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Implications of aphasia on abstract and concrete noun processing

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Abstract

This paper examines the processing of abstract and concrete nouns in four Swedish subjects with aphasia; two with left hemisphere frontoparietal lesions, one with left hemisphere temporoparietal lesions, and one with left hemisphere occipital lesions. The study was carried out in order to investigate a number of assumptions related to the concept known as the 'concreteness effect'. The 'concreteness effect' refers to the phenomenon where concrete words are generally processed faster and more accurately than abstract words. One possible explanation is that concrete words to a higher degree activate sensory-motor representations in more wide-spread, bilateral brain areas, whereas abstract word processing is mainly dependent on verbal representation forms in the language-dominant left hemisphere (Paivio, 1986; Pulvermüller, 1999). Other theories attribute the concreteness effect to concrete words being associated with a larger amount of contextual information (Schwanenflugel et al., 1988) or having a greater number of semantic features (Plaut & Shallice, 1993). Since the bilateral, sensory-motor representations of concrete nouns could be expected to result in their being better preserved in aphasia than abstract nouns, the aphasic participants were hypothesized to show an enhanced concreteness effect compared to healthy subjects. The accuracy and speed with which concrete and abstract nouns were processed were tested with a multiple-choice test and a free word association test. Multiple-choice test scores and verbal association access times were compared with those from a healthy control group. An enhancement of the concreteness effect was found in the aphasic participants with frontoparietal and temporoparietal lesions. However, signs of a reverse concreteness effect were observed in the participant with the occipital lesions.

Sammanfattning: Konsekvenser av afasi för processandet av abstrakta och konkreta substantiv

I den här uppsatsen undersöks processandet av abstrakta och konkreta substantiv hos fyra svenska försökspersoner med afasi; två med vänstersidiga frontoparietala skador, en med vänstersidiga temporoparietala skador och en med vänstersidiga occipitala skador. Studien genomfördes för att undersöka vissa antaganden relaterade till 'konkrethetseffekten', ett begrepp som syftar på fenomenet att konkreta ord generellt processas snabbare och mer exakt än abstrakta ord. En möjlig förklaring är att konkreta ord i högre grad aktiverar bilaterala, sensorimotoriska representationer, medan processandet av abstrakta ord huvudsakligen är beroende av verbala representationsformer i den språkdominanta vänstra hemisfären (Paivio, 1986; Pulvermüller, 1999). Andra teorier förklarar konkrethetseffekten med att konkreta ord är associerade med en större mängd kontextuell information (Schwanenflugel et al., 1988) eller att konkreta ord har fler semantiska särdrag (Plaut & Shallice, 1993). Eftersom de konkreta substantivens bilaterala, sensorimotoriska representationer kan förväntas bidra till att de är bättre bevarade vid afasi, sattes hypotesen upp att försökspersonerna med afasi därför skulle uppvisa en förstärkt konkrethetseffekt jämfört med friska försökspersoner. Exaktheten och snabbheten i processandet av abstrakta och konkreta substantiv testades med ett flervalstest och ett ordassociationstest. Poängen från flervalstestet och svarstiderna för ordassociationer jämfördes med testresultaten från en frisk kontrollgrupp. En förstärkt konkrethetseffekt fanns hos försökspersonerna med frontoparietala och temporoparietala skador. Försökspersonen med occipitala skador uppvisade däremot tecken på en omvänd konkrethetseffekt.

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1. Introduction

1.1 The ‘concreteness effect’ and aphasia

Concrete nouns are processed faster and more accurately than abstract nouns in various cognitive tests, including word recognition, recall, lexical decision and sentence comprehension. This phenomenon is known as the ‘concreteness effect’, and there are different explanations of what its neurophysiological basis might be (Jessen et al., 2000).

The ‘dual coding theory’ (Paivio, 1986) suggests that whereas the processing of abstract words is mainly dependent on verbal representation forms in the language dominant left hemisphere, concrete words also have non-verbal, sensory-motor meaning representations in both hemispheres. These additional representations facilitate the processing of concrete nouns. This suggestion is also consistent with a Hebbian view, stating that a word form activates cell assemblies related to its meaning – e.g. actions or sensory experiences (Pulvermüller, 1999). The context availability theory (Schwanenflugel et al., 1988) attributes the concreteness effect to a quantitative difference in contextual information, rather than stating that different representational systems are involved. According to this theory, concrete words are more easily processed because they are associated with a larger amount of contextual information. It has also been proposed that concrete nouns have a greater number of stable semantic features, whereas abstract nouns have fewer and less consistently accessed features (Plaut & Shallice, 1993).

Although the concreteness effect is well documented in healthy subjects, the processing of abstract and concrete nouns in aphasia patients has not been as extensively studied. It is, however, a well-known fact that aphasia patients generally have greater difficulty in processing abstract words (Hagoort, 1998). The above mentioned models all offer possible explanations for why this amplification of the concreteness effect is present in many aphasics. Aphasia is most commonly caused by lesions in left hemisphere perisylvian language areas (e.g. Broca’s area and Wernicke’s area). Both the fact that the sensory-motor features associated with concrete nouns have meaning representations in posterior association cortices and the fact that many of these representations are bilateral could contribute to the relatively better preservation of concrete nouns in aphasia. Richer associations to contextual information in general, or a more robust set of semantic features might also make it more likely for concrete nouns to be accessed even if individual features are unavailable due to the lesions.

The present study is intended to shed more light on the ‘concreteness effect’ phenomenon by comparing aphasic and healthy subjects’ processing of concrete and abstract words. It will be shown that aphasic subjects with anterior and temporal lesions show an enhanced concreteness effect as compared to healthy subjects. However, one aphasic participant with occipital lesions showed a reverse concreteness effect, i.e. abstract words were more accurately processed in the participant with posterior brain damage.

1.2 Mental representations

1.2.1 Words and concepts

Words are verbal symbols that can be used to *refer to* or *denote* things. Referring means pointing out things in the world. Although names and noun phrases usually have a referential function, they can also refer to things without real-world equivalents. In addition, a one-to-one relationship is not always present between words and their referents. In contrast to the context-dependent referential function of words, the denoting function involves a more stable relationship between words and the world, where words must be associated with something in a person's mind - a *mental representation*. Mental representations are sometimes described as images, but perhaps a more accurate description is that they are *concepts*, also containing non-visual features (Saeed, 2003). Paivio (1986) makes a distinction between picture- and language-like representations, where picture-like representations are iconic, whereas language-like representations are arbitrary signs. According to this view, the more arbitrary a symbol/representation is, the more abstract it is.

One way to define a concept is to specify the information needed to identify it – the necessary and sufficient conditions. These conditions can be listed as meaning components called *semantic features*. It may, however, be difficult to decide which semantic features are necessary and sufficient (Saeed, 2003). For example, the concept 'blackbird' may be described as a black bird which sings in the springtime, but white blackbirds also exist, and still are blackbirds. And it is not entirely straightforward (unless you are a bird expert) to identify exactly which additional semantic features are needed to separate blackbirds from other types of black, singing birds.

1.2.2 The mental lexicon

The mental lexicon can be described as the knowledge a speaker has about the form and meaning of words (Hagoort, 1998). The relations in the mental lexicon can be seen as a network comprising connected *lexical fields*, groups of words that are related to the same activity or area of knowledge. Lexical relations include homonymy (the same form has two or more unrelated meanings), polysemy (the same form has two or more related meanings), synonymy, antonymy, hypo-/hyperonymy, mero-/holonymy, member-collection and portion-mass relations (Saeed, 2003).

Rosch et al. (1975, 1976) suggest that concepts are structured in categories with three levels of generality (superordinate, basic and subordinate), each containing more and less typical (central and peripheral) members. When asked to name a member of a category, we are more likely to name a central – prototypical – one. This central prototype may be an abstraction, i.e. a set of characteristic semantic features. Another view is that the prototypes we organise categories around are memories of specific exemplars that we have experienced (Saeed, 2003).

1.3 The neural basis of mental representations

1.3.1 Cell assemblies

Neurons are the basic units of cognition. Individual neurons respond to simple features. For instance, basic visual features include the orientation of lines, contrasts in light intensity and movement in different directions. Cell assemblies (Hebb, 1949) consisting of interconnected neurons represent complex concepts (Kolb & Wishaw, 2006). They constitute networks of neurons which have become associated due to frequent coactivation and thus function as units (Pulvermüller, 1999).

Since the cell populations responding to different features form neuronal networks, information can be integrated and a complex stimulus can be perceived as a whole (Kolb & Wishaw, 2006). The above mentioned basic visual features are combined to create colour, shape, movement and spatial positions, properties which in turn can be integrated to a complete visual experience and combined with other experiences in higher order networks (Eriksson, 2001). Although the visual system is the most extensively investigated, the other sensory systems are believed to be similarly organized.

Signalling patterns in individual nerve cells as well as in nerve cell populations is a result of inhibition and excitation. Inhibitory/exitatory signals from neurons are spatially or temporally summated, resulting in different activity patterns in other neurons. A neuron may receive input from more than 50,000 other neurons (Kolb & Wishaw, 2006).

1.3.2 Semantic and episodic memory

Mental representations of knowledge in long term memory are assumed to be of two types: *Implicit* or *explicit*. Whereas implicit memories – e.g. learned motor skills such as riding a bike – are recalled unconsciously, the recall of explicit memories involves conscious effort (Kandel et al, 2000; Eriksson, 2001).

The formation of an explicit memory representation begins when information is perceived and activates neurons in association areas in the frontal, parietal, temporal, occipital and limbic cortices (see Fig. 1 and Fig. 2). Sensory information then, through a series of steps, is conveyed to the hippocampus, a structure in the medial temporal lobe (Kandel et al., 2000). The hippocampus mediates long-term memory storage by preserving the cortical neural activity pattern associated with the stimulus, and by strengthening the interconnections between areas containing different aspects of the new information and areas containing previous knowledge (Eriksson, 2001). Explicit memories are stored in the cortical association areas where they were initially processed (Kandel et al. 2000). When a stimulus simultaneously activates different parts of the cortex, cell assemblies form which include neurons in all of the activated areas – e.g., when a stimulus is both seen and heard, cell assemblies form which include neurons in both visual and auditory cortices (Pulvermüller, 1999).

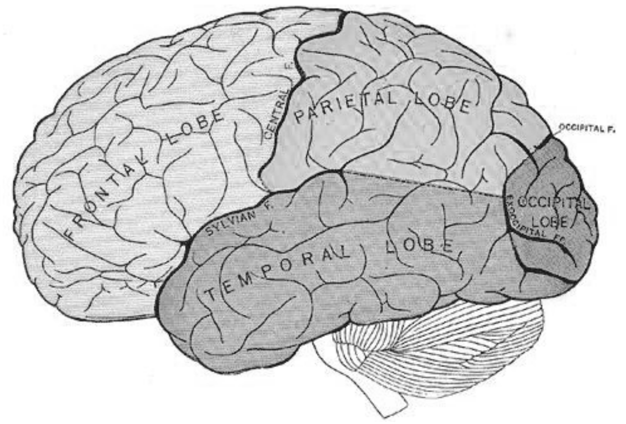

Figure 1: Left frontal, parietal, temporal and occipital lobe (Wikimedia Commons, 2008). The temporal lobe contains the primary auditory cortex and visual association areas. The occipital lobe contains the primary visual cortex. The parietal lobe is involved, among other things, in the perception of touch and the processing of visuo-spatial information. The frontal lobe is involved in motor and executive functions (Kolb & Wishaw, 2006).

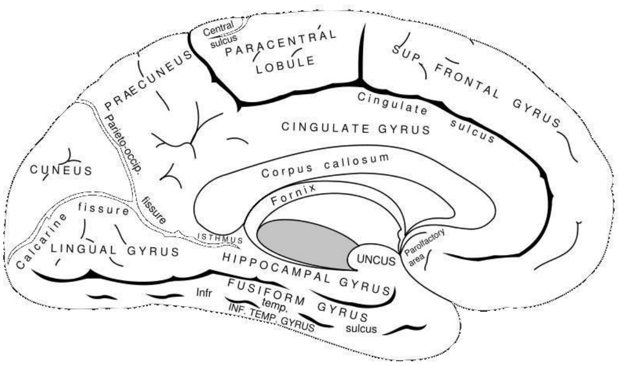

Figure 2: Sagittal section with cingulate gyrus in the middle (Wikimedia Commons, 2008). The cingulate cortex is part of the limbic system, which also comprises, among other structures, the hippocampus and the amygdala. The limbic system consists of forebrain structures that are evolutionary older than the neocortex, and it is involved in emotional and motivated behaviour (Kolb & Wishaw, 2006).

Explicit memory can be further subdivided into *episodic* and *semantic* memory. Whereas episodic memory consists of personal experiences, semantic memory stores objective facts. Semantic knowledge is built up by learned associations and stored in a distributed way in the neocortex. Knowledge of words is one example of semantic knowledge. The word 'elephant' is associated with all information about elephants one knows. Different features of the concept 'elephant', such as its size, colour, shape, movement pattern, sound and smell, are stored in different parts of the brain, a fact which becomes clear when distinct brain areas are damaged. Any feature may give access to the rest of the related knowledge (Kandel et al., 2000). More specifically, in the case of words, either the phonological signal or some aspect of its associated semantic knowledge has the possibility to activate the whole cell assembly (Pulvermüller, 1999). In neuropsychological disorders, semantic memories are more commonly disturbed than episodic memories. Aphasia is one of the most clear examples of a selective semantic memory disturbance (Eriksson, 2001).

Frontal lobe association areas seem to be important for long-term storage of episodic memories. These areas are interconnected with other cortical association areas and involved in remembering the time and place when the memory was encoded (Kandel et al., 2000). The strength and availability of an episodic memory is influenced by the emotional intensity and the amount of sensory input present at the moment when it was experienced (Eriksson, 2001). Emotional memories frequently have both explicit and implicit components. The amygdala, which is connected with brainstem structures controlling autonomic responses and hormonal systems, is involved in the formation of emotional memories (Kolb & Wishaw, 2006).

