Processing of Proper Names in Mandarin Chinese: A Behavioral and Neuroimaging Study

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In memory of my father

Contents

Introduction: Categories, linguistic categories and their cognitive representation

This question has often been raised whether thought is possible without speech; further, if speech and thought be not but two facets of the same psychic process.

(Sapir, 1921/1970, p. 13).

Building categories seems to be the most natural cognitive ability for human beings. This capability is demonstrated earlier than the use of language (for a review see Mandler, 2004). Three month old infants are already able to form ‘basic-level’ categories of animals, such as dogs and cats, as well as furniture, such as tables and chairs (Quinn & Eimas, 1996). Moreover, three-month-olds can form a more global category of mammals (Behl-Chadha, 1996). By observing the language acquisition process of children, one will surprisingly discover how commonly they apply the technique of categorizing. Children create possible meanings to correspond to word forms by drawing on their own experiences and on patterns of use for each form in the input language. By the age of one, most children have built up a considerable repertoire of conceptual categories. They have assimilated a significant amount of information about those categories represented in their memory (Clark, 1993). The word *dog* is used to refer to animals like cast, caws, sheep etc. that have four legs and a tail whereas the word *bird* is used to refer to flying creatures with wings such as sparrows and bats. It is more than a mystery what features belongs to a conceptual category. One of the important features is, for example, the shape of objects. However, by identifying more and more items with different features and creating categories to make those items organized, an important part of language acquisition forms.

Categorizing does not only occur in daily life but is also applied in sciences. Thinking as process such as induction is an important strategy in many classical sciences. Induction can be seen as a process of categorizing in which features are summarized into an upper class. Taking a view into the classical zoology, its main aim is to describe living creatures systematically. For this purpose, hierarchical categories are used and general features of those categories are defined. For example, the category ‘mammal’ includes animals with features such as homoeothermic vertebrates, parental care including the feeding of milk to offspring, mammary glands, fur, specialized teeth, secondary jaw, palate etc. Without definitions for this category, one would difficultly categorize whales as mammals since they look like fish and, unlike the most mammals, live in the ocean (Müller, 2004).

Another example for the use of categorizing in the science can be found in the descriptive linguistics. Language as a research object can be traced back to the ancient Greeks in which etymology, phonetics and grammar were topics of study. The framework of grammatical description in western Antiquity was the word and paradigm model.

> *A word-based grammar involves three main procedures: the identification of the word as an isolable linguistic entity; the establishment of a set of word classes to distinguish and classify the words in the language; and the working out of adequate grammatical categories to describe and analyze the morphology of words entering into paradigms of associated forms and the syntactic relations obtaining between words in the construction of sentences.*
>
> *(Hockett, 1954, as cited in Robins, 1997, p. 31).*

This is clear evidence that a category of word was defined as a basic linguistic unit and further subcategories could be differentiated within this class. For instance, Aristotle gave a formal definition for *ónoma*, name or noun as "a sound sequence having a meaning by convention without any temporal reference". He further found the categories of gender in nouns and listed typical gender determinations (Robins, 1997, p. 33).

Since categorizing has been a human instinct, there are cognitive categories which are different even amongst native speakers. Categories such as 'edible' *vs*. 'inedible', 'animate' *vs*. 'inanimate' are differently represented in human cognition (Caramazza & Shelton, 1998; Tyler & Moss, 2001). There is also evidence that such conceptual categories exist in infants' brain. The category 'animate' *vs*. 'inanimate', for example, are differentiated by infants as well. In Mandler's studies (for a review see Mandler, 2004), nine-month-olds can differentiate airplanes and birds which are perceptually highly similar, but fail to differentiate dogs and fish.

As was mentioned, there are many conceptual categories that are universal and independent from the mother tongue. Interestingly, some categories in the classification of words are considered to be universal as well, since one can find the class of nouns, the class of verbs, and the class of adjectives in almost all languages.

This dissertation is intended to investigate the dissociation between proper names and common nouns for several reasons. First of all, proper names have been considered as an universal language class (Bright, 2003; Müller, 2004). The dissociation between proper names and common nouns has been discussed in both the European and Chinese philosophy of language for more than two thousand years (Yen & Müller, 2003). Furthermore, this dissociation has been found in experimental data as well (Müller & Kutas, 1996; Müller & Kutas, 1997, Schuth et al., 2002; Weiss & Müller. 2003; Werner & Müller, 2001, Yen & Müller, 2003, Yen et al., 2005a, b; Yen et al., 2006). In addition, proper names provide a special function which is more than conventional language. From a biological point of view, names serve the function of identifying individuals for human beings just like acoustic signals for colonial breeding birds (Müller & Kutas, 1997). One may ask if the cognitive representation of proper names is independent of languages and if there are more cognitive mechanisms supporting the processing of proper name than conventional theories suggest.

This dissertation is divided in two main parts. Part one, including chapter one to chapter four, aims to introduce linguistic definitions of proper names and provide a brief review of empirical studies. Theoretical foundation of proper names will be discussed from four points of view: philosophical linguistics, descriptive linguistics, cognitive psychology and neurological findings, respectively in chapter one to chapter four. Since the present experiment investigates Mandarin Chinese speakers, Chinese-specific aspects will be integrated in these four chapters. In addition, chapter five will give a brief introduction of fMRI (functional magnet resonance imaging) that is applied to explore the neural correlates of the processing of proper names. In part two, a behavioral study and an fMRI study, which contribute to my research questions, will be described in chapter six and chapter seven. Chapter eight is intended to provide a general discussion.

Part I Theoretical Background

What's in a name? That which we call a rose.
By any other word would smell as sweet.

(Shakespeare, as cited in Ingeledew, 1965, p. 62).

1. Philosophical linguistics of proper names

1.1 Introspections in the philosophy of Chinese language

The development philosophy of Chinese language can divided in six eras (Wu, 1997): Pre-Qin (ca. 2000 B.C. – 221 B.C.), Han (206 B.C. – 220 A.D.), Three-Kingdoms-Jin-Southern and Northern Dynasties (220 – 588 A.D.), Sui-Tang (581- 907 A.D.), Sung-Yuan-Ming (961 –1644 A.D.) and Qing (1644 –1911 A.D.). The development in the first era was the most liberal concerning politics and academic developments. Many philosophers in this era, e.g. Laozi, Confucius, Mozi, Xunzi, dealt with the topic of 'name' and 'reality'. This section is intended to introduce two important philosophers who explicitly explored the differentiation between proper names and common nouns in their work.

