequency between high dominant properties (mean=20.63) and low dominant properties (mean=15.81), $t(30) < 1$.

Experimental sentences and negative probes

Experimental sentences and probes were the same as in experiment no. 2 (see appendix D) except for the exclusion of sentence-probe sets relating to the items not included in the aphasic version of the test. t-tests (at the .05 level of significance) were repeated for the new version of the test and showed no significant differences in frequency between experimental objects (mean=17.06) and control objects: in high dominant control condition (mean=16.50), $t(30) < 1$; and in low dominant control condition (mean=23.06), $t(30) < 1$. t-tests on length in letters (at the .05 level of significance) showed no significant differences between experimental objects (mean=5.50) and control objects: for high dominant control condition (mean=5.25), $t(30) < 1$; and for low dominant control condition (mean=5.88), $t(30) < 1$.

Filler sentences and positive probes

The filler sentences were the same as in experiment no. 2 (see appendix E) except for the exclusion of sentence-probe sets relating to the items not included in the aphasic version of the test. t-tests showed no significant differences in length and frequency between positive probes from initial, middle, and final position. Nor were there any significant differences between the overall length and frequency of negative probes and positive probes.

Appendix S

Aphasics Grouped by Fluency : Errors in Probe Rejection

Subject	HIGH DOMINANCE			LOW DOMINANCE		
	App.	Inappr.	Unrel.	App.	Inappr.	Unrel.
Nonfluent aphasics :						
RP	1	0	2	0	0	0
MN	0	1	0	0	3	0
EH	1	1	0	1	0	0
CC	8	5	1	4	2	1
NL	1	2	0	1	1	1
JL	1	0	0	1	1	1
mean	2.00	1.50	0.50	1.17	1.17	0.50
Fluent aphasics :						
JP	1	0	0	1	1	0
EA	3	7	3	2	0	1
KB	3	0	0	2	1	0
CD	3	2	2	1	4	4
JA	0	0	0	0	0	0
BJ	1	2	1	0	0	0
EN	4	1	1	2	1	0
HS	0	0	0	0	0	0
HP	1	1	0	0	0	0
mean	1.78	1.44	0.78	0.89	0.78	0.56

Table T

**Aphasics Grouped by Fluency : Anova Table from Analysis
of Errors in Probe Rejection**

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	.22	1	.22	.03	.862
between cells	92.73	13	7.13		
DOMINANCE	5.20	1	5.20	2.47	.140
G. x A.	.22	1	.22	.11	.750
within cells	27.40	13	2.11		
CONTEXT	11.80	2	5.90	3.73	.038
G. x C.	.78	2	.39	.25	.783
within cells	41.13	26	1.60		
D. x C.	2.03	2	1.01	1.06	.362
G. x D. x C.	.07	2	.04	.04	.964
within cells	24.91	26	.96		

Table U

**Aphasics Grouped by Comprehension: Anova Table from Analysis
of Mean Probe Rejection Latencies**

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	1139917.70	1	1139917.70	1.19	.294
between cells	12403050.79	13	954080.83		
DOMINANCE	13619.29	1	13619.29	.07	.797
G. x A.	10066.89	1	10066.89	.05	.825
within cells	2562240.93	13	197095.46		
CONTEXT	781888.84	2	390944.42	12.11	.000
G. x C.	64398.71	2	32199.36	1.00	.382
within cells	839233.67	26	32278.22		
D. x C.	179463.19	2	89731.59	2.44	.107
G. x D. x C.	101327.72	2	50663.86	1.38	.271
within cells	957968.52	26	36844.94		

Table V

Aphasics Grouped by Comprehension : Anova Table from
Analysis of Errors in Probe Rejection

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	34.34	1	34.34	7.61	.016
between cells	58.62	13	4.51		
DOMINANCE	6.43	1	6.43	3.40	.088
G. x A.	3.05	1	3.05	1.61	.226
within cells	27.40	13			
CONTEXT	12.17	2	6.08	4.58	.020
G. x C.	7.37	2	3.68	2.77	.081
within cells	34.54	26	1.33		
D. x C.	2.26	2	1.13	1.26	.301
G. x D. x C.	1.64	2	.82	.91	.414
within cells	23.34	26	.90		

Appendix W

**Aphasics Grouped by Fluency : Mean Probe Acceptance
Latencies in Milliseconds**

Subject	SENTENCE POSITION		
	Initial	Middle	Final
Nonfluent aphasics :			
RP	2407	2612	2145
MN	1307	1327	1487
EH	1516	1514	1540
CC	1307	1336	1407
NL	1531	1450	1410
JL	1816	1942	1833
mean	1647	1697	1637
Fluent aphasics :			
JP	1141	1222	1212
EA	4121	1760	1896
KB	2444	2820	2467
CD	1561	1668	1515
JA	1531	1076	1486
BJ	1026	993	1129
EN	947	1485	1399
HS	2454	2428	1907
HP	1575	1501	1436
mean	1867	1661	1605

Appendix X

**Aphasics Grouped by Fluency : Anova Table from Analysis
of Probe Acceptance Latencies**

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	27745.07	1	27745.07	.03	.860
between cells	11139904.80	13	856915.75		
POSITION	134001.21	2	67000.60	.44	.646
G. x POS.	153609.92	2	76804.96	.51	.607
within cells	3922220.48	26	150854.63		

Appendix Y

Aphasics Grouped by Fluency: Errors in Probe Acceptance

Subject	SENTENCE POSITION		
	Initial	Middle	Final
Nonfluent aphasics :			
RP	9	18	12
MN	13	17	9
EH	11	14	7
CC	11	6	3
NL	2	1	1
JL	4	5	4
mean	8.33	10.17	6.00
Fluent aphasics :			
JP	5	4	1
EA	4	1	3
KB	4	19	9
CD	5	8	4
JA	10	2	4
BJ	3	2	4
EN	1	3	4
HS	2	6	2
HP	5	6	3
mean	4.33	5.67	3.78

Appendix Z

**Aphasics Grouped by Fluency : Anova Table from Analysis
of Errors in Probe Acceptance**

Source	Sum of squares	df	Mean square	F	Signif. of F
GROUP	137.96	1	137.96	3.55	.082
between cells	505.02	13	38.85		
POSITION	66.05	2	33.03	3.32	.052
G. x POS.	10.32	2	5.16	.52	.601
within cells	258.70	26	9.95		

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