1.3.3 Mental representations and the dual coding theory

The basic idea of the dual coding theory is that information processing involves two structurally and functionally different systems – a verbal system, which involves arbitrary language symbols such as word forms, and a nonverbal (imagery) system, which handles representations of experiences that are related to the five senses, such as the perception of visual objects, environmental sounds, touch, taste and smell. There is, however, interaction between the two systems, e.g. when one names objects or creates images for words. Concrete words activate both systems to a higher degree, whereas abstract words mainly activate the verbal system. This makes abstract words more dependent on verbal context and explains the processing advantage for concrete words (Paivio, 1986).

As regards the neural basis for dual coding, Paivio (1986) focuses mainly on hemispheric differences, where the left hemisphere is more exclusively involved in verbal information processing, whereas non-verbal information processing to a higher degree involves right-hemisphere or bilateral areas. Functional neuroimaging studies comparing concrete and abstract noun processing have shown somewhat variable results (for a review, see Sabsevitz et al., 2005), but a number of event-related fMRI studies offer support for the theory that abstract word processing is more left-hemisphere dependent. Sabsevitz et al. (2005) and Binder et al. (2005) both found that the processing of concrete nouns resulted in greater activation in a bilateral network of association areas[1], whereas abstract noun processing produced greater activation in the left inferior frontal and left superior temporal cortex, areas associated with phonological processes, verbal short-term memory and lexical retrieval. This might reflect a situation where the processing of abstract words puts higher demands on keeping the words' phonological forms in working memory and retrieving other words, as compared to concrete word processing which more easily activates concepts.

Pulvermüller (1999) also suggests that word form representations are lateralized to the left hemisphere perisylvian[2] area, but emphasizes that a lateralized cell assembly may consist of a bilateral neuronal network with a greater percentage of the neurons localized to one hemisphere. He further proposes that the more weakly associated with concrete stimuli a word is, the more form-dependent and left-localized its corresponding cell assembly will be. Thus, the neural representations of concrete content words, which refer to clearly defined entities or actions, can be assumed to be distributed over both hemispheres, whereas the representations of words which lack

1 The ventral and medial temporal, posterior-inferior parietal, dorsal prefrontal and posterior cingulate cortex.
2 The area around the sylvian fissure, which is the fissure separating the temporal and frontal lobe from the parietal lobe (see Fig 1).

such referents, e.g. function words and abstract content words, are likely to be more strongly left-lateralized. In other words, although *all* cell assemblies which represent word forms have a left perisylvian part, concrete word forms should also activate neuronal networks in sensory-motor areas. For example, words with strong visual associations might involve posterior visual cortices (Fig. 4), and words that are associated with motor behaviour might activate areas close to the motor cortex (Fig. 3) (Pulvermüller, 1999).

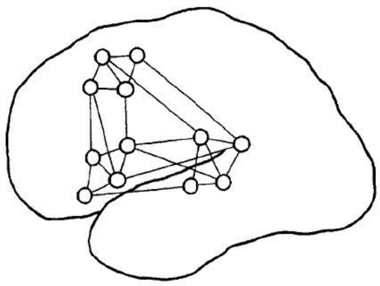

Figure 3: Possible distribution of cell assemblies representing "action words", e.g. movement verbs (Pulvermüller, 1999).

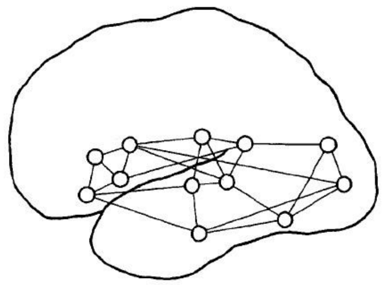

Figure 4: Possible distribution of cell assemblies representing "vision words", e.g. concrete nouns (Pulvermüller, 1999).

1.4 Word meaning and context: pragmatics

1.4.1 The context availability theory

According to the 'context availability theory', the most likely explanation for the concreteness effect is that concrete words are easier to associate with a context than abstract words. Comprehension of a concept is facilitated by access to contextual information, because it activates the other concepts that are needed to comprehend it. Contextual information can either be retrieved from memory or present in the stimulus environment. When no contextual information is provided, people have greater difficulty mentally constructing a context for abstract words. Differences in the processing of concrete and abstract words and sentences have been shown to disappear when the words and sentences are presented in appropriate contexts. The context availability model, in contrast with the dual coding model, does not focus on the concrete word linkage to sensory/visual information, but instead emphasizes the importance of being able to access *any* associated information when processing a concept (Schwanenflugel et al., 1988).

1.4.2 Pragmatics

In natural languages, meaning is communicated by units on several linguistic levels – e.g. phonology, syntax and morphology – which cannot be easily separated. Furthermore, the meanings of words are context-dependent as well as dependent on the listeners' inferences, and non-verbal cues such as gestures also play a major role in communication (Saeed, 2003). It has even been suggested that all words are polysemous to some extent, since they do not have exactly the same meaning in every possible context (Crutch & Warrington, 2005). Pragmatic aspects of meaning can therefore be assumed to be an integral part of words' mental representations.

1.5 Concrete and abstract nouns

The Swedish National Encyclopedia Lexicon (2007) defines concrete and abstract nouns as follows:

> **concrete noun**, noun which describes something that can be weighed and directly perceived with the senses: creatures, objects, materials etc. Opposite: abstract noun. (author's translation)
>
> **abstract noun**, noun which describes an intangible phenomenon (without physical mass), e.g. property, condition, event and time. Many abstract nouns are derived from adjectives or verbs. Opposite: concrete noun (author's translation).

Abstractness/concreteness may also, alternatively, be viewed as a continuum instead of a dichotomy (Wiemer-Hastings et al., 2001; Crutch & Warrington, 2005).

In humans, the dominant sense is vision. The ability to perceive information at a distance has been evolutionarily advantageous, and a vast amount of the human cerebral cortex is devoted to the processing of visual information. This influences not only the way we see the world but also our whole way of thinking. Metaphors from the realm of vision are used to describe various cognitive states (Gazzaniga et al., 2002), and we have a natural tendency to associate even other sensory experiences with images. Sounds, for example, are frequently described in terms of the events that give rise to them (Eriksson, 2001). Ratings of imageability (how easy it is to create a mental image of a word) are strongly correlated with ratings of concreteness (how concrete a word is percieved to be) (Fliessbach et al., 2006). Although the visual representations of concrete nouns may be especially important, all sensory information associated with a noun is likely to contribute to how concrete it is perceived to be.

Some nouns are more difficult than others to categorize as abstract or concrete based on definitions such as the ones above. Emotion related terms have been suggested to belong to a group that is neither abstract nor concrete, since they are perceived within (Wiemer-Hastings et al., 2001). In addition, emotion words are likely to be related to visual representations of facial expressions as well as muscle activity patterns, and may also involve limbic structures such as the amygdala (Pulvermüller, 1999).

Factors external to the noun itself may also determine its perceived concreteness. Context availability ratings (how easy it is to think of a context for a word) are correlated with concreteness ratings. This correlation, however, has been shown to be highest for concrete words, intermediate for emotion words and lowest for abstract words. Wiemer-Hastings et al. (2001) suggest that whereas imageability and context availability are both good predictors of whether a word is at the abstract or concrete end of the spectrum, variation in abstractness among abstract words is better explained by differences in their contextual constraints. The less constrained the contexts in which a word can appear are, the more abstract that word is.

Many abstract nouns share some characteristics with verbs, e.g. they are related to observable events with a temporal dimension (Wiemer-Hastings et al., 2001).

Crutch & Warrington (2005) investigated the processing of abstract words in a patient with semantic refractory access dysphasia, a disorder which implicates a reduction in neural activation for a time-period after activation. Among other things, this makes the patient's performance more sensitive to the semantic relatedness of test stimuli. Since semantically related stimuli involve closely linked neurons, refractoriness spreads among them when one stimulus partially activates the other, thus impairing test performance. A greater refractoriness was found for *associated* than for *synonymous* abstract words, whereas the reverse pattern has been observed for concrete words. This suggests that there is a qualitative difference in the organization of concrete and abstract concepts, with concrete concepts being organized by *category* and abstract concepts by *association*. Whereas the organisation in categories with different levels described in **1.2.2** applies to concrete nouns, abstract nouns may be more likely to share neural space with concepts that are contextually related rather than similar. This might reflect that the meanings of abstract words are determined by context to a higher degree than the meanings of concrete words, which are more constant across contexts (Crutch & Warrington, 2005).

1.6 Aphasia

1.6.1 Aphasia in general

Aphasia is a language disorder caused by acquired brain damage, most commonly due to a stroke (Eriksson, 2001). Aphasia can be described as a disturbance in the ability to use language symbols. This disturbance may affect the ability to interpret or produce the symbolic form and/or the ability to connect the symbolic form with content (Apt, 1998).

Different types of aphasia have traditionally been classified according to the Wernicke-Geschwind model, which describes Wernicke's Area (Fig. 5) as a speech perception area and Broca's Area (Fig. 5) as a speech production area, connected by the arcuate fasciculus, a bundle of nerve fibers. However, modern brain imaging studies have revealed that the functions of the areas mentioned above are more complex, and in addition that a large network of other brain areas are involved in language processing. For example, frontal, temporal and parietal association cortices (Fig. 1) of the left hemisphere connect concepts with language, and prefrontal and cingulate areas are involved in executive control, memory and attention (Kandel et al., 2000).

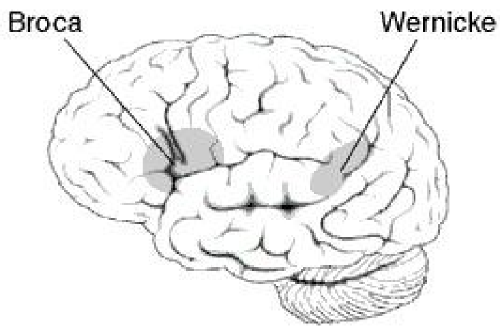

Figure 5: Broca's and Wernicke's area (Wikimedia Commons, 2008)

The symptoms of aphasia vary roughly depending on the localization of the brain damage as described in **1.6.2.** and **1.6.3.** Still, it is important to remember that many aphasics have a mixture of anterior and posterior damage, and the boundaries between different types of aphasia are not always clear-cut (Ahlsén, 2006). [3]

Anomia, a syndrome characterized by difficulties finding content words, is present in virtually all aphasics. The ability to name objects from pictures, from descriptions or from memory is impaired. When the word the aphasic is looking for is difficult to find, it is common that associations and related words are activated instead (Ahlsén, 2006). Anomia does not mean that the word is lost from memory, but rather that that it cannot be accessed at the right time (Apt, 1998).

3 There are reports of patients suffering from the type of aphasia normally associated with frontal lobe lesions, whose CT-scans show no frontal damage. Patients with extensive damage to the "language areas" of the brain, who despite this are not aphasic, also occur. However, these are rare exceptions, and in most cases there is a correlation between the symptoms of aphasia and the localization of the lesions (Eriksson, 2001).

1.6.2 Broca's aphasia/anterior damage

Left hemisphere anterior lesions mainly affect language functions such as grammar and speech fluency. Prosody, stress and the timing of sounds are also frequently affected. Many patients with frontal damage have difficulties initiating an utterance, and sometimes they do not speak at all. The comprehension of speech is better than the ability to produce speech, but rarely intact (Eriksson, 2001).

The 'phonological loop' is the subpart of working memory involved in the processing of speech based information (Baddeley, 1997). In order to keep a word in working memory, it must be updated through silent repetition (subvocal articulation). Without subvocal articulation, the information disappears within 2-3 seconds. The phonological loop is associated with activity in Broca's Area as well as a region in the left parietal lobe. The cerebellum and premotor cortex are also involved, presumably because the words are articulated mentally (Nyberg, 2002). Thus, lesions of Broca's Area may affect the ability to keep speech based information in working memory. This may be a primary cause of the difficulties Broca's aphasics have comprehending syntactically complex sentences (Kandel et al., 2000).

Many aphasics with frontal lobe lesions have greater problems with verbs than with other word classes (Ahlsén, 2006; Apt, 1998). This is consistent with the theory that movement and action verbs have neural representations frontally, adjacent to the motor cortex. If verb acquisition is closely linked with action planning and motor execution, the semantic representations of verbs are likely to be linked to the areas controlling these functions. Verb problems following frontal damage may also be related to the role of verbs in grammatical structure (Ahlsén, 2006).

1.6.3 Wernicke's aphasia/posterior damage

Left hemisphere posterior lesions - that is, lesions of the parietal, temporal or occipital lobe - do not cause problems with speech fluency. Instead, the major problem for patients with posterior damage is substitutions of words and sounds (semantic and phonemic paraphasias) (Eriksson, 2001). Semantic paraphasias in aphasia tend to be words belonging to the same lexical field as the intended word. This pattern can also be seen in the word substitutions (Freudian slips) that are sometimes produced by unimpaired speakers (Hagoort, 1998). Speech comprehension is generally more severely impaired in patients with posterior lesions than in patients with frontal lesions (Eriksson, 2001).

Wernicke's aphasia is normally caused by lesions in the posterior part of the auditory association cortex in the left posterior superior temporal lobe known as Wernicke's Area. Wernicke's area is involved in processing speech sounds and associating them with concepts (Kandel et al., 2000).

Many patients with posterior damage have great difficulties finding the right words, especially nouns. Instead they tend to use paraphrases (circumlocutions) (Apt, 1998; Eriksson, 2001). The reason why posterior lesions often result in problems with nouns might, as discussed in **1.3.3**, be the linkage to sensory features, which are represented in different posterior parts of the brain (Ahlsén, 2006).