1.1.1 Proper name as the smallest classifying term: Xunzi (319-230 B.C.)

> *For although all things are manifold, there are times when we wish to speak of them all, so we call them 'things'. 'Things' is the most general term. We press on and generalize; we generalize and generalize still more, until there is nothing more general; then only we stop. There are times when we wish to speak of one aspect, so we say "birds and beasts". "Birds and beasts" is the greatest classifying term. We press on and classify; we classify and classify still more, until there is no more classification to be made, and then we stop.*
>
> *(Xunzi, as cited in Dubs, 1977, p. 492).*

Xunzi's discussions questioning names and reality is based on an empirical epistemology. The idea "formulating names in order to indicate the reality" is a sign that he emphasizes the cultural meaning of the language system and logic (Chao, 1999, p. 6). According to Chen (2002), Xunzi's language philosophy can be summarized by five aspects: agreement makes customary (nature of language), following the ancient terms and reforming the new terms (development of language), general terms and classifying terms (structure of language), dialect and standard language (standard of language) and the realization of language. Two relevant themes in this dissertation will be discussed here.

Nature of Language

Xunzi's greatest contribution is clarifying what a concept is. He said "The mind also gives meaning to impressions" (Dubs, 1977, p. 490). Considering this idea from a linguistic point of view, it is the relationship between speech and the world, which is also an essential question in the philosophy of Chinese language (Chen, 2002). As *Xun Zi* pointed out: "There are no terms assuredly appropriate of themselves. There was an agreement and things were named" (Dubs, 1977, p. 492). Language is a product of mind, especially the common thoughts of individuals (what Xunzi called ***agreement***). According to this statement, differences in the language structure must be represented in mind as well. And this representation in the mind must be similar among all language users within the same language.

As to the nature of names, Xunzi gave definition that "terms or names are that wherewith we designate many realities" (Dubs, 1977, p. 500). That is to say, a concept is a way of thinking, which represents an abstract reflection of common features of the same class of thing. The center of concept is "class", the class is abstract and general (Liao, 1994, p. 231).

Structure of Language

Xunzi's work *Zhèng Míng* (=正名, rectification of names) addresses the precise definition of actions and things, as well as their relationship to each other. His consideration about language is based on the classification of concepts and the concomitant features belonging to them.

Xunzi stated five principles for establishing correct names (Liao, 1994). Three of these principles are related to the structure of language. First, "When things are alike, they are named alike; when different, they are named different" (Dubs, 1977, p. 490). Same things in the real world should have the same names whereas different things should have different names. Names should reflect the reality.

Second, "when a simple term would be sufficient to convey the meaning, a simple term is used; when a simple term is insufficient, then a compound term is used" (Dubs, 1977, p. 490). In ancient Chinese, words often consisted of a single syllable. According to Xunzi, if a single syllable is sufficient to express the reality, such as *mǎ* (=馬, horse), *níu* (=牛, cow), then a single syllable should be used. If not, more syllables should be used, such as *baí mǎ* (=白馬, white horse), *huáng niú* (=黃牛, yellow cow).

The third principle is the use of general terms and classifying terms. "When simple and compound concepts do not conflict, then the general term may be used; although it is a general term, there is no harm in using it" (Dubs, 1977, p. 492). Names are classified in *Dà Gòng Míng* (=大共名, general term) and *Dà Bié Míng* (=大別名, classifying term). The principle of this classification is similar to collective nouns *vs.* proper names in linguistics (Chen, 2002).

As the citation at the beginning of 1.1.1 points out, Xunzi's idea not only clarifies the way of establishing correct names, but also creates a theory for classifying concepts reflected in language. He created *Gòng Míng*, *Bié Míng*, *Dà Gòng Míng* and *Dà Bié Míng* and taught one how to use them. When one focuses on the general feature of a class of things, that is, different things which contain the unifying features, one must use *Gòng Míng*. When one intends to indicate a small part of a big class, one must use *Bié Míng*. *Dà Gòng Míng* must be applied to indicate many things whereas *Dà Bié Míng* is applied for differentiating things. These concepts have their own intension, and one should not confuse establishing names and using names. Liao (1994) suggests that the idea of classification is the greatest contribution of Xunzi. The ideas of *Gòng Míng*, *Bié Míng*, *Dà Gòng Míng* and *Dà Bié Míng* are based on different standards, e.g. if names reflect one class, or some objects of a class; if names are extreme or not extreme in a classifying hierarchy, etc.

Xunzi's idea of classification is analogue to modern semantics; the general term is analogue to hypernym whereas the classifying term is similar to hyponym. Conceptual knowledge is classified in two directions. According to bottom-up generalization, general terms are developed at the higher hierarchy of the concepts; if one makes the classification via top-down specifying, one will arrive at the individual representative of the specified class. By naming the smallest class, so called proper names are given. A proper name is considered as the smallest classifying term.

1.1.2 Proper name as an independent concept: Mozi (470-391 B.C.)

> *Ming ['name']. Unrestricted, similarity-based, private. [Canon I:78]*
>
> *Wu ['thing'] is an unrestricted name. If there is stuff it necessarily requires this name. To name it horse is to base on similarities. That of which we would say "it is like the stuff" must use this name. Naming it "Jack" is a private name. This name is confined to this stuff. Whenever sounds issue from mouth there are names. [Explanation I:78]*
>
> *(Mozi, as cited in Hansen, 1983, p. 111).*

Mozi's best work on the philosophy of language at the micro-level is the classification of nouns and his discussion of the connections between speech, sound and meaning, etc. He defined nouns in three aspects: *Dá* (=達, common concepts), *Lèi* (=類, sub-categorical common concepts) and *Sī* (=私, independent concepts). The appearance of *Dá* in the linguistics is common noun; *Lèi* belongs to the sub-categories of *Dá*, a further differentiation of common nouns; *Sī* is a very a special term which is similar to a proper name in the western philosophy of language (Wu, 1997). Liao (1994) suggests that the name which Xunzi defined was the name of class. Xunzi did not explicitly express the existence of proper names whereas Mozi explicitly differentiates class-names and non-class-names, i.e. proper names.