1.6.4 Concreteness and aphasic naming tasks

The effects of imageability and concreteness in aphasic naming tasks have not been extensively investigated. This is not surprising, since word production and comprehension in aphasics is normally tested with picture stimuli, which inevitably have high imageability and consequently also high concreteness (Nickels & Howard, 1995). Nevertheless, Nickels & Howard (1995) studied the concreteness effect in a picture naming task in aphasics. Although all of the stimuli were from the high end of the concreteness/imageability scale, significant concreteness effects were found in some aphasics. Nickels & Howard (1995) discuss the possibility that it is not concreteness (which they define as ”accessability to sensory experience”) or imageability in itself that improves naming performance. The advantage for concrete words may instead be a result of a greater number of semantic features as suggested by Plaut and Shallice (1993).

1.6.5 Lexical relations and aphasia

Ahlsén & Allwood (1991) investigated operations on semantic categories in aphasics. They found that accessing a subordinate category (e.g. ‘poodle’) when given a basic-level word (e.g. ‘dog’), was easier for the aphasics than performing the opposite operation. Since generalizing can be seen as an abstracting operation, and specifying as a concretizing operation, this can be interpreted as more abstract categories being more difficult for the aphasics[4]. When the aphasics were asked to name a superordinate category, they tended to name some features first, thereby accessing the abstract concept more indirectly and by concretizing it first. When asked to describe a prototype, the controls gave features, while the aphasics tended to give one subcategory member and then sometimes features. Accessing opposites, on the other hand, was not very problematic for the aphasics.

The left hemisphere may be especially important for prototypical representations. Visual representations of shape are situated in the inferior temporal lobes, but these representations seem to differ between the two hemispheres. Whereas the left temporal lobe seems to contain representations which are of a more categorical, abstract and prototypical nature, the right temporal lobe representations are more exemplar-oriented and specific (Gazzaniga et al., 2002).

Ahlsén & Allwood (1986, 1991) also found that holistic situation anchoring seems to be important when people with aphasia perform semantic operations. The aphasic participants in their study frequently provided more contextual information when describing words compared to the controls.

The search for words via specification and contextualization might be a strategy to access a target word which is not initially activated, but might also be a result of a failure of inhibition, where the aphasic cannot separate the word (s)he is looking for from other related words and phrases that are being activated – e.g. its semantic features and the context as a whole (Ahlsén & Allwood, 1991).

1.6.6 Category-specific semantic deficits

Word finding problems can be limited to specific semantic categories. For example a patient may have great difficulties with words for natural objects such as vegetables and animals, while (s)he performs better with words for man-made objects such as tools and vehicles. In patients who have problems with words for living things, lesions of the anterior parts of the inferior and medial temporal lobe have been found. The anterior inferior temporal cortex is adjacent to parts of the brain that are important for visual object perception, and is the end station for the visual ”what”-stream, which involves processing of colour and shape. PET- and fMRI-studies of healthy participants have shown that naming animals, in addition to temporal lobe structures[5], also activates early visual processing areas in the left medial occipital lobe (Gazzaniga et al., 2002).

4 Some persons with aphasia, however, find superordinate, more general categories easier (Ahlsén, 2006).

5 The lateral fusiform gyrus and the superior temporal sulcus.

Other (although fewer) patients have greater difficulties with man-made objects. This seems to be associated with lesions of the left frontal and parietal areas, which are close to the sensorimotor areas of the cortex. This dissociation might reflect that living things/artefacts are associated with different kinds of information – while living things are identified mainly via visual features, tools are identified by how they are used (Warrington et al.). Another theory (Caramazza) is that object categories are organized depending on animacy (Gazzaniga et al, 2002).

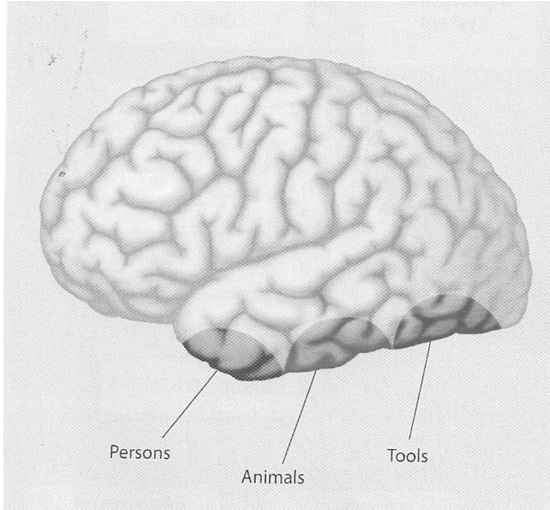

Figure 6: Temporal lobe areas that have been shown active i PET-studies when naming persons, animals and tools (Gazzaniga et al., 2002).

1.7 Case studies versus group studies

In the 1970s, group studies of lexical semantics in aphasics were common. Today, although group studies are still used, the extensive case study has become a more popular method, because of the considerable individual variation in groups of people with aphasia (Ahlsén 2006). Nickels & Howard (1995) also emphasise that since aphasics constitute a very heterogenous group, it is difficult to draw general conclusions about aphasic naming performance based on group studies.

Although group studies of neurological patients have these limitations, they still have proved to be useful when it comes to linking specific brain structures with cognitive operations (Gazzaniga et al., 2002).

1.8 The present study

1.8.1 Goals of the present study

The main goal of the present study is to examine the processing of concrete and abstract nouns in four subjects with aphasia; two with left hemisphere anterior (frontoparietal) lesions and two with left hemisphere posterior (temporoparietal and occipital) lesions.

The accuracy and speed with which concrete and abstract nouns are processed is tested and compared with a healthy control group, using a multiple-choice test and a word association test (further described in part 2). The processing of the two noun types is also compared as regards lesion area, to see if there are differences depending on the localization of the brain damage.

An additional goal is to obtain information about the structure of the lexical fields associated with concrete and abstract nouns, and to see if there are differences in the types of words the aphasics associate abstract and concrete nouns with, as compared to the control group.

1.8.2 Specific hypotheses for the multiple-choice test

Due to overall difficulties with words, the aphasic participants were expected to answer more of the multiple-choice questions incorrectly than the controls.

On the assumption that concrete nouns are better preserved in aphasia than abstract nouns, it was also hypothesized that the aphasic participants would have greater difficulties with the abstract questions, scoring lower on the abstract part of the multiple-choice test relative to the concrete part.

1.8.3 Specific hypotheses for the word association test

The main goal with the word association test was to be able to compare access times for verbal associations for concrete and abstract nouns in the aphasic and healthy subjects. Given the fact that concrete nouns generally are processed faster in cognitive tests, the overall access times for word associations were expected to be longer for the abstract nouns.

If the aphasic participants have greater problems with the processing of abstract nouns, this can be assumed to be reflected as relatively longer access times for the abstract nouns. Thus, it was hypothesized that the difference in verbal association access time for abstract and concrete nouns would be greater for the aphasic group.

1.8.4 Additional predictions

An additional goal with the word association test was to see if there were any qualitative differences in the associations depending on concreteness and group.

If abstract and concrete nouns are differently organized, it is possible that there will be qualitative differences in the associations depending on the concreteness of the test nouns. This could for example be differences in word class, lexical relations or the concreteness of the associations. Since abstract nouns are often derivations from verbs and adjectives, and share some characteristics with verbs, it was hypothesized that these word classes might be more common associations for the abstract words than for the concrete words.

One could also expect differences in the word classes produced by the aphasics compared to the control group. The aphasic subjects with anterior damage may produce fewer verbs, whereas nouns may be less likely to be produced by the aphasic subjects with posterior damage. Differences in the lexical relations of the associations might be present if the aphasic subjects have difficulties accessing superordinate levels, or if they have problems with specific lexical fields. If the aphasic subjects have problems with abstract words, the abstraction level of the associations they produce may be generally lower as well.

There might be differences in comprehension as well as access time and type of associations depending on the type of abstract word (EMOTIONS, INTERACTION STATES, ABSTRACT RELATIONS), or the type of concrete word (NATURAL OBJECTS, MAN-MADE OBJECTS).

2. Method

2.1 Participants

2.1.1 Aphasic participants

Contact with four aphasic participants (Tab. 1) was established through the Neurology Department at Malmö University Hospital and the Aphasia Association in Malmö-Lund. All participants had been treated at the Stroke Clinic at Malmö University Hospital. They all volunteered to participate in the study and were guaranteed anonymity. All aphasic participants were right-handed, native Swedish speakers. The two aphasics with anterior (frontoparietal) lesions were classified as non-fluent, the two with posterior (temporoparietal and occipital) lesions were classified as fluent.

Participant	Age	Onset of aphasia	Diagnosis	Latest CT-scan	Localization of lesions
1 (female)	41	1989 04 25	Cerebral infarct	2000 08 22	LH frontoparietal, mainly frontal
2 (female)	66	2004 10 08	Cerebral infarct	2004 10 27	LH frontoparietal, mainly frontal
3 (female)	31	2007 02 12	Cerebral infarct	2007 10 30	LH temporoparietal
4 (male)	76	2004	Cerebral infarct	2004	LH occipital

Table 1: Aphasic participants.

2.1.2 Healthy participants

The healthy control group (Tab. 2) consisted of ten females and two males, approximately matched for the aphasic participants' age groups and education levels. Eleven of the controls were right-handed and one (B) was ambidextrous. All were native Swedish speakers.

Participant	Age	Participant	Age	Participant	Age
A (female)	53	E (female)	54	I (female)	23
B (female)	25	F (female)	49	J (female)	33
C (male)	79	G (female)	26	K (female)	58
D (male)	78	H (female)	44	L (female)	44

Table 2: Control group.

2.2 Materials

2.2.1 The nouns

120 nouns (60 concrete and 60 abstract) were chosen from the list of nouns rated for concreteness and imageability in the MRC (Medical Research Council) Psycholinguistic Database. The MRC database, which is available online via a dictionary interface, contains syntactic and psychological data for a large number of English words, making it a suitable source of psycholinguistic stimulus materials (Coltheart, 1981). Concreteness ratings range from 100-700, with 100 being the most abstract and 700 the most concrete. Imageability is expressed on a similar scale, with 100 being the least imageable and 700 the most imageable. Roget's Thesaurus (1992) was helpful in the search for nouns. The English nouns from the MRC database were translated to Swedish with Lexin (2007).

The 60 concrete nouns (Tab. 3) are all entities that can be perceived visually and with at least one additional sense (in other words they can, in addition to being seen, also be touched, heard, smelled or tasted). They were divided into two subcategories: NATURAL OBJECTS, which contains nouns for animals, plants, food etc and MAN-MADE OBJECTS, which contains nouns for tools, vehicles, buildings etc. The concrete nouns have a mean concreteness rating of *M* = 605, *SD* = 27 and a mean imageability rating of *M* = 599, *SD* = 30.

NATURAL OBJECTS/FOOD				**MAN-MADE OBJECTS**			
Swedish	**English**	**C**	**I**	**Swedish**	**English**	**C**	**I**
ananas	pineapple	653	569	ambulans	ambulance	595	627
apelsin	orange	601	626	cigarett	cigarette	607	645
björk	birch	620	561	diamant	diamond	610	623
blomkål	cauliflower	642	567	dragkedja	zipper	599	632
choklad	chocolate	576	611	dragspel	accordion	586	576
ek	oak	588	590	dörröppning	doorway	578	548
fjäril	butterfly	593	624	fönster	window	609	602
gorilla	gorilla	620	634	förstärkare	amplifier	564	559
gräshoppa	grasshopper	660	630	hammare	hammer	605	618
gurka	cucumber	653	623	järn	iron	584	561
hallon	raspberry	594	636	kamera	camera	627	576
jordgubbe	strawberry	610	631	kanon	cannon	604	588
juice	juice	599	593	klarinett	clarinet	633	593
krokodil	crocodile	583	601	klänning	dress	595	595
leopard	leopard	595	635	limousin	limousine	624	595
lera	clay	606	575	paraply	umbrella	606	592
makaron	macaroni	631	608	pincett	tweezers	590	619
mjölk	milk	670	638	revolver	revolver	592	629
morot	carrot	622	577	roman	novel	529	547
nejlika	carnation	625	611	sammet	velvet	580	569
pepparkaka	gingersnap	623	572	siden	silk	538	510
persika	peach	617	613	silver	silver	564	582
påsklilja	daffodil	595	611	skyskrapa	skyscraper	618	577
räka	shrimp	629	618	smaragd	emerald	613	602
skallerorm	rattlesnake	586	611	stuga	cottage	593	607
sköldpadda	tortoise	602	539	säckpipa	bagpipe	601	594
stek	steak	646	647	telefon	telephone	619	655
utter	otter	631	572	termometer	thermometer	612	581
varg	wolf	595	610	trombon	trombone	606	579
vulkan	volcano	591	627	uniform	uniform	550	591

Table 3: Concrete nouns with concreteness (C) and imageability (I) values.

The 60 abstract nouns (Tab. 4) were divided into three subcategories: EMOTIONS includes nouns which describe inner feelings, such as *ilska (anger), glädje (joy), lättnad (relief)*, INTERACTION STATES includes nouns which describe states or acts based on human interaction, such as *diskussion (discussion), kärlek (love), förolämpning (insult)*. ABSTRACT RELATIONS includes nouns which describe relations in time or space, e.g. *början (beginning), riktning (direction)*, relations between states or objects, e.g. *kombination (combination), skillnad (difference)* or whole situations e.g. *framtid (future), kaos (chaos)*. They can be used in a variety of contexts. The abstract nouns have a mean concreteness rating *M* = 281, *SD* = 34 and a mean imageability rating *M* = 386, *SD* = 74.