As the citation at the beginning of 1.1.2 points out, Mozi not only differentiates the three types of nouns, but also expounds the principles of differentiating nouns via examples. Compared with Xunzi's terms, *Dà Gòng Míng* and *Dà Bié Míng*, Mozi's conception is more perspicuous. "Whenever sounds issue from mouth there are names, just like that each person has a name" (Hansen, 1983, p.111) points out the congruency between speech and language. Speech indicates language in the same way that a name indicates a person. "Sound as realization of the language".

1.2 Introspections in the philosophy of western language

In contrast to the philosophy of Chinese language, in which the dissociation between common noun and proper name is seldom explicitly mentioned, the philosophy of western language has received a more systematic discussion. The tradition of this debate can be traced back to Chrysippus (280 – 207 B.C.) in ancient Greek who appears to have been the first to have divided *ónoma* (study of names) in two subclasses: *ónoma* and *proēgoria* which can be translated as proper noun and common noun (Nicolaisen, 1995, p. 385). In western philosophical linguistics, two important aspects are used to describe the differences between proper names and common nouns: reference and degree of meaning (cf. Algeo, 1973).

1.2.1 Proper name as a mono-referential expression

"Reference is a term used in philosophical linguistics and semantics for the entity (object, state of affairs, etc.) in the external world to which a linguistic expression relates" (Chrystal, 1997, p. 326). The earliest and the most often used definition of proper names is that they are "words used to refer to single, particular or unique individuals – names for classes that have only one member" (Algeo, 1973, p. 42). This definition appears in the oldest Western grammars, that of Dionysius Thrax. Dionysius says that a proper noun is one which signifies an "individual or particular" substance, whereas a common noun signifies a "general substance". The themes can be seen again in the definitions of the Port Royal grammar (Lancelot, 1660, as cited in Algeo, 1973, p. 42). Later in the twentieth century, a similar approach was stated by Bloomfield (1933, p. 205), who defines proper names as "species of object containing only one specimen".

However, this definition is controversial, because the mono-referential function of proper names seems to be a problem if it is associated with personal names or place names (Algeo, 1973, 42 et seqq.). The simplest example is that one certainly knows more than one person whose name is *John* and there are at least two places that have been named *San Diego*. On the other side, some common nouns are not poly-referential as they are supposed to be, but mono-referential (e.g. *sun*, *moon*).

It was suggested that the hypothesis which postulates that proper names have unique reference can only be maintained by recourse to the notions of “homonymy” or “polysemy” (Algeo, 1973, p.44). That is, one can say that either *John* applied to *John Adams* and *John* applied to *Elton John* are two different words that are pronounced alike, or that they are the same word with different meanings. Both approaches imply that the word *John* has a different sense, as it is used for different referents (e.g. Gardiner, 1954).

Algeo (1973) argued that these two approaches are unacceptable both theoretically and practically. In the case of homonymy, one would say that there are an unlimited number of different words *John* and *John*^{a} is different from *John*^{b}. In the case of polysemy, one would say that John has infinite meanings. Both approaches have the consequence that it makes it impossible to describe vocabulary because homonymy and polysemy have finite word forms and meanings.

A better alternative is to say that proper names are used, depending on the given discourse and context, to identify a particular individual. The speaker can further assume that the hearer will succeed in identifying that individual from the name (Werner, 1995). Actually, from a grammatical point of view, the feature of unique referent of proper names is related to its ***definiteness*** (Leys, 1989, p. 155). The expression such as, *There is a Mary who lives next to me*, appears in daily dialogue and is an example of the use of infinite article for proper names. But this does not influence the status of definite reference of proper names at a semantic and pragmatic level. It is more correct to say that for many proper names, definite reference is the unmarked state whereas for common nouns indefinite reference is the case.

Both proper names and common nouns are used to refer to objects in the world, but the main difference is that proper names are able to refer to one individual or object whereas common nouns refer to a class of objects (Lötscher, 1995). When one uses a definite common noun or a definite description in order to identify one referee successfully (e.g. *the tallest building*), one needs to utilize our world knowledge as well as the context in question. This referring ability changes because of different contexts, for example, it depends on the city the speakers are in. In contrast, the referring ability of proper names does not change because of its inherent feature of definiteness (Leys, 1989; Lötscher, 1995; Werner, 1974). The referring ability of proper names is solid and independent of where and when they are used. Therefore, they are described as “rigid designators” or “fixed denotation” (Leys, 1989, p. 146; Lötscher, 1995, p. 452).

Concluding, the definition of a unique and definite reference provides a general possibility to differentiate proper names and common nouns. This must be performed cautiously, since language use is so variable and the context needs to be taken in account.

1.2.2 Proper name as a low-degree-of-meaning expression

Another way to differentiate proper names and common nouns is to judge the degree of meaning (cf. Algeo, 1973). The definition of meaning of proper names has been a controversial topic in the philosophy of language. There are two major directions within this discussion: one is to claim that proper names do not have meaning whereas the other suggests that the description of the referent constitutes the meaning of them.

Proper name does not carry meaning

Mill (1843/1973) inferred that proper names are meaningless marks by which one thing is distinguished from another. In his terminology, a proper name is non-connotative, it identifies an individual without providing any attributes of him (e.g. the word *Mary* has no meaning, it refers to all creatures whose name is *Mary*). For Mill, proper name and common nouns are alike in denoting things. In addition to denoting, a common noun implies attributes (e.g. the word *girl* has a meaning, such as *a non-adult female human being*).

Some authors suggested that proper names and common nouns differ in the way, in which the former denote without connoting whereas the latter connote without denoting directly (Austin, 1961; Sørensen 1963; as cited in Algeo, 1973, p. 54). Similarly to Mill's view, Kripke (1980) pointed out that proper names can just have reference but no meaning. In his opinion, the description of a proper name can not be seen as the meaning of it, because the use of a proper name is independent of its description. The same name can be used to refer to another person even though one does not know him or her or that one can not describe the referent. Furthermore, the same name can be used to refer to another person, even though the description of this name does not fit the bearer of the name.

Proper name can carry meaning

Contrary to the aforementioned ideas, some philosophers believe that proper names can carry meaning, too. Russell (1905, as cited in Valentine, 1996, p. 12) suggested that the meaning of a name is given by a definite description of the individual it names.

Frege (1892) made further distinctions of meaning in sense and reference and declared that proper names' sense contains what speakers associate when they use the name (Frege, 1966). For example, the name *Mother Teresa* has the meaning of the *Indian catholic sister who helped the poor* or *the winner of the Nobel Peace Prize*. A further famous example is: The planet *Venus* can be referred to as the *morning star* and the *evening star*. In this case, these two expressions have the same referent but different sense.

Along the same line, Searle (1958) and Wittgenstein (1960) are representatives of the view that proper name can carry meaning. In their ***theory of bundles***, different object and subject features which are associated with different speakers, consist the meaning of a proper name. A speaker must know a great number of those descriptions in order to establish a unique relationship to the object, to which one is referring. Similarly, Jespersen (1965, p. 67) suggested that the meaning of a proper name is “the complex of qualities characteristic of the bearer of the name”.

Proper names may have some descriptive features as common nouns. But generally speaking, proper names, unlike common nouns, do not carry systematic lexical linguistic meaning.

1.3 Summary

The discussion concerning dissociations between proper names and common nouns has a long history in both Chinese and European philosophical linguistics. Philosophers exploring the Chinese language, such as Xunzi and Mozi, focus on this theme at a level of organizational hierarchy whereas western philosophers debate the topic more semantically. In Chinese philosophy, common nouns describe a class of objects, whereas proper names denote independent concepts. The same idea has been proposed in western philosophy in the form of reference. Furthermore, the degree of meaning ignited a controversial discussion related to the difference between proper names and common nouns. Do proper names carry meaning or not? It depends on the definition of meaning. On the one hand, proper names do not carry meaning because they only provide function of denotation. On the other hand, it is proposed that the associated description when using a proper name constitutes the meaning of proper names.

2. Descriptive linguistics of proper names

Rather than having an abstract definition of proper names in the philosophical linguistics, there are many concrete features in the structures of language marking the special status of proper names. A number of studies have claimed that proper names and common nouns differ in aspects of phonology, morphology and grammaticality. This chapter will also address the sociolinguistics of proper names since the cultural meaning of names may be helpful to interpret the language-specific data.

2.1 Phonological characteristics of proper names

Dissociation between proper names and common nouns at the phonological level has been found in many different languages. In German, proper names may carry some repeated phoneme sequence which are usually suffixes (Fleischer, 1992; Leys, 1966; Wimmer, 1973). Cutler et al. (1990) have revealed that the sound pattern for female and male names in English, by means of stress patterns, number of syllables and nuclear vowels, are different so that they may contribute to recognize the gender of a personal name.

2.1.1 Segmental dissociation

Proper names vs. common nouns

Proper names have their origin in the homophone form of common nouns (Leys, 1966). According to Leys, due to different functions of these two word classes, there must be a formal difference developed in language use. This difference can be seen, for example, in last phoneme. The phoneme [-ts] occurs relatively often as a suffix of German proper names, e.g. *Fritz*, *Heinz*, whereas this phoneme appears as a suffix of common nouns seldom. A further example is that in German place names, the final phoneme [-a] is not pronounced as [ə] as in the common nouns with the same etymological origin, such as *Eicha* instead of *Eiche*, *Heida* instead of *Heide* etc (Fleischer, 1964).

Moreover, compared to common nouns, proper names utilize certain specific phonemes more frequently than common nouns (Mangold, 1995). For example, in English, [χ] appears in proper names more often than common nouns. Furthermore, Mangold has suggested that there are more heterographical homophones for proper names than common nouns. For instance, *Broke/Brook/Brooke* (name) vs. *brook* (noun) [bruk] (Mangold, 1995).

Gender-specific features of personal names

Within the word class of proper names, gender-specific phonological features have been found in personal names. Cassidy et al. (1999) also showed that in English, female and male first names have different phonotactic structures, e.g. female names are often ended with [ə]. The authors suggested that it may be related to the Latin origin of names. Besides, female names often begin with [ai], which may be due to their Greek, Irish or German origin (Cassidy et al., 1999).

Cutler et al. (1990) explain the phonological difference between female and male names in a view of ***phonetic symbolism***. The speech sound [i:] has features which characterizes women: smaller, weaker, little, timid, etc. Evidence of this approach can be found in Chinese names as well. In Chinese, some phonotactic rules for first names reflect the differences between genders. Sound combination with back rounded vowel, e.g. [hong], which signalize ‘great’, ‘ambitious’ can be observed in male names more often. For female names, it is more common to use sounds signalizing ‘delicate’, ‘frail’ and ‘weak’, e.g. [yi]. This symbolism has been confirmed by a sociolinguistic study of names by Barry and Harper (1995) and Hough (2000). They have shown that phonetic attributes of male names are for instance, powerful, whereas beauty attributes are often associated with female names.

Slater and Feinman (1985) compared north American female and male names in a view of phonological structure and revealed that the gender of names can mostly be differentiated by hearer, albeit there were not necessarily gender-specific suffixes. The authors suggested that it may be due to some specific structure of names, e.g. male names are abbreviated more often than female names. Their study also indicated that female names have more phonemes and syllables, whereas male names are relatively short.

2.1.2 Suprasegmental dissociation

The study of Cutler et al. (1990) investigated the stress patterns of 1667 name entries in *The Oxford minidictionary of first names* (1986) and 19334 head nouns in the *Longman’s dictionary of contemporary English* and indicate that 85 % of the initial syllables are strong in the nouns set while for male names 95 % and for female names 75 % of initial syllables are strong. In another study, it has been suggested that the stress of the north American female and male names have different patterns. Female names, with more syllables, are usually initial-syllable-stressed (Slater and Feinman, 1985). The stress difference is also a further property describing the dissociation between proper names and common nouns (Mangold, 1995). In Turkish, for example, the last syllable of many important place names are usually not strong while common nouns have often stress in the last syllable e.g. *Ánkara*, *Edírne*.

2.2 Morphological features of proper names

Defining a word in Chinese is especially difficult, because Chinese orthography does not represent word boundaries. Before discussing the morphology of proper names and common nouns in general, a brief introduction to the morphology of Chinese will be provided.

2.2.1 Chinese morphological phenomena

As words in other languages, Chinese words are also constructed out of one or more morphemes. However, what exactly a morpheme is, in Chinese, remains controversial. It is often said that a morpheme in Chinese is something that is written with a single character and pronounced as a single syllable. This is not always true, disyllable and morphemes consisting of more than one syllable are also quite common cases in Chinese (Sproat, 2001, 2002). For example, *dōng xī* (=東西, east west → thing) does not literally derive from a compound meaning 'east and west'. In contrast, *mǎ shàng* (=馬上 horse on → suddenly) is commonly assumed to derive its meaning from the literal source (Sproat, 2001, 2002).