EMOTIONS				INTERACTION STATES				ABSTRACT RELATIONS			
Swedish	**English**	**C**	**I**	**Swedish**	**English**	**C**	**I**	**Swedish**	**English**	**C**	**I**
depression	depression	303	453	ansvar	responsibility	222	294	början	beginning	318	359
desperation	desperation	257	389	attityd	attitude	265	321	framtid	future	311	413
entusiasm	enthusiasm	266	464	avundsjuka	jealousy	250	475	fördel	advantage	282	292
förvåning	amazement	277	456	diskussion	discussion	341	381	ideal	ideal	253	331
glädje	joy	300	533	fientlighet	hostility	277	437	kaos	chaos	299	464
hat	hatred	239	417	förolämpning	insult	375	477	kombination	combination	326	326
hopp	hope	261	421	förtroende	confidence	270	371	konsekvens	consequence	260	299
humör	mood	234	394	komplimang	compliment	302	406	kris	crisis	319	375
ilska	anger	315	488	kärlek	love	311	569	metod	method	303	304
lättnad	relief	303	432	lojalitet	loyalty	261	411	mysterium	mystery	256	472
njutning	pleasure	302	511	lydnad	obedience	238	394	omständighet	circumstance	250	210
nyfikenhet	curiosity	303	394	löfte	promise	---	320	orsak	reason	332	285
optimism	optimism	240	418	medlidande	pity	303	391	reaktion	reaction	312	395
oro	anxiety	241	422	moral	morale	220	341	riktning	direction	336	399
osäkerhet	uncertainty	237	283	prestige	prestige	248	394	skillnad	difference	270	293
passion	passion	300	467	rykte	rumour	311	353	tendens	tendency	243	261
raseri	fury	305	462	samvete	conscience	255	386	undantag	exception	260	232
rädsla	fear	326	394	tacksamhet	gratitude	239	396	värde	value	260	289
sorg	sorrow	282	429	tradition	tradition	291	354	ögonblick	moment	301	334
tvekan	hesitation	257	332	ärlighet	honesty	278	386	överflöd	abundance	267	386

Table 4: Abstract nouns with concreteness (C) and imageability (I) values.

There are a number of factors besides concreteness and imageability which may possibly affect how easily a word is processed. Age of acquisition, operativity, frequency, familiarity, word length and visual complexity are all factors that might influence naming performance in aphasics (Nickels & Howard, 1995).

Since long words take longer time to articulate, working memory capacity is better for short words (Nyberg, 2002). The nouns used in the present study have 1-4 syllables (M = 2.6, SD = 0.8), to minimize the risk that word length could affect comprehension negatively for the aphasic participants. The abstract and concrete nouns were matched for number of syllables: Concrete nouns $M = 2.45$, $SD = 0.769$ and abstract nouns $M = 2.65$, $SD = 0.899$, $t(118) = -1.310$, $p = 0.193$.

Word frequencies were obtained from the Stockholm Umeå Corpus (Ejerhed et al., 1992) to give some information as to how common the Swedish translations of the nouns are. Due to time limitations, no extensive search was made to match abstract and concrete nouns for frequency. Although the abstract nouns used in the tests have a higher mean frequency $M = 61.35$, $SD = 75.065$ than the concrete nouns $M = 11.88$, $SD = 22.179$, $t(118) = -4.895$, $p < 0.001$, this difference was deemed acceptable, since neither Allwood & Ahlsén (1987) nor Nickels & Howard (1995) found any great effect of word frequency on aphasic word access and naming performance. One could also argue that the greater frequency of the abstract nouns, if anything, would make them easier to access, which would work against the hypothesis being tested in the study.[6]

Another way to get a picture of how common a word might be is to look at familiarity ratings. Familiarity ratings were obtained from the MRC database. There is a significant difference in

6 One explanation of the higher frequency of the abstract nouns might be that the texts in the SUC are rich in abstract terms, but it could also be explained by the contextual constrains theory (Wiemer-Hastings et al., 2001). If the possible contexts for abstract nouns are less constrained, that would make them likely to be more frequent.

familiarity ratings, with the abstract words being rated more familiar $t(118) = -2.582$, $p = <0.05$.

Age of acquisition (AoA) ratings was the factor found to have the greatest effect on aphasic naming performance by Nickels & Howard (1995). However, many of the nouns had no AoA ratings in the MRC database. When choosing the concrete nouns for the present study, an attempt was made not to include too many that were likely to have been learned at a very young age (such as *ball*, *cat*, *car*...etc).

2.2.2 The multiple-choice test

The multiple-choice test included 60 questions, each consisting of an abstract or concrete noun followed by one correct and three incorrect definitions (Fig. 7). The noun and the alternatives were always read aloud by the test leader embedded in a phrase with 'is' - e.g., *"RATTLESNAKE is... a reptile, a worm, an insect, a lizard?"*. The 30 concrete and the 30 abstract questions were mixed, with every second question being abstract. Each question was presented on a separate sheet of paper.

9) SKALLERORM 'RATTLESNAKE'	7) AMBULANS 'AMBULANCE'	32) LÄTTNAD 'RELIEF'	36) VÄRDE 'VALUE'
☐ reptil 'reptile'	☐ fartyg 'vessel'	☐ befrielse 'alleviation'	☐ krav 'claim'
☐ mask 'worm'	☐ apparat 'device'	☐ förståelse 'understanding'	☐ sätt 'way'
☐ insekt 'insect'	☐ fordon 'vehicle'	☐ förälskelse 'love'	☐ del 'part'
☐ ödla 'lizard'	☐ automat 'machine'	☐ belåtenhet 'contentment'	☐ pris 'price'

Figure 7: Examples of concrete (9, 7) and abstract (32, 36) multiple-choice questions.

Nouns were consistently used as answer alternatives. The incorrect answer nouns in each question had some semantic features in common with the correct one, but were unrelated enough not to be thought of as likely correct answers for a native speaker of Swedish without cognitive or language impairments. The nouns were all looked up in The Swedish National Encyclopedia Lexicon (2007) to make sure that the correct answers to the multiple choice test really accurately defined the nouns, and conversely, to make sure that the incorrect answers were highly unlikely to be percieved as possible correct choices.

An attempt was made to avoid the use of long, unusual, or difficult nouns as answer alternatives, and only nouns that most Swedish speakers should be familiar with were included. The nouns used as answer alternatives had 1-4 syllables. The nouns used as answer alternatives in each question did not differ in length by more than one syllable. No data was obtained about concreteness, imageability, familiarity and frequency for the answer alternatives, but in a pilot study with 7 healthy participants, virtually all of the questions were answered correctly. A couple of questions were modified after the pilot study, since it was found that they could be interpreted as having more than one possible answer.

2.2.3 The word association test

The word association test consisted of a list of 30 concrete and 30 abstract nouns. When nouns were chosen for the association test, they were matched with the nouns used in the multiple-choice test, so that every association test noun had a semantically corresponding noun in the multiple-choice test. The reason for this was that it would make the results of the word association test comparable to the results of the multiple-choice test, in the sense that it could be seen if the free associations were other nouns, as the alternatives in the multiple-choice test, or words of different classes.

Since the fact that only nouns were used as answer alternatives in the multiple-choice test could make the questions either easier or more difficult for the aphasics to process, depending on their individual differences, it was considered interesting to see which word classes they produced when they were allowed to associate freely to the same type of word.

2.3 Procedure

The word association test was carried out before the multiple-choice test, to avoid any influence from the multiple-choice test on the associations. Both tests were recorded with a Marantz PMD660 Portable Solid State Recorder and a IMG Stage Line ECM-302 B Boundary Microphone.

Prior to the word association test, the participants were instructed to say the first word that the word uttered by the test leader made them think of, and informed that any answer would be correct as long as it was the first word that came to mind. Two concrete nouns, *katt (cat)* and *stol (chair)*, which were not part of the test, were presented before the real test nouns, in order to verify that the participants had understood the instructions correctly. The concrete and abstract nouns were then read from a list by the test leader. Every second noun presented was abstract. Pauses and repetitions of the nouns were made when necessary.

Prior to the multiple-choice test, all participants were instructed to choose the ”best alternative”, to avoid the additional pressure it may put on the aphasic subjects to be asked to choose between ”right” and ”wrong” answers. When performing the multiple-choice test, the test leader sat beside the participant with a test form from which the noun and the alternatives were read aloud as described in **2.2.2**. Thus the questions were presented visually as well as auditorily. The nouns and the alternatives were repeated when necessary.

Since the aphasics had reading difficulties of varying degree, filling in the test forms on their own was deemed to be too difficult a task, but seeing the questions in written form in addition to hearing them was assumed to provide some support in keeping the answer alternatives in working memory.

Valuable information about how to facilitate communication with aphasia patients was found in Apt (1998).

2.4 Data analysis

2.4.1 Data analysis of the multiple-choice test

Three different scores, corresponding to the following criteria, were possible in the multiple-choice test:

a) Choosing *only the correct alternative* gave 1 point (which was the maximum score for a question).

b) Stating that *one of the incorrect alternatives was the best answer* or that *two or more alternatives were equally good* gave 0 points.

c) Considering *the correct alternative to be the best answer, but an additional answer to be somewhat correct* gave 0.5 points.

The reason for not simply categorizing the answers as correct or incorrect, was that there were cases where the participant chose more than one alternative. Thus, the three-step scale takes into consideration to some extent the participant's comprehension of the word in the cases where s(he) has not simply chosen one answer. Stating that one or more of the incorrect alternatives is as good as the correct one as in b) indicates an incomplete understanding of the word, while being able to single out the correct word as in c) indicates a better, although not perfect, word comprehension.

2.4.2 Data analysis of the word association test

Access times for the word associations were obtained from the recordings using the sound-editing software Audacity. Access time was defined as the time period from the point when the test leader had finished uttering the whole test word to the point when the participant began to utter the association word. In other words, access time is normally the silent period between the words. This period was marked in the waveform so the exact time could be seen (Fig. 8).

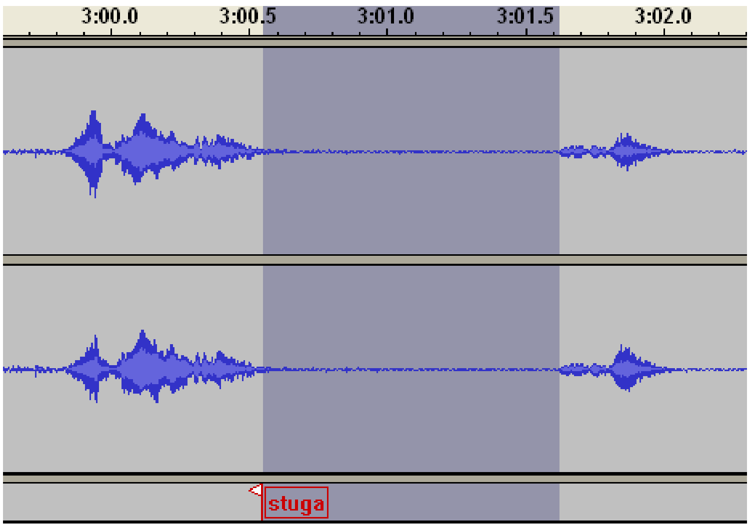

Figure 8: Waveform of a concrete test word 'stuga' (cottage) and an association word 'hus' (house). The silent periods between words were marked so that the exact access times could be seen.

There were, however, some occurrances of "non-association" words or phrases between the test word and the association word. Most frequently, these utterances consisted of the participant repeating the test word, but cases where a participant stated that (s)he found the task difficult, or that nothing came to mind, also occurred (Tab. 5). In these cases, the test leader sometimes repeated the test word or asked the participant to think a bit longer, to make sure that (s)he did not give up too quickly. In the majority of these cases, the participant eventually came up with an association word. Utterances such as these were considered as "thinking aloud", and included in the access time, measured until the participant began uttering the intended association word.

Examples	*'Nothing comes to mind'*
1. (Subject G)	**Lojalitet** Oj...jag tänker inte på någonting direkt. *Om du väntar en stund? Ibland så dyker det upp ett ord efter ett tag.* **Trofasthet**. **Loyalty** Wow...I don't think of anything right now. *If you wait for a while? Sometimes a word comes up after a while.* **Faithfulness**.
2. (Subject K)	**Undantag** Åh...där står det stilla...undantag...ja vad ska vi säga...**alla**. **Exception** Oh... it stands still there...exception...well what should we say... **everybody**.
3. (Subject 4)	**Leopard** Ja...jag vet inte om jag kan komma på något...En leopard...ja...**djur**, bara. **Leopard** Well..I don't know if I can come to think of anything... A leopard...well... **animal**, only.
4. (Subject 2)	**Persika** Persika...em...ja...persika...em...nä... *Du hade något där på gång?* Ja, persika och så ...eh...ja... *Fundera lite så...* Persika och så...**apelsin**. **Peach** Peach...um...well...peach...um...no... *You had something there?* Yes, peach and then...um..well...*Think about it for a while.* Peach and then...**orange**.

Table 5: Associations where the subject said (s)he could not come up with an association at first, but did so eventually. Utterances made by the test leader are in italics. Access time was measured between the two words in bold.

In a few cases, the participant did not hear the test word the first time it was uttered, and the test leader repeated the word. In these cases, access time was measured from the repetition (i.e. from the point when the participant could be considered to have heard the whole word for the first time).

When the association was a phrase consisting of a content word surrounded by function words, access time was measured up to the beginning of the content word (Tab. 6).

Examples	*Content word surrounded by function words*
1. (Subject I)	**Entusiasm** Åh, jag kommer på ett ord men kan inte förklara det...eh...att det **spritter** i en. **Enthusiasm** Oh, I know a word but I can't explain it... um.. when it **quivers** in you.
2. (Subject 3)	**Humör** När man är **glad**. **Mood** When you are **happy**.
3. (Subject D)	**Ideal** Ja det är ju...man...det är svårt med ett ord, ideal...ja det är en form av **synpunkt**, eller något. **Ideal** Well it is...you... it is difficult with one word, ideal..well it is a kind of **viewpoint**, or something.
4. (Subject J)	**Prestige** Det första jag får fram det är **ytlighet**. **Prestige** The first thing I can think of it is **shallowness**.