According to Sproat (2001, 2002), there are six main principles of Chinese morphology: verbal reduplication, adjectival reduplication, measure word reduplication, prefixation, suffixation and compounding. A summary and examples based on Sproat is given in the following:

a) Verbal reduplication is usually used to convey the meaning 'X a little', where 'X' is the meaning of the verb, for instance, *shuō shuō* (=說說, speak speak → speak a little).
b) Adjectival reduplication is the similar to verbal reduplication. The reduplicated form means 'a bit X', for instance, *màn màn* (=慢慢, slow slow → slow).
c) Measure words can also reduplicate with the meaning of 'every X', for example, *bàng bàng* (=磅磅, pound pound → every pound).
d) Chinese has a few productive prefixes such as *lǎo-* (=老, old), *xiǎo-* (=小, little). They are usually used with proper names, for example, *lǎo-wáng* (=老王, old Wang → someone who is called Wang).
e) Suffixes are relatively plentiful are more common productive prefixes. There are derivational and inflectional suffixes (Packard, 2000). One Example of a derivational suffixe is *–xué* (=學, science) and hence psychology is *xīn lǐ xué* (=

心理學, psycho science). A common inflectional suffix is for example *–le* (=了), which is an aspectual marker for past, for example, *chī le* (=吃了, eat –le → have eaten).

f) Compounding is the largest category of morphological derivations in Chinese. Noun compounds in Chinese display the same range of meaning as equivalent constructions in English, for example, *hăi gŏu* (=海狗, see dog → seal), *zhĭjiă yóu* (=指甲油, nail polish). Chinese has a large number of root words. An example is the word for 'termite' *báiyĭ* (white ant), where the portion meaning 'ant' determines the meaning of the word.

2.2.2 Morphology of proper names

Full Chinese personal names are in one respect simple: they are always of the form family name plus given name. The family name is restricted: there are about one hundred single-character family names such as *Chén*, *Lín*, and about ten double-character ones, e.g. *Sī Mă*, *Ōu Yáng*. However, there are almost no rules for constructing a first name. They are usually two characters long, occasionally one character long. In general, any characters or pair of characters can be used. Characters from all categories of words such as verbs, nouns, adjectives or adverbs can be used to construct a first name. The only restriction is the number of characters, albeit some characters are certainly more likely than others. Foreign names are usually transliterated using characters whose sequential pronunciation mimics the source language pronunciation of the name, for instance, 'Horst Müller' can be transliterated in *hò sī tè· mù lè* (=霍斯特 穆勒, Horst Müller).

With regard to naming patterns, using pleasing sounds and choosing elegant characters are much more important when naming females than males (Liao, 1991). Therefore, the meaning of the words or morphemes in female names mostly comprise words expressing beauty appearance e.g. *měi* (=美, beautiful); elegant manner, e.g. *yă* (=雅, elegant); virtue, e.g. *hùi* (=惠, grace); jewellery, e.g. *líng* (=玲, tinkling of jade) and flowers, e.g. *fēn* (=芬, fragrant). The meaning of words in male names mostly comprise words of auspicious prospects, great achievement, erudition and morality (Liao, 1991). Some typical examples are: *hóng* (=宏, great), *wěi* (=偉, great), *zhì* (=志, ambition), *míng* (=明, smart) and *rén* (=仁, kind). More about the naming patterns of Chinese names will be provided in 2.4.

According to Kolde (1995), grammatical features that dissociate proper names from common nouns are reflected in internal structure, flexion rules and syntax. Since internal structure and flexion belong to the section on morphology, they will be examined here. Syntax will be discussed in 2.3.2.

In Indo-European languages, male names are morphological gender-unspecific, a part of female names sometimes come from the suffixation of male names, e.g. *George vs. Geoginia* (Siebicke, 1977). As well, first names can be changed into a form of nick name, e.g. *Jack vs. Jackie, Bob vs. Bobbie.* Compared with proper names, suffixation of common nouns is more often, e.g. *wellness*, *poorness* in English, *Achtung* (attention), *Untersuchung* (investigation) in German.

The majority of current English names are derived from biblical, classical and vernacular sources (Dorward, 1995). This results in a very different linguistic appearance of personal names from other ordinary vocabulary (Hough, 2000). By observing of German names, one may notice that personal names, relative to common nouns, usually consist of one morpheme (Kolde, 1995; Wimmer, 1973). Therefore they can not be further segmented like common nouns and have a limited internal structure (Allerton, 1987). In English and some other European languages, proper names often appear in writing with an initial capital letter. But this can not define the term for spoken language, or for writing systems like Chinese which have no capital letters (Bright, 2003).

Some authors postulate that proper names, in contrast to common nouns, can not be used in plural form since a name refers to a single individual (Blanár, 1977; Kolde, 1995). In the spoken languages of English, German and Russian, plural form of proper names occurs quite often. In German, the plural form of proper names usually does not follow the rules for common nouns such as –en and -e but apply a special rule in which a morpheme –s is added to the end of names (Fleischer, 1992).

2.3 Grammaticality of proper names

2.3.1 Classification of proper names

Subcategories of proper names in Indo-European languages

Based on the semantic content of words, there are two subclasses within the class of substantives: concrete nouns and abstract nouns. The class of concrete nouns can be further categorized into proper names (Nomina propria) and common nouns (Nomina appellativa) (Knobloch, 1992; Sonderegger, 1985; Wimmer, 1978), collective nouns and measure words (Duden, 1995). It is difficult to give a clear definition for proper names and common nouns since the transition between these classes is vague. Allerton’s (1987, 73 et seqq.) definition of subcategories of proper names may help one acquire a more clear insight into the linguistic status of them. According to Allerton, sub varieties of proper names are:

a) Human beings, together with certain animals such as pets and racehorses: for example, *Socrates, Fido, Pegasus.*
b) Vessels, vehicles and machines: in other words, ships, boats, aircraft, together with some complex machines like computers. All of them have a close relationship to individual human beings, for example, *Mayflower, Discovery*.
c) Geographical locations: some are natural, for instance, names of lakes, deserts, mountains; some are man-made, e.g. roads, buildings. Examples are *Mars, Everest, the White House*.
d) Social organizations: such as commercial companies, political parties, religious groups, for instance, *IBM, the Labor Party*.
e) Publications and works of art: Newspapers, periodicals, books, operas, paintings, etc. can also be included, for example, *The Times, Newsweek, Animal Farm, the Mona Lisa*.
f) Languages and dialects: *English, Dutch, Chinese*.

Common nouns, in contrast, refer to creatures and things representative of a species or class, e.g. *plant*, *animal* (see Figure 1 for classification of substantive)

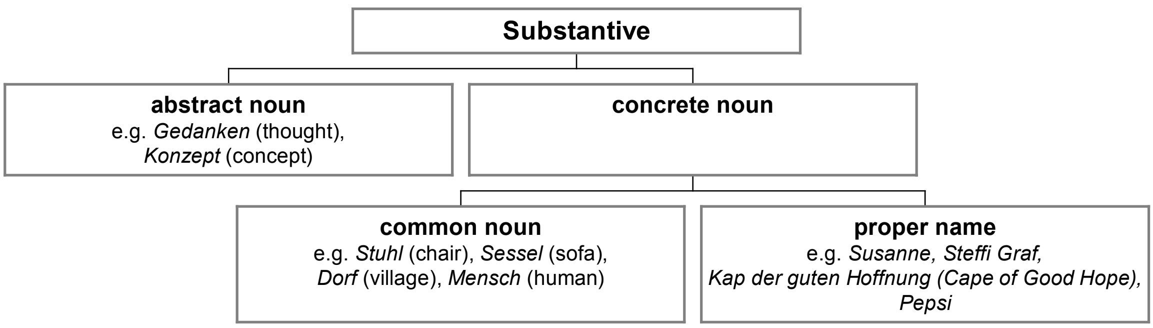

Figure 1: Classification of substantive in German (after Müller & Kutas, 1997, p. 149).

The problem with brand names: are they proper names or common nouns?

Unlike personal names and geographical names, the status of brand names is controversial. The problem is that, do brand names belong to the word class of proper names or common nouns? Gläser (1973, as cited in Shippan, 1989, p. 50) described brand names as a “shift” between proper names and common nouns because they do not denote the object directly, but as with a name of species, they represent the type of good.

As Schippan (1989) pointed out, the origin of brand names is in appellatives, since they denote goods and wares. In the linguistic point of view, brand names must comprise some promotional efficiency, they must be easy to understand, evoke positive association and they must contain information. They denote a product and categorize it into a class, just like common nouns. Brand names contain semantic information such as, the sort of the product and origin of products. For example, *Fewa* (= *Feinwäsche*, fine washing) denotes a class, each sample of this class must have the feature such as ‘a special washing agent’. Syntactically, brand names act like common nouns (Lehrer, 1999; Vater, 1965), e.g. *He used to buy only Buicks, but now he has a Ford.* Furthermore, they do not refer to unique individuals but to classes of objects or to mass produced substances (Lehrer, 1999).

On the other hand, in some encyclopedia, brand names are often considered to be a subclass of proper names, including names of literature work, names of newspapers and magazines (e.g. Fleischer et al., 1986, p. 299). Another reason to include brand names as proper names is that they are usually written in capital letters. And they are, like proper names, consciously and carefully applied. However, unlike personal names, they can be copyrighted so that no one else can use them (Lehrer, 1999). A further aspect is the naming tradition. Brand names are similar to proper names if one emphasizes the singleness and naming procedure of the naming act (Berger, 1976).

Inner structure of the substantive in Mandarin Chinese

In Chinese, the substantive is divided in eight categories that are described as the following (Chao, 1968; Chinese knowledge information processing group ‘CKIP’, 1993) (see Figure 2):

a) Nouns: Including mass nouns, individual nouns, countable abstract nouns, abstract nouns, collective nouns, e.g. *yén* (=鹽, salt), *jūozi* (=桌子, table), *mèng* (=夢, dream)’, *ài* (=愛, love), *fūqī* (=夫妻, husband wife → couple).
b) Proper Names: Personal names, names of work of art, and surnames, excluding time and place words, for example, *Shú Měi* (=淑美, virtuous beautiful → female first name)*, Zhōng gúo shí bào* (=中國時報, China Times), *Húang* (=黃, surname).
c) Place Nouns: Place names, nouns of places used as place names, noun-localizer compounds, position words, determinative-noun compounds, for instance, *tái běi* (=台北, Taipei), *xúe xìao* (=學校, school), *hǎi wài* (=海外, sea

out → abroad), *zhōng jīan* (=中間, middle between → in the middle), *sì hăi* (=四海, four sea → oversea).

d) Time Nouns: Historical time names, time names used in cycles, noun-localizer as time words, relative time words, for example, *táng cháo* (=唐朝, Tang dynasty), *xí èr yùe* (=十二月, twelve month → December), *nían dĭ* (=年底, year end → end of the year), *gùo qù* (=過去, across go → in the past).

e) Determinatives: Demonstrative determinatives, specific determinatives, numeral determinatives and quantitative determinatives, for example, *zhè* (=這, this), *dì* (=第, order marker), *wàn* (=萬, ten thousand), *quán* (=全, all).

f) Measure Words: including classifier such as *bĕn* (=本, classifier for book), *jìan* (=件, classifier for things, clothing).

g) Localizers: A kind of postposition, for instance, *shàng* (=上, on), *yĭ-shàng* (=以上, up to)

h) Pronouns: Personal pronouns, interrogative pronouns, for example, *wŏ mén* (=我們, we), *shéi* (=誰, who).

Here one can see that the classification of substantives of Mandarin Chinese is quite different from the Indo-European languages. One reason is that the classification of Chao (1968) considers mainly syntactic feature instead of semantic features. Grammatical features of proper and common names will be discussed in 2.3.2. As result of this, place names, which are categorized together with personal names as proper names in Indo-European languages, are separated from personal names and other type of proper names. It is the main interest of this dissertation to investigate which categorization reflects the natural categorization in human cognition? Do such ‘grammar structures’ existing in our mind? Are they language-specific or not?