Table 6: Associations with content words surrounded by function words. Access time was measured between the two words in bold.

When the association was a phrase consisting of two content words, access time was measured up to the beginning of the first content word. Associations consisting of two content words were considered to include both words, since removing one of the words would alter the fundamental meaning of the association. Associations consisting of idioms and phrasal verbs, which are strings of words corresponding to single semantic units (Saeed, 2003) were treated in the same way (Tab. 7).

Examples	*Phrases consisting of two content words or phrasal verbs*
1. (Subject 1)	**Optimism → Glada människor** **Optimism → Happy people**
2. (Subject 1)	**Humör → Ups and downs [sic]** **Mood → Ups and downs**
3. (Subject F)	**Limousin → Lång bil** **Limousine → Long car**
4. (Subject F)	**Ansvar → Ta hand om** **Responsibility → Take care of**

Table 7: Associations consisting of phrases with two content words, e.g. adjective + noun (Ex. 1, 3), idioms (Ex. 2) and phrasal verbs (Ex. 4).

Sometimes the utterances contained disfluencies, i.e. cases when the participant began producing a speech sound present in the beginning of the word later given as association word, but repeated the sound or started over before uttering the whole word. Strong syllables are important for recognizing words in an incoming speech signal (Cutler & Norris, 1989). Producing the primary stressed syllable indicates that the association word has been accessed, whereas producing only a phoneme or an unstressed/secondary stressed syllable from the beginning of the word may be a part of the process of choosing a lexeme. Thus, when the part of the word uttered included the primary stressed syllable, access time was measured to that point. Otherwise access time was measured to the point where the production of the whole association word began (Tab. 8).

Examples	*Associations with repetitions or restarts*
1. (Subject 3)	**Tendens** Att man...vad ska man säga...man är **målmed**...vålmedveten. **Tendency** That one is...what should one say...one is **goal-ori**...oalgoriented.
2. (Subject 3)	**Mjölk** Lak...**Laktolmjölk**. **Milk** Lac... **Lactose-free milk**.
3. (Subject 1)	**Samvete** Me..mo...**moral**...eller. **Conscience** Me...mo...**morale**...or...
4. (Subject 1)	**Ärlighet Männur**...människa. **Honesty Huma**...human.
5. (Subject 1)	**Glädje** Eh...sss...**surhet**...eller. **Joy** Um...g...**grumpyness**...or...

Table 8: Associations with repetitions or restarts.

Associations were also classified as regards word class. Nine different word classes were given as associations: Nouns, adjectives, verbs, adverbs, interjections, pronouns, prepositions, conjunctions and numerals. Short phrases consisting of either phrasal verbs or two content words from the other word classes (most commonly adjective + noun) were considered two categories of their own (Tab. 7).

2.5 Statistical analysis

All statistical analysis was performed in SPSS. ANOVAs were performed with participant group (aphasic/control) as a between-subjects factor and concreteness (abstract/concrete) as a within-items factor, for both the multiple-choice test and the word association test. F_1 and F_2 tests were performed. F_1 and F_2 tests are frequently used in psycholinguistic research, and have the advantage that they can be used on data sets with missing data. In the F_1 test, subjects are treated as random factor and words as fixed factor. In the F_2 test, subjects are treated as fixed factor and words as random factor (Rietveld & van Hout, 2005).

Initially, an analysis was carried out which compared a group of all four aphasic participants with the control group. However, since subject 4, the participant with occipital lesions, showed signs of a reverse concreteness effect, a second analysis with him excluded was also carried out, comparing the other three (frontoparietal and temporoparietal) aphasics with the controls.

3. Results

3.1 Results for the multiple-choice test

3.1.1 Test scores

The participants in the control group all had close to a full score on the multiple-choice test. There was no great variability and none of the healthy participants showed a difference in their scores on the concrete and abstract questions (see Tab. 9).

Controls	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**Mean**
Concrete	30.0	29.0	28.0	30.0	29.0	29.0	30.0	30.0	30.0	29.5	30.0	29.0	29.5
Abstract	30.0	29.5	29.0	29.0	30.0	30.0	30.0	30.0	30.0	29.0	29.0	30.0	29.6

Table 9: Individual and mean multiple-choice test scores of the control group.

The participants in the aphasic group differed more in their multiple-choice test scores (see Tab. 10). Subjects 1-3 all had lower scores on the abstract questions, whereas subject 4 scored lower on the concrete questions. Subject 3 had close to a full score on the concrete questions and subject 4 had a full score on the abstract questions.

Aphasics	**1**	**2**	**3**	**4**	**Mean 1-4**	**Mean 1-3**
Concrete	26.0	25.0	29.5	23.5	26.0	26.8
Abstract	21.5	13.0	23.5	30.0	22.0	19.3

Table 10: Individual and mean multiple-choice test scores of the aphasic participants.

3.1.2 Analysis 1 of multiple-choice test scores: All aphasic participants included

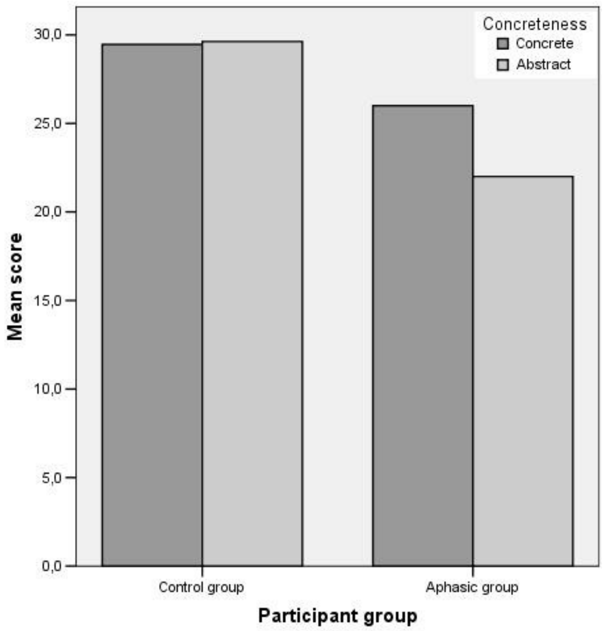

Figure 9: Mean multiple-choice test scores for concrete and abstract questions for the control group and the aphasic group.

With all aphasic participants included, the aphasic group's overall test scores were significantly lower than the control group's test scores $F_1(1,14) = 30.117$, $p < 0.001$; $F_2(1,58) = 63.194$, $p < 0.001$.

Overall test scores for the abstract questions were only significantly lower in the F_2-analysis $F_1(1,14) = 2.924$, $p = 0.109$; $F_2(1,58) = 5.858$, $p = 0.019$.

A marginal interaction of group and concreteness was present, with the test scores being relatively lower in the abstract condition in the aphasic group $F_1(1,14) = 3.494$, $p = 0.083$; $F_2(1,58) = 8.260$, $p = 0.006$.

3.1.3 Analysis 2 of multiple-choice test scores: Subject 4 excluded

When excluding the participant with occipital lesions, the aphasic group's overall test scores remained significantly lower than the control group's test scores $F_1(1,13) = 38.925$, $p < 0.001$; $F_2(1,58) = 57.876$, $p < 0.001$.

Overall test scores were significantly lower for the abstract questions $F_1(1,13) = 34.484$, $p < 0.001$; $F_2(1,58) = 15.127$, $p < 0.001$.

There was a significant interaction of group and concreteness $F_1(1,13) = 37.847$, $p < 0.001$; $F_2(1,58) = 19.590$, $p < 0.001$. The test scores thus depended on the group, with relatively lower scores for abstract questions in the aphasic group than in the control group.

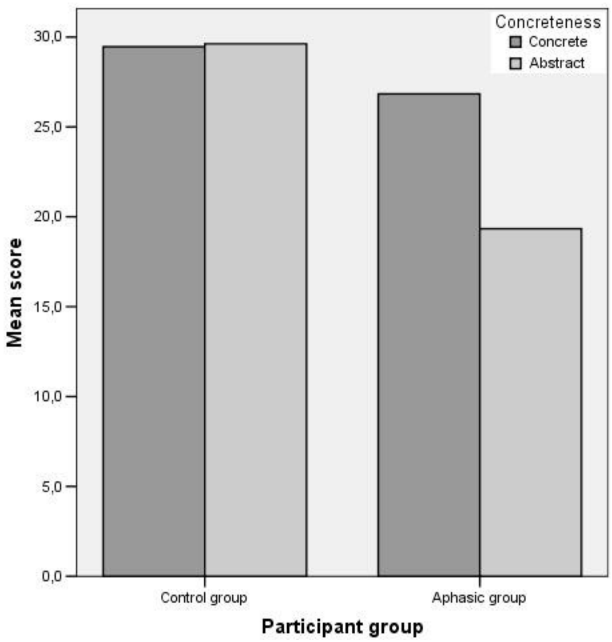

Figure 10: Mean multiple-choice test scores for concrete and abstract questions for the control group and the aphasic group without subject 4.

3.2 Results for the word association test

3.2.1 Access times

Mean access times for word associations were longer for the abstract nouns for all participants (Tab. 11-12). A considerable individual variation was present as regards both the overall access times and the difference between concrete and abstract nouns. In the control group, the mean access times for the concrete nouns ranged from being 17 % to 63 % of the mean access times for the abstract nouns. In the aphasic group, the mean access times for the concrete nouns varied between 26 % and 93 % of the mean access times for the abstract nouns (Tab.13).

Controls	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**All**
Concrete	1.2	1.0	3.0	2.3	2.1	1.7	2.0	1.1	2.1	4.3	2.4	1.5	2.1
Abstract	4.7	2.1	17.2	8.1	10.1	5.0	4.8	2.8	4.9	8.0	10.0	2.4	6.7

Table 11: Mean access times in seconds for word associations for concrete and abstract nouns, for the controls as individuals and as a group.

Aphasics	**1**	**2**	**3**	**4**	**Subjects 1-4**	**Subjects 1-3**
Concrete	3.7	8.8	2.3	11.4	6.6	4.9
Abstract	14.2	12.3	5.3	12.2	11.0	10.6

Table 12: Mean access times in seconds for word associations of concrete and abstract nouns, for the aphasics as individuals and as groups with and without subject 4.

Subject	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**1**	**2**	**3**	**4**
Quotient	0.26	0.48	0.17	0.28	0.21	0.34	0.42	0.39	0.43	0.54	0.24	0.63	0.26	0.72	0.43	0.93

Table 13: Quotients between access times for word associations for abstract and concrete nouns for all participants.

3.2.2 Analysis 1 of access times: All aphasic participants included

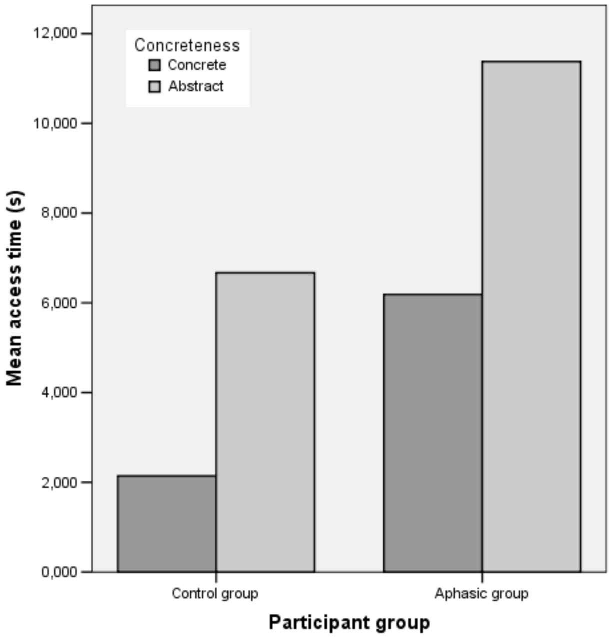

Figure 11: Mean access times for word associations for concrete and abstract nouns in the control group and aphasic group.

When all four aphasic participants were included in the analysis of word association access times, overall access times were significantly longer for the aphasic group than for the control group $F_1(1,14) = 8.217$, $p = 0.012$; $F_2(1,58) = 36.395$, $p < 0.001$.

Access times were significantly longer in the abstract condition $F_1(1,14) = 15.920$, $p = 0.001$; $F_2(1,58) = 21.896$, $p < 0.001$.

No interaction of participant group and concreteness could be seen in the access times $F_1(1,14) = 0.015$, $p = 0.903$; $F_2(1,58) = 0.763$, $p = 0.386$.

3.2.3 Analysis 2 of access times: Subject 4 excluded

When the word association access times were analyzed without subject 4, overall access times were marginally longer for the aphasic group than for the control group $F_1(1,13) = 4.260$, $p = 0.06$; $F_2(1,58) = 28.681$, $p < 0.001$.

Access times were significantly longer in the abstract condition $F_1(1,13) = 17.157$, $p = 0.001$; $F_2(1,58) = 29.257$, $p < 0.001$.

No interaction of participant group and concreteness could be seen in the access times $F_1(1,13) = 0.406$, $p = 0.535$; $F_2(1,58) = 2.717$, $p = 0.105$

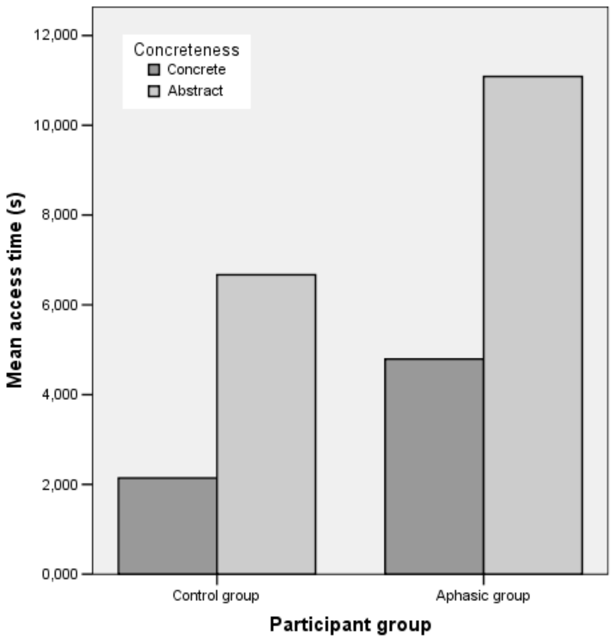

Figure 12: Mean access times for word associations for concrete and abstract nouns in the control group and aphasic group without subject 4.