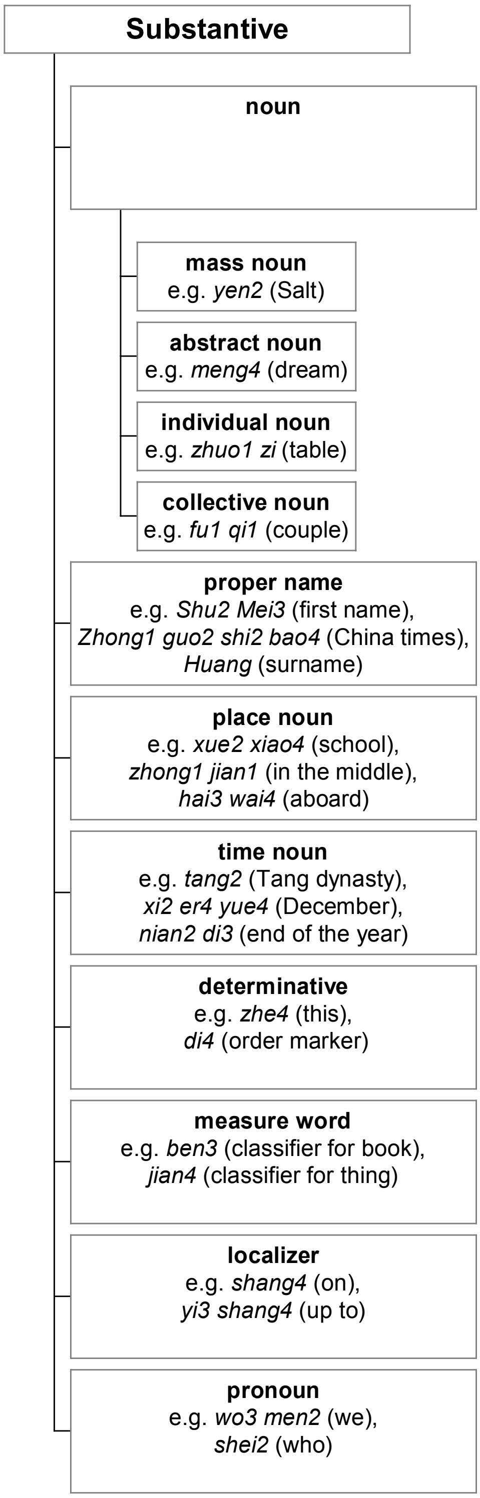

Figure 2: Classification of substantive in Chinese (number: tone of Mandarin).

2.3.2 Syntax of proper names

In English, it is often observed that it is unusual for proper names to occur with articles – either indefinite or definite. A sentence like *The George and a Henry come from England* is very hard to interpret unless someone explains the intension (Bright, 2003).

The same occurs in German, proper names are usually used without articles although there are some exceptions in dialect and sociolect (Müller, 1997).

However, the article use account is controversial, because in some cases, it is possible to use an article before a proper name if the speaker or writer intends to emphasize it. Some authors argued that the use of an article made a proper name similar to a common name because the name is a common noun derived from proper names in this case, at least functionally at a syntactic level (e.g. Allerton, 1987; Conrad, 1985). Conrad's argument is that a proper name is not a word class but a grammatical construction. Proper names are nominal phrases that refer to individuals and they are not accompanied by determiners. The same words that may be used as proper names have instances in which they behave like ordinary common nouns (Conrad, 1985).

Other scholars have claimed that the influence of articles is not essential (e.g. Vater, 1965), because the semantic content of a proper name is definite, so that one does not need the differentiating functions of articles to identify it. In Knobloch's (1992) opinion, the function of the article that accompanies proper names is very limited. They do not have the function of determinatives at all, since proper names are a universal phenomenon and they exist in the languages, without articles, too. Besides, there are a number of proper names in which use of article is obligatory, e.g. *the United Nations*, *die Schweiz* (Switzerland).

It is important to discuss the syntactic criteria when talking about the linguistic dissociation between proper names and common nouns, since the flexion and the use of article is not typical in Chinese. Unlike common nouns, proper names in Chinese can not be modified by determinative-measure compounds. They can be referred to by the pronouns *tā* (=他，她，牠，he/she/it) and *tā mén* (=他們，they) and they can be the subjects of certain verbs. But they can't be objects to words like *dào* (=到, to) and *zài* (=在, to be)', as time and place words can (Chao, 1968). Compared with the English and German grammar, in which geographical names are included in the category of proper names, proper names and geographical names in Chinese are differentiated because of the divergent syntactic constraints (Chao, 1968; CKIP, 1993). However, geographical names and proper names have the same feature in that both of them have a definite reference. Semantically, proper names are mostly the names of people (Chao, 1968). Like proper names, geographical names can not be modified by determinative-measure compounds.

2.4 Sociolinguistics of proper names

How does a proper name come into existence? From an anthropological point of view, names did not exist in primitive times. At that time, voices and external features were used to recognize a person. There was no need to name people. Since society was accreting, a social life became inevitable. Voices and memorizing the appearance of people were not effective enough to differentiate different people in the same context. People began to name themselves with sounds. This sound functionalizes as a symbol for a person. This is the first hypothesis as to the existence of proper names (Xiao, 1987). During this period of time, external features such as *big eye*, *round face* could have been applied as long as the context did not change.

In another context, some feature might not be universally conspicuous. Therefore, it was necessary to develop an "ego" name that represented an individual identity (Xiao, 1987, p. 2). The second stage of name development was to build an "ego", but a familiar and relative affiliation made more sense than a private name since there were no private belongings. As result of this, a public name, i.e. what we call surname today, was used. As human culture and economic life had developed, family belongings were retained so that single individuals of a family, especially males, could keep their own war trophies. The use of private name, i.e. what we call a given name, came into existence.

The third hypothesis concerning the origin of given names is a mystic superstition of "totem" (Xiao, 1987, 3). The origin of this kind of superstition was established in clan societies, where people believed that having a personal totem name was a guarantee that the mystic power would bless the name bearer.

2.4.1 Naming patterns of personal names in Chinese

Personal names are considered as a typical class of proper names in both Indo-European and Chinese languages although the naming tradition is totally different. In the Indo-European culture, parents usually name a new born baby using a given list. In the Chinese culture, one has some kind of creativity and freedom to 'invent' a first name which reflects social values of the periods (cf. Chang, 2003; Hsu, 1990). Since Chinese is a pictographic language, the meaning of characters or single morphemes may play a role when comprehending personal names.