3.2.4 Distributional analysis of word classes

A total number of 936 word associations were produced. The distribution of word classes can be seen in Tab. 14 and in Fig. 13-15.

noun	adjective	verb	numeral	phrase	adverb	interjection	phrasal verb	preposition	pronoun	conjunction	total
645	212	34	3	20	4	5	4	2	6	1	936

Table 14: Word classes given as word associations by all participants.

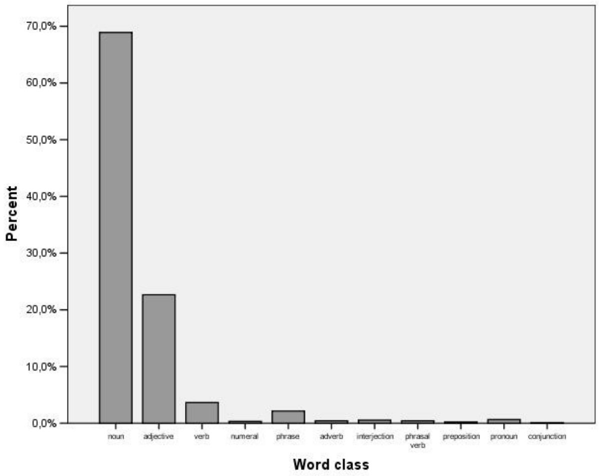

Figure 13: Word classes given as associations by all participants.

Nouns were by far the most common word class produced in the word association test, constituting 69 % of the associations; adjectives the second most common (23 %). Verbs were relatively rare (4 %) (Fig. 13).

A relatively greater percentage of adjectives and verbs were produced as associations for the abstract test nouns compared to the concrete test nouns. Still, the majority of the associations were nouns both for concrete and abstract test nouns (Fig. 14).

The aphasic participants associated to nouns even more consequently than the controls. (Fig. 15)

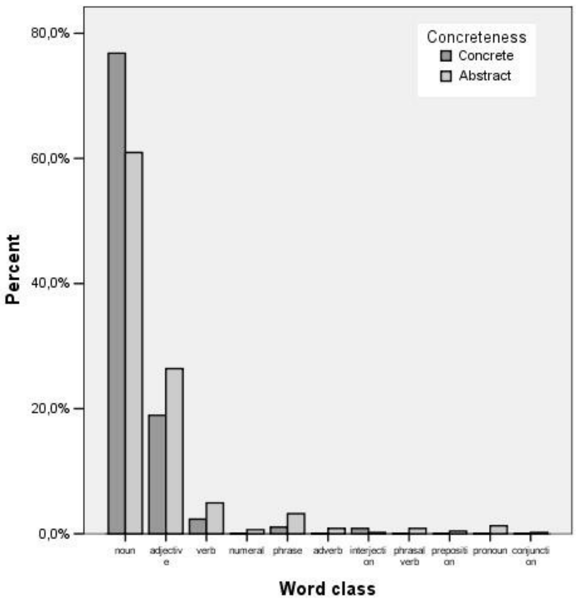

Figure 14: Word classes given as associations for concrete and abstract nouns.

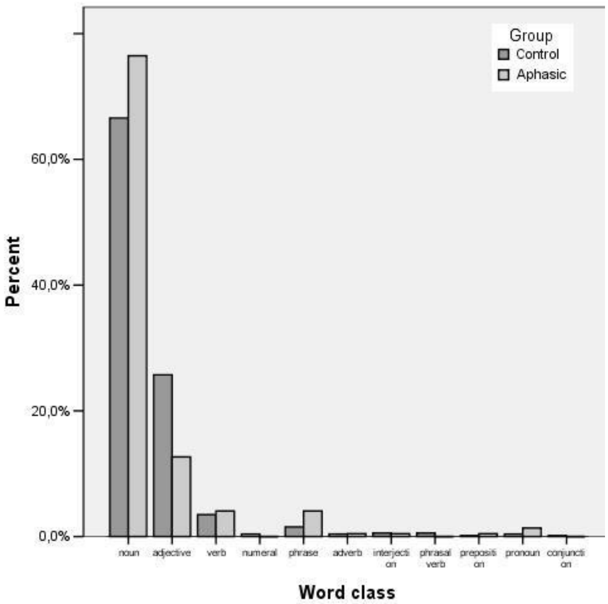

Figure 15: Word classes given as associations by healthy and aphasic participants.

3.2.5 Qualitative differences between the aphasic group and the control group

There were a number of qualitative differences in the associations produced by the aphasic participants compared to the associations produced by the controls.

A) Two of the aphasic participants tended to associate several of the abstract nouns with words from a fixed semantic field. In particular, nouns from the EMOTIONS category elicited associations to personal experiences (see Tab. 17). Subjects 1 and 3 both showed this pattern: Subject 1 associated several of the abstract nouns with persons she knew and terms from an organization she is active in. Subject 3 associated many of the abstract nouns with personal characteristics, her stroke or the hospital. No such pattern could be seen for the concrete nouns in any of the participants (see Tab 16).

B) Aphasic speech is sometimes characterized by perseverations. Perseverations are most commonly observed in patients with frontal damage, and refer to the situation where a behaviour is repeated in an inadequate way as a response to new input. In aphasia, this means that the same word or phrase is repeated as a response to new questions (Apt, 1998). Subject 2 showed signs of perseveration when the test noun was abstract (see Tab. 17). She used the same word, *sant (true)* and the opposite *osant (untrue)* several times when given abstract nouns as input. She also had a strategy of constructing answers with the prefix *o- (un-)* attached to a form of the given noun (in some cases the same form, in some cases inflected). This sometimes resulted in real words such as *oansvarig (irresponsible),* but equally often in neologisms such as *opassion (unpassion)*. Words of the above mentioned types constituted a majority of her associations for the abstract nouns. In contrast, she succeeded in coming up with an independent, semantically related association for nearly all of the concrete nouns.[7]

C) Subject 4 constructed some new compound words. Again, this also occured in the controls, but only rarely.

3.2.6 Qualitative differences between concrete and abstract nouns

As can be seen in Tab. 15, words that had occurred earlier in the word association test, either as test nouns or associations, were repeated to a higher degree for the abstract nouns.

Participant	A	B	C	D	E	F	G	H	I	J	K	L	1	2	3	4	Total
Concrete	1	0	4	0	0	1	2	3	4	3	1	5	0	2	0	4	30
Abstract	6	1	5	4	2	3	4	5	1	5	1	11	7	10	5	3	73

Table 15: Number of repetitions of words that had occurred earlier in the word association test.

7 The same pattern was seen in word association data from a fifth aphasic (see *Tab. 16-17*), not included in the present analysis since his diagnosis was not known at the time of completion of this thesis. Subject 5's perseveration consisted of frequently responding to the abstract nouns with either *glädje (joy)* or *förstå (understand)*. He also created antonyms by adding prefixes to the test nouns, e.g. *reaktion (reaction)* elicited the association *inreaktion (inreaction)*, and *framtid (future; literally "forward time")* gave the association *baktid ("back time")*.

Concrete nouns	1	2	3	4	(5)
katt 'cat'	mus 'mouse'	hund 'dog'	hund 'dog'	kvinna 'woman'	mjau 'miaow'
stol 'chair'	bord 'table'	bord 'table'	bord 'table'	sitta 'sit'	---
krokodil 'crocodile'	giraff 'giraffe'	fanta* 'elefant'	ödla 'lizard'	trädgård 'garden'	stor 'big'
pincett 'tweezers'	mjölk 'milk'	peang 'forceps'	ögonbryn 'eyebrow'	huvud 'head'	borste 'brush'
klarinett 'clarinet'	gitarr 'guitar'	trumpet 'trumpet'	spela 'play'	instrument 'instrument'	saxofon 'saxophone'
jordgubbe 'strawberry'	mjölk 'milk'	hallon 'raspberry'	hallon 'raspberry'	mat 'food'	---
dragkedja 'zipper'	knappar 'buttons'	dragsko '~grommet'	jacka 'jacket'	mage 'belly'	står igen [sic] '~closes'
makaron 'macaroni'	pasta 'pasta'	---	pasta 'pasta'	efterrätt 'dessert'	mexikansk 'Mexican'
fönster 'window'	dörr 'door'	karm 'frame'	putsa 'polish'	utsikt 'view'	utkik 'lookout'
sköldpadda 'tortoise'	bur 'cage'	våreld 'kalanchoe flower'	hav 'sea'	---	liten som klättrar 'small that's climbing'
persika 'peach'	frukt 'fruit'	apelsin 'orange'	banan 'banana'	efterrätt 'dessert'	äpplen 'apples'
termometer 'thermometer'	Fahrenheit	feber 'fever'	kallt 'cold'	temperatur 'temperature'	två sorter 'two kinds'
stuga 'cottage'	hus 'house'	sommarnöje 'summer relaxation'	skog 'forest'	boning 'dwelling'	liten 'small'
leopard 'leopard'	tiger 'tiger'	geopard[sic] 'cheetah'	savann 'savannah'	djur 'animal'	mindre än lejon 'smaller than lion'
blomkål 'cauliflower'	broccoli 'broccoli'	rosenkål 'brussels sprout'	usch 'yuck'	mat 'food'	växter 'plants'
fjäril 'butterfly'	puppa 'pupa'	---	himmel 'sky'	fågel 'bird'	blommor 'flowers'
klänning 'dress'	kjol 'skirt'	kostym 'suit'	fashion	klädnad 'clothing'	fruntimmer '~dame'
limousin 'limousine'	taxi 'taxi'	bil 'car'	New York	---	bil 'car'
smaragd 'emerald'	diamant 'diamond'	---	safir 'sapphire'	---	guld 'gold'
mjölk 'milk'	grädde 'cream'	smörgås 'sandwich'	laktolmjölk [sic] 'lactose-free milk'	dryck 'drink'	komjölk 'cow milk'
siden 'silk'	tyg 'fabric'	koppar 'copper'	Indien 'India'	plagg 'garment'	tyg 'fabric'
choklad 'chocolate'	godis 'candy'	kola 'toffee'	gott 'tasty'	mat 'food'	äter 'eats'
nejlika 'carnation'	blomma 'flower'	ros 'rose'	jul 'Christmas'	---	blomma 'flower'
revolver 'revolver'	gevär 'rifle'	skott 'shot'	pistol 'pistol'	uppskjutningsredskap* '~launching device'	pang 'bang'
järn 'iron'	guld 'gold'	koppar 'copper'	rost 'rust'	---	järnvägsräls 'rail track'
varg 'wolf'	björn 'bear'	räv 'fox'	Norrland	---	stor hund 'big dog'
säckpipa 'bagpipe'	instrument 'instrument'	klarinett 'clarinet'	Skottland 'Scotland'	blåsinstrument 'wind instrument'	stor pipa 'big pipe'
gurka 'cucumber'	tomat 'tomato'	tomat 'tomato'	grön 'green'	mat 'food'	grönsak 'vegetable'
förstärkare 'amplifier'	högtalare 'loudspeaker'	radio 'radio'	högtalare 'loudspeaker'	höjare* '~increaser'	förstärker upp 'amplifies'
vulkan 'volcano'	vatten 'water'	berg 'mountain'	Etna	---	berg 'mountain'
ek 'oak'	träd 'tree'	björk 'birch'	golv 'floor'	träd	träd 'tree'
kamera 'camera'	lins 'lens'	foto 'photo'	digital 'digital'	tar bilder 'takes pictures'	videokamera 'video camera'

*Table 16: Word associations for the concrete nouns produced by the aphasic participants. Words marked with * are, to the best of the author's knowledge, new constructions.*

Abstract nouns	1	2	3	4	(5)
glädje 'joy'	surhet* '~grumpyness'	sorg 'sorrow'	glad 'happy'	sorg 'sorrow'	glad 'happy'
tradition 'tradition'	kontext 'context'	glädje 'joy'	stenbock 'capricorn'	sed 'custom'	glatt 'happy'
början 'beginning'	the end	slut 'end'	slut 'end'	inledning 'introduction'	slutet 'the end'
ilska 'anger'	arg 'angry'	---	arg 'angry'	arg 'angry'	glädje 'happiness'
lojalitet 'loyalty'	upprättelse 'redress'	---	jag 'me'	mycket lojal 'very loyal'	glädje 'happiness'
undantag 'exception'	expression	---	odd	bekräftelse 'confirmation'	---
depression 'depression'	meditation 'meditation'	fönster 'window'	MAS	sorglighet* '~sadness'	ledsen 'sad'
moral 'morale'	etik 'ethics'	tankeställare 'eye-opener'	Lund	gärningsåsikt*	högt stående 'advanced'
reaktion 'reaction'	kontext 'context'	sant 'true'	stroke 'stroke'	reagera 'react'	inreaktion* 'inreaction'
hat 'hatred'	ilska 'anger'	ilska 'anger'	MAS	ilska 'anger'	glädje 'happiness'
ärlighet 'honesty'	människa 'person'	sant 'true'	lojal	varar längst 'lasts the longest'	glädje 'happiness'
fördel 'advantage'	jobb 'work'	sant 'true'	logoped 'speech therapist'	mitten 'the middle'	nackdel 'disadvantage'
osäkerhet 'uncertainty'	skälvningar 'tremblings'	sant 'true'	feg 'cowardly'	jag 'me'	osäker 'uncertain'
samvete 'conscience'	moral 'morale'	osant 'untrue'	vän 'friend'	förmåga 'ability'	förstå 'understand'
kris 'crisis'	glädje 'joy'	osant 'untrue'	stress 'stress'	svårighet 'difficulty'	upprörd 'upset'
passion 'passion'	NAMN (NAME)	opassion* 'unpassion'	röd 'red'	önskan 'wish'	känsla 'feeling'
förolämpning 'insult'	mamma 'mother'	osant 'untrue'	mobba 'bully'	nedsågande*	tar vid mig '~feels hurt'
ideal 'ideal'	NAMN (NAME)	sant 'true'	---	bästis '~best friend'	förstå 'understand'
entusiasm 'enthusiasm'	together	---	NAMN (NAME)	entusiastisk 'enthusiastic'	förstå 'understand'
lydnad 'obedience'	kris 'crisis'	olydnad 'disobedience'	hund 'dog'	eftergöra* '~do as someone says'	förstå 'understand'
kombination 'combination'	arg och ledsen 'angry and sad'	---	dans 'dance'	samband 'relation'	lika 'similar'
humör 'mood'	ups and downs	ohumör*'unmood'	glad 'happy'	ilska 'anger'	glatt 'happy'
prestige 'prestige'	inte bra 'not good'	---	bra jobb 'good work'	---	förstå 'understand'
omständighet 'circumstance'	väljer 'chooses'	---	läkare 'doctor'	orsak 'cause'	omständigt 'lengthy'
rädsla 'fear'	glad 'happy'	orädd 'unafraid'	inte prata 'not to speak'	feghet 'cowardice'	rädd 'afraid'
ansvar 'responsibility'	föräldrarna 'the parents'	oansvarig 'irresponsible'	svara 'answer'	veta 'know'	förstå 'understand'
framtid 'future'	purples?	orädd 'unafraid'	arbeta 'work'	imorgondag* '~tomorrowday'	baktid* 'back time'
optimism 'optimism'	glada människor 'happy people'	orädd 'unafraid'	jag 'me'	braåsikt* '~goodopinion'	glad 'happy'
fientlighet 'hostility'	mamma 'mother'	---	ovänner 'enemies'	ilska 'anger'	fientlig 'hostile'
tendens 'tendency'	kulturen 'culture'	otendens* 'untendency'	målmedveten 'goal-oriented'	framåtskådande* '~forward looking'	förstå 'understand'

*Table 17: Word associations for the abstract nouns produced by the aphasic participants.Words marked with * are, to the best of the author's knowledge, new constructions. For anonymity reasons, person names are not specified.*

	jordgubbe 'strawberry'	**makaron 'macaroni'**	**persika 'peach'**	**blomkål 'cauliflower'**	**mjölk 'milk'**	**choklad 'chocolate'**	**gurka 'cucumber'**
A	grädde 'cream'	spaghetti	nektarin 'nectarine'	soppa 'soup'	kall 'cold'	sött 'sweet'	svalt 'cool'
B	hallon 'raspberry'	spaghetti	hallon 'raspberry'	grönsak 'vegetable'	mejeriprodukt 'dairy product'	godis 'candy'	grön 'green'
C	hallon 'raspberry'	pasta	frukt 'fruit'	grönsak 'vegetable'	bomull 'cotton'	gott 'tasty'	gott 'tasty'
D	smultron 'wild strawberry'	spaghetti	plommon 'plum'	grönkål vegetable'	vatten 'water'	kola 'toffee'	tomat 'tomato'
E	bär 'berry'	pasta	frukt 'fruit'	grönsak 'vegetable'	grädde 'cream'	godis 'candy'	gott 'tasty'
F	äta 'eat'	pasta	luddig 'fuzzy'	huvud 'head'	kaffe 'coffee'	dryck 'drink'	grön 'green'
G	sommar 'summer'	pasta	sharonfrukt 'persimmon'	grönsak 'vegetable'	kor 'cows'	rättvisemärkt 'fair trade'	NAMN (NAME)
H	sommar 'summer'	NAMN (NAME)	len 'smooth'	gott 'tasty'	kaffe 'coffee'	sött 'sweet'	grön 'green'
I	god 'tasty'	god 'tasty'	mjuk 'soft'	stuvning 'stew'	vitt 'white'	mörkt 'dark'	vatten 'water'
J	sommar 'summer'	pasta	luden 'hairy'	nyttigt 'healthy'	ko 'cow'	kexchoklad 'chocolate wafer'	fräscht 'fresh'
K	sommar 'summer'	hungrig 'hungry'	len 'smooth'	grönsak 'vegetable'	kossor 'cows'	kakao 'cacao'	Västerås (Swedish pickle brand)
L	gott 'tasty'	barn 'child'	lent 'smooth'	gott 'tasty'	vitt 'white'	gott 'tasty'	tsatsiki
1	mjölk 'milk'	pasta	frukt 'fruit'	broccoli	grädde 'cream'	godis 'candy'	tomat 'tomato'
2	hallon 'raspberry'	---	apelsin 'orange'	rosenkål 'brussels sprout'	smörgås 'sandwich'	kola 'toffee'	tomat 'tomato'
3	hallon 'raspberry'	pasta	banan 'banana'	usch 'yuck'	laktolmjölk [sic] 'lactose-free milk'	gott 'tasty'	grön 'green'
4	**mat 'food'**	**efterrätt 'dessert'**	**efterrätt 'dessert'**	**mat 'food'**	**dryck 'drink'**	**mat 'food'**	**mat 'food'**

Table 18: Word associations for food-related nouns. Words without translation are the same in English as in Swedish. Associations produced by subject 4 are written in bold at the bottom row. For anonymity reasons, person names are not specified.

4. Discussion

4.1 The test results

4.1.1 The multiple-choice test

The results from the multiple-choice test indicate a concreteness effect in noun comprehension for the participants with the frontoparietal and temporoparietal lesions (subjects 1-3). That is, the comprehension of concrete nouns was better relative to the comprehension of abstract nouns for these participants as a group. Whereas subjects 1-3 all scored lower on the abstract questions in the multiple-choice test, subject 4 showed the opposite results, reaching a maximum score on the abstract questions, but giving several incorrect answers for the concrete ones.

As a rule, the participants in the control group waited for all answer alternatives to be read and then quickly chose one alternative without hesitating or discussing the options. In contrast, the aphasic participants frequently relied on a process of elimination to make their decisions. The use of this strategy was more common in the abstract questions for all of the aphasic participants except subject 4, who used it more frequently in the concrete questions. The participants with frontoparietal lesions, subjects 1 and 2, both showed a tendency of taking a great deal of time answering many of the abstract questions, whereas several of the concrete questions were answered even before the test leader had read all of the alternatives. There were also cases where the aphasic participants could not limit themselves to only one alternative, because they felt that multiple alternatives could be correct.

The use of the scale with the three possible scores 1 p, 0.5 p and 0 p (described in **2.4.1**) accounts for the cases where more than one alternative was chosen, but the time-consuming process of elimination strategy and the contrastingly fast responses for the concrete questions are not captured using the present method. If the response times from the multiple-choice test could be compared, the results would probably show substantially longer response times for the abstract questions. However, since the original plan with the multiple-choice test did not include any measuring of response times, no explicit instructions were given to the participants about when to answer them. Some participants waited to answer the questions until all answer alternatives were read, whereas some answered as fast as they could, which makes a precise comparison of response times impossible. For this reason, no attempt was made to make a quantitative analysis of response times in the multiple-choice test. Still, the difference deserves to be mentioned.

4.1.2 The word association test

As regards access times in the word association test, an overall concreteness effect was present, with the access times for abstract noun associations being longer for all participants, but this difference was not significantly greater for the aphasic participants. In contrast, the time difference was quite small for subject 2 and even smaller for subject 4 (see Tab. 13). In subject 2's case, a likely explanation for the small time difference is the fact that she was perseverating when given abstract but not when given concrete nouns. Whereas a semantically related association, such as the ones given by subject 2 for most of the concrete nouns, must be the result of a search for a related word, a perseveration does not have to be. In subject 4's case, the close to equal access times for concrete and abstract nouns can be seen as a reflection of his specific difficulties with concrete nouns as compared to the other participants. With the qualitative word association differences described in **3.2.6** taken into consideration, the results indicate that the aphasic participants, except subject 4, had greater difficulties producing word associations for abstract nouns relative to concrete nouns.

It is, of course, very difficult to decide whether an association is ”normal” or not.[8] Although it is fair to assume that the nouns do have some prototypical associations – e.g. *ek (oak)* elicited the hyperonym *träd* (*tree)* in a majority of the cases, *säckpipa (bagpipe)* made many of the participants think of *Skottland (Scotland)*, and *glädje (joy)* often elicited the antonym *sorg (sorrow)* – participants also sometimes gave an association which at first glance seemed far-fetched, but had a close relation with the test word for this particular person. For example, one of the participants, who works as a welder, associated *järn (iron)* with *jobb (work)*.

”Common” as well as ”personal” associations can be activated by a test noun independently of the context and previously uttered words. Associations of the types A) and B), described in **3.2.6**, on the other hand, are situation dependent and not completely new. Instead, they depend on words or contexts which are already activated. Perseverations cannot be considered specific associations for the given words at all. These answers thus are qualitatively different from those that are specifically related to each new test noun.

Another difference was that whereas the controls rarely failed to access a verbal association, two of the aphasics were unable to access verbal associations for 13-16 % of the test nouns. Subject 4 was unable to access a verbal association for 8 nouns (7 concrete and 1 abstract) and subject 2 was unable to access a verbal association for 10 nouns (7 abstract and 3 concrete). Taking the rest of the results into account, this can be seen as further support for the assumption that the concrete nouns were particularly difficult for subject 4, while the abstract nouns were particularly difficult for subject 2. If there had been some kind of ”time penalties” for perseverations and omitted associations, the differences in the processing of concrete and abstract nouns would have shown more clearly even in the access times.

There was a great variability in access times between the participants, which may reflect individual differences in the way they reacted to the test situation. Sometimes the participants got ”blocked” when trying to associate to a word. A tendency to stick to one word class was observed – that is, if a participant began giving associations from one word class, a group of associations from the same word class frequently followed, perhaps indicating that they became ”primed” on that word class. This would also be one explanation for why nouns constituted such a large portion of the word associations.

4.2 Reverse concreteness effect in subject 4

Subject 4 had greater problems with the concrete nouns than with the abstract nouns in both tests. Nouns from the NATURAL OBJECTS category, e.g. animals, plants and food, seemed to be particularly difficult for him. Most of the questions he answered incorrectly in the multiple-choice test were from this category, and in the cases he produced associations for NATURAL OBJECTS nouns, they tended to be less specific than the ones given by the other participants – e.g. several of the food items elicited the not so specific association *mat (food)*, while the other participants' associations were words describing the type of food, properties of the food or concepts associated with the particular type of food (see Tab. 18). Although this might have been an individual strategy, it was not present in any of the other participants. Words for animals seemed to be the most difficult for subject 4, with some animals generating no association at all (*sköldpadda (turtle), varg (wolf)*),

8 Latent Semantic Analysis (LSA), which is based on the distribution of words in different contexts in large text corpora, can provide a way to quantify the association strength of word pairs. With LSA, pairs of words can be assigned different association values depending on how often they appear in the same type of context, thus giving an objective measurement of ”normality” (Landauer et al., 2007).

and some animals generating somewhat unusual associations (*katt - kvinna (cat – woman), krokodil -trädgård (crocodile – garden)*). In the two latter cases, subject 4 responded ”Cat... that is a strange word... I have never had a cat... I can see a cat in front of me, but I cannot think of any word that has to do with cat.” and ”Crocodile...it is far away from me...well, where can a crocodile be...well, I can say anything...garden for example”. The majority of the other participants associated cat with other animals (*dog, mouse*...) or the fact that it has *fur*. Crocodile was most frequently associated with other animals (e.g. *lizard*, *elephant*) or with being *green* or *dangerous*.

Although subject 4 has a right-sided homonymous hemianopia, i.e., a lack of vision on the right side of the visual field, he has no other known perceptual deficits. There are case reports of patients who show normal visual perception but impaired mental imagery. Farah et al. (1988) examined a patient with parieto-occipital lesions, who was able to recognize and draw objects when they were present, but unable to draw them from memory. This patient also had difficulties answering questions involving imagery, e.g. comparing the size of different objects (Goldstein, 2008).

Occipital lesions may result in a loss of knowledge of visual features. Since subject 4's lesions are localized to the left occipital lobe, it could be hypothesized that his difficulties with concrete nouns are caused by a failure to access words that are linked to visual representations of concrete concepts. Subject 4 claims that he is able to visualize a cat, but cannot come to think of any word that is associated with it. It is perhaps the case that he can access the concept 'cat' in a more general and abstract sense, but has difficulties accessing words describing some of its visual features. He produced no concrete adjectives as associations for any of the nouns, and rather many superordinate terms (Tab. 16-17).

A number of lesion studies as well as neuroimaging studies of healthy subjects have revealed that anterior inferior temporal lobe areas are important for the naming of living things (Gazzaniga et al., 2002). The results from the present study indicate that the occipital lobe may also be intimately involved in the processing of concrete nouns. This might be related to the linkage of concrete nouns – in particular natural objects – with visual features. Such a finding is consistent with the dual coding theory and the suggestion that cell assemblies representing concrete words include neuronal networks in the cortices involved in the perception of the concepts associated with them.

Producing new compound words may be a way to get more contextual information into one word (being able to give a more complete description of the word and still follow the instructions to say *the* first word that comes to mind).

4.3 General discussion

4.3.1 What the theories have in common

Although the different models for explaining the concreteness effect (dual coding, cell assemblies, context availability, greater number of semantic features) focus on different aspects of word representations, what they do have in common is that they all attribute the concreteness effect to ”more roads” leading up to concrete concepts (this is also pointed out by Hagoort (1998) and Crutch & Warrington (2005)). Since words are arbitrary symbols, some kind of associated knowledge has to be accessed to be able to comprehend them. The theories all say that concrete words are associated with more information, although they differ in their opinion about what this associated information primarily consists of. Thus, the greater number of semantic features suggested by Plaut and Shallice (1993) might involve sensory-motor information as well as more abstract features such as superordinate categories. The dual coding theory could be expanded to include e.g. associated emotional information, and the context suggested by the context availability theory may include sensory-motor as well as verbal information.

Although all associated knowledge can be assumed to facilitate the processing of words and be part of the cell assemblies associated with words, different types of knowledge may not be equally important. Considering the relative importance of vision compared to the other senses, and the large brain areas devoted to visual processing, being able to associate a word with an image may result in more widespread neural activity than if the word is associated with other modalities.

4.3.2 Concreteness and context

Schwanenflugel et al. (1988) showed that differences in the processing of concrete and abstract words can disappear when the words are presented in appropriate sentence or paragraph contexts. Ahlsén & Allwood (1991) observed a greater need to put words into verbal context for people with aphasia. Multimodal communication such as gestures, sounds and facial expressions also become more important for people with language disorders (Ahlsén, 2006).

In the word association test, nouns were presented one at a time, without any context and the participants had to come up with a one-word association. This, of course, is a more difficult task than explaining/associating to words with all possible means. The aphasic participants in this study frequently used gestures and sometimes pointed to objects in the room when they knew a word but could not come up with an association for it. Both the aphasic subjects and the controls sometimes produced associations consisting of more than one word despite the instructions (see e.g. Tab. 5, 6 and 7).

Whereas concrete nouns contain most of the features needed to comprehend them and have meanings that are stable across different contexts, abstract nouns frequently do not have a stable context-free meaning. For example, the meaning of the concept *birch* does not change much depending on context, and can be understood without much extra information, whereas highly abstract nouns such as *difference, comparison, direction* and *beginning* only have clear meanings in relation to something else. This lack of independent meaning makes context crucial to understanding such nouns.

When constructing the multiple-choice test questions, hyperonyms could in most cases be used as answer alternatives for the concrete nouns. For the abstract nouns, however, this was in most cases not possible. Because of this, synonyms were, in most cases, used as answer alternatives for the abstract nouns. Since many abstract nouns do not have synonyms or cannot be appropriately defined with a single noun, several of the abstract nouns that were initially on the list were discarded because it was impossible to construct one-noun answer alternatives for them. This difficulty of constructing exactly the same type of multiple-choice test alternatives for concrete and abstract nouns can be explained by a different organisation of concrete and abstract concepts as suggested by Crutch and Warrington (2005).

Although abstract nouns can be compared or contrasted with other abstract nouns, e.g. their synonyms or antonyms, the foundation needed to understand them in the first place is likely to be something more basic and concrete. When a concept such as *comparison* is acquired, it might be by imagining two different objects placed beside each other. If the information that is needed to comprehend abstract nouns is not *similar* words, but rather *more concrete* words, their connections to associated concrete words may be stronger than their connections to categorically related, abstract nouns. Whereas concrete nouns in themselves directly activate a number of other concrete properties and concepts, abstract nouns might have to activate more wide-spread and varied neuronal networks to evoke enough concrete knowledge to understand them. The fact that many of the abstract nouns describe more complex situations with temporal or spatial components is also likely to make them associated with definitions that consist of more than one word.

The abstract nouns that are emotionally charged because they denote positive or negative feelings, actions or situations, are probably easier to create a context for than the abstract nouns that are emotionally neutral. The tendency among the aphasic participants to associate the abstract nouns with personal positive or negative experiences may be a reflection of the ability of these nouns to evoke emotional and episodic memories. This may activate different brain structures than the processing of emotionally neutral words, e.g. the limbic system. Affective communication is to a high degree expressed with other aspects of language than words, e.g. prosody, facial expressions, gestures and nonverbal vocalisations, and is associated with subcortical, bilateral prefrontal and right-hemisphere structures (Van Lancker & Pachana, 1998). Since the lesions of the aphasic participants in the present study were localized to left-hemisphere cortical regions, the above mentioned structures would still be able to function normally.

4.4 Suggestions for improvement

Following are some aspects of the tests which have shown to be a bit problematic as well possible ways to improve the tests and the testing procedures for future studies discussed.

4.4.1 The nouns

In the present study, the nouns were chosen based on their semantic properties only. Since phonology was not weighed in as a factor, the nouns were not matched as regards orthographic/phonological features. It cannot be ruled out that this may have affected comprehension.

Age of acquisition was not a strictly controlled factor in the present study. Although an attempt was made to balance the words as regards age of aquisition, it is possible that a greater percentage of the concrete nouns were acquired at an earlier age – e.g., many of the nouns denoting animals can be assumed to have been learned at a relatively young age. In contrast, the abstract nouns include some complex concepts that may require more knowledge of the world to be understood.

Another factor that may affect how accessible a word is might be its emotionability. Learning and memory is strengthened when associated with strong emotions. In memory tests, emotionally charged words are easier to recall than neutral words (Goldstein, 2008). Nouns denoting emotions as well as other nouns with a positive/negative valence were among the abstract nouns in the present study, whereas the concrete nouns used in the study can be assumed to be less emotionally charged.

4.4.2 The multiple-choice test

Differences in the strategy used as well as the time it took to answer the multiple-choice questions were present, but difficult to quantify using the present method. There was a tendency among some of the aphasic participants to discuss the answer alternatives with the test leader, especially the abstract ones. This indicated comprehension difficulties which were not captured by the test scores in the cases when the correct answer was eventually chosen. Moreover, it cannot be excluded that they sometimes managed to get clues from the test leader. These problems could be solved by presenting the test with a computer. Without the test leader being present in the room, any influence from the test leader can be excluded. Response times could be registered from the point when the question is presented to the point when the participant marks an alternative. The questions could still be presented both auditorily and orthographically, with a possibility to click on the words to hear them again. The number of times the words were clicked on could also be registered and weighed into the results.

Sometimes more than one alternative was perceived as possible in the multiple-choice test. Keeping the incorrect alternatives not too obvious, yet not possible as anwers, is a fine balance. One example of this is *attityd (attitude)*, where the synonymous word *inställning* was used as the correct answer, and the words *intelligens (intelligence)*, *möjlighet (possibility)* and *utseende (appearance)* as incorrect answers. Here some of the controls considered *utseende* to be a possible answer.

Fruits and vegetables are a special case, where the biologically correct category is not always the same as the prototypical category. Biologically, a raspberry consists of several small fruits, whereas banana, cucumber and melon are all classified as berries. Knowledge of the biological categories might have led to some confusion for some of the participants. When it comes to the questions with nouns denoting animals, very few answered them incorrectly, but it was not unusual to add some kind of uncertainty expression like ”I think it is..” or a comment such as: ”I am not a biologist, but...”.

With respect to Crutch & Warrington’s (2005) conclusions, answering the concrete questions would have required choosing the right categories for concepts which are primarily organized by categories, whereas the abstract questions required choosing the right categories for concepts which are primarily organized by association, with the latter being more difficult in itself. Furthermore, the incorrect alternatives were concepts that shared semantic features (or, in some cases, the lack thereof) with the correct alternative, but in many cases they were also associated with the correct alternative in the sense that they could be part of the same lexical field or situation. Thus, the incorrect alternatives for the abstract nouns might have been less clearly delimited from the test noun than the incorrect alternatives for the concrete nouns. (Since the words always were read in phrases with *is*, it was made clear in every question that what was sought for was a definition and not just a related word. The questions did not constitute any difficulties for the healthy participants, but for the aphasic participants, this still might have added to the difficulty of the abstract questions.)

A possible problem with a multiple-choice test is that a participant may understand the question noun and still be unable to answer the question correctly if (s)he does not recognize the noun provided as the correct answer alternative.

4.4.3 The word association test

There is no way of knowing for sure whether the participants always say the first word they come to think of, or if they sometimes discard the first word they think of and try to give ”correct” answers, despite the instructions. The test situation in itself may induce some performance anxiety, and the fact that the participants have to tell their associations directly to the test leader might make them selfconscious and hesitate to say the first word that comes to mind if they feel that it is perhaps wrong. For participants without reading impairments, individually filling in test forms would make the test more anonymous. Another possibility could be to present the test nouns with a computer and instruct the participant to say the answer outloud.

The results of the word association test are not entirely straightforward to interpret, especially when it comes to lexical relations. One reason for this is that an association may be related to the test word in more than one way – e.g. words such as *cat* and *dog* are categorically as well as contextually related. Another reason is that, as mentioned above, although there are common associations and personal associations, there is no reason to consider the personal associations to be less ”normal”. Marking unusual associations during the test and asking the participants how they were thinking after the test can be informative. This was done in some cases in the present study, but not in a very systematic way. A third reason why the results of the word association test were difficult to interpret is that there were quite many cases of associations consisting of phrases. Removing words, even function words, alters the meaning of the association. Measuring the access times and categorizing the associations might have been easier if the participants had been more explicitly instructed not to talk while thinking of an association (and if they followed those instructions!). However, a possible drawback with giving such instructions is that it would be likely to increase the difficulty of the test for the aphasics. The fact that the word association test sometimes elicited phrases or longer explanations can also be seen as an advantage, since it provided some insight in the thought processes involved when the participants were accessing associations.

Although truly homonymous/polysemous words were not included in the word association test, two of the words were sometimes interpreted in another sense than the one intended. These are *nejlika (carnation)* which in addition to being a flower also, with the prefix *krydd-*, means *cloves*, and *omständighet (circumstance)*, which can be a kind of event but was interpreted by many participants as *omständlighet*, a noun derived from the adjective *omständlig* which means *lengthy* or *roundabout*. A pilot study with a greater number of participants might have revealed such cases.

There are clear priming effects in many subjects, especially with the abstract words (see Tab. 15). Perhaps some of the abstract words used in the test were too similar, for example *entusiasm (enthusiasm)* and *optimism (optimism)*. The noun *hat (hatred)* in seven cases elicited *ilska (anger)* which was one of the earlier test nouns, but only in one case the antonym *kärlek (love)*, which might otherwise have been expected to occur more often.

4.4.4 Other aspects

The limited number of aphasic participants and the heterogeneity of the localization of their lesions makes it difficult to generalize about groups of aphasics based on data from the present study. A greater number of aphasic participants with more homogenous diagnoses would, of course, be desirable. Quite clear differences could, however, still be seen in the processing of concrete and abstract nouns in the participants in this study.

4.5 Suggestions for further research

- Further analysis of the data collected for the present study, as regards e.g. lexical relations and the concreteness of the word associations, could be carried out.

- The present study provided no direct information about the neurophysiological correlates of the processing of abstract and concrete nouns. Such information could be obtained by carrying out an Event Related Potentials (ERP) study of abstract/concrete noun processing.

- Another possibility could be to investigate the influence of concreteness in the processing of other word classes, e.g. concrete and abstract adjectives (red-nice) or verbs (run-dream) with similar tests. It could be tested whether aphasics with specific verb difficulties have equal problems with motion verbs and other types of verbs.

- A fourth idea for a follow-up of the present study would be to investigate the effect of phonological similarity on the processing of abstract and concrete words in aphasics. Binder et al. (2005) found some evidence that the processing of abstract words may be more dependent on phonology than the processing of concrete words is, and a follow-up study by Moroschan & Westbury (2006) indicates the same. A modified version of the multiple-choice test from the present study could be used to test how phonological similarity between the answer alternatives affects the ability to choose the correct answer for questions with concrete and abstract words. Using questions with answer alternatives from the same auditory neighborhood is likely to increase the overall difficulty of the test, but if the processing of abstract words is generally more dependent on phonological features, it could also be hypothesized that phonological similarity of the answer alternatives might increase the difficulty more in the abstract condition.

- Onomatopoetic words could be described as the auditory domain's equivalents to iconic signs, since they, in addition to representing a sound, also have a phonological representation that is often very close to the actual sound. While a dual coding system with additional visual representations for concrete nouns is likely to contribute to their processing advantage, the extra 'auditory iconic' dimension of onomatopoeia might increase their concreteness and facilitate processing in a similar way. For example, animal calls, or the onomatopoetic versions of them, might be preserved even if the word for the animal is unaccessible due to brain damage.

- The spontaneous speech material in the recordings contains many word processing aspects other than concreteness, e.g. phonematic and lexical paraphasias and grammatical errors. With some additional material, these aspects could be analysed.

- If possible, it would be interesting to carry out more extensive case studies of some of the aphasic participants.

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Appendix: Glossary

anterior. Located near or toward the front of the head.

association cortex. Neocortex outside the primary sensory and motor cortices that functions to produce cognition.

bilateral. On both sides of the body.

cerebellum. Major structure of the hindbrain specialized for motor coordination.

cerebral cortex. Outer layer of brain-tissue surface composed of many neurons.

gyrus. A small protrusion or bump formed by the folding of the cerebral cortex.

hemisphere. Literally, half a sphere, referring to one side of the cerebellum or one side of the cerebral cortex.

inferior. Located below.

lateral. Toward the side of the body.

medial. Toward the body's midline.

posterior. Located near or toward the back of the head.

prefrontal cortex. The cortex lying in front of the motor and premotor cortex of the frontal lobe.

Rolandic fissure (central fissure). Fissure which marks the boundary between the frontal and parietal lobe.

sagittal. Parallel to the length (from front to back) of the skull.

sulcus. A groove in brain matter, usually a groove found in the neocortex or cerebellum.

superior. Located above.

Sylvian fissure (lateral fissure). Fissure on the side of the brain which constitutes the boundary between the temporal lobe and the frontal and parietal lobe.

(Kolb & Wishaw, 2006)