Chinese personal names display a complex system since one person may have many different names with different functions (Chao, 1956). A child may have a 'milk name' or pet name for use during early childhood. Every person has a given formal name or legal name, known as *míng zì* (=名字, name) or *shúe míng* (=學名, school name). A formal name is given to a child at birth or later, before school age. In addition to the formal name, a person usually has a *hào* (=號, appellation), translated as 'style name' or 'courtesy name'. It is used in biographies which are written in classical Chinese.

In the following sections, an introduction about some naming patterns will be given in order to give an insight into the semantic content of names. According to Chang's (2003) empirical research on personal names in Taiwan during the past hundred years, naming patterns can be summarized in nine types:

Names representing order of birth

Characters such as *bó* (=伯, first)*, zhòng* (=仲, second)*, shú* (=叔, third)*, jì* (=季, fourth) may signalize the order of birth. This tradition can be traced to the period of warring states. The order of birth is an essential point in Chinese ethics. Those characters were used for male names more often because ancient China was a paternal society. Occasionally, characters of numbers were used to characterize the order of birth. Numbers have not only the function of counting but also a cultural sense, e.g. *yī* (=一, one) symbolizes the best status, a high degree, alone, leader; *sān* (=三, three) is usually associated with three positive virtues.

Names representing personal characters

Names often reflect some social phenomenon. To express this properly, parents' wishes that their children can achieve some moral standards, are reflected in names. Use of *jīao* (=嬌, pretty), *xìu* (=秀, excellent), is typical for naming females, while *zhōng* (=忠, loyal) and *xían* (=賢 virtuous) are characteristic of male names.

Names describing destiny

Believing in destiny is a culture-specific feature of the Chinese society. Destiny includes something that was decided by a mystery power and is not changeable by any single individual. On the other side, destiny also maintains a changeable part that develops with people's expectations. This is usually realized in two characters of names, such *xìang róng* (=向榮*,* in direction to flourishing)'.

Names symbolizing political wish

Due to the political conflict between Taiwan and China, male naming patterns in Taiwan is often a raising of political wish for peace in the nation. Names such as *dìng bāng* (=定邦, fix nation) and *jìang gúo* (=建國, establish country) were often given „around 1944" (Chang, 2003, p. 160). This shows the political earthquake during the war and the wish to have a peaceful life was greater than ever.

Names reflecting demands for wealth

In the sixties, the industrialization in Taiwan began to peak during the end of eighties. The economical structure of Taiwan was totally changed and a middle class arose

(Huang, 1995, as cited in Chang, 2003, p. 167). Names such as *tīan cái* (=添財, gain fortune) and *yǔn fù* (=永富, forever rich) became quite common.

Names displaying extrinsic beauty

This pattern is usually found in naming females. Applying characters such as *měi* (=美, beautiful), *húa* (=華, flower), as names was popular between 1940 and 1970. This naming pattern became less popular during the ninety's. Due to the improvement in education, more and more females become more self-confident, their definition of 'beauty' was not limited to external appearance anymore but also other aspects of life (Chung, 1993, as cited in Chang, 2003, p. 188).

Names showing family interests

Besides names representing personal characters, this type of naming pattern is the most used, e.g. *chúan zōng* (=傳宗, having a son to carry on the family name), *jīa píng* (=家平, home safe).

Names exhibiting health and long life

The use of this type of naming is related to the mortality of human, e.g. *yǔn kāng* (=永康, forever healthy).

Names propounding wisdom

Wisdom is considered as being able to solve all problems. Names with this pattern also reflects the parental expectations of their children, e.g. *búo-zhì* (=博智*,* wide wisdom), *cōng míng*(=聰明, smart).

Naming patterns reflect a degree of social values and names with clear naming patterns are simpler to catch someone's attention when meeting someone in first time. Clear semantic content may influence the remembering of a name and the recognition of names in further encounters. Chinese names can be seen as words consisting of two morphemes (characters in literal language) under certain circumstances. There is experimental evidence that for example, the frequency of morphemes affects the speed of word recognition when the word frequency is balanced (e.g. Liang, 1992; Tsai, 1996). Furthermore, there is a positive correlation between semantic transparency and recognition speed (Tsai, 1996). It will be interesting to examine if this affects the recognition of names or if name recognition is a kind of processing of non-words since names are in some sense artificial because of the high degree of freedom in choosing a name.

2.4.2 Geographical Naming

Generally, geographical naming had an individualizing function like other proper names. Geographical naming became necessary as people found the need to mention localities in communicative situations. Actually, there were many different motives behind place naming, such as agriculture, animal breeding, natural conditions, colonization and the utilization of nature, profane and sacral relationship, etc. (Helleland, 1995).

The following Chinese geographical names are examples which are taken from Cremer and Park (1995). Most Chinese geographical names have lexical meaning so that even "with the most basic understanding of Chinese characters one can readily decipher meaning of a name" (p. 907). *Zhōng gúo* (=中國) is the Chinese name of China. This name is composed of two characters; 中 is a pictographic character which means 'middle'. The second one is a picot-phonetic character which means nation. China was indeed the 'middle kingdom' of Asia in the previous two thousand years. The ethnocentrism explicit in the name *zhōng gúo* reveals much about the Chinese mindset, past and present (Creamer & Park, 1995).

The most common character in place names is *dà* (=大, big; great). In the Atlas of the People's Republic of China (Atlas, 1977, in Creamer & Park, 1995), approximately 600 of the 19,000 places begin with the character *dà,* e.g. *dà chéng* (=大城, big city), *dà cūn* (=大村, big village), *dà mìao* '(=廟, big temple).

Compass bearings also play a major role in the naming of Chinese cities. For instance, *tái-běi* (=台北, abbreviation of Taiwan, north → Taipei) ', *tái zhōng* (=台中, Taiwan, middle → Taichung) and *tái nàn* (=台南, Taiwan, south → Tainan) signalize the geographical positions of the cities. Natural indication can be a motive of place naming as well, e.g. *sì chūan* (=四川, four river → Szechwan), *shàng hǎi* (=上海, above sea → Shanghai).

The naming of Chinese cities frequently conjures up ideas of peace and harmony, wealth and happiness, idyllic surroundings and so on, for example: *cháng ān* (=長安, lasting peace → Chang´an), *dà túng* (=大同, great harmony → Datong). Place naming, as with personal naming, reveals some degree of semantic transparency. The question here is, if this transparency influences the understanding of place names.

2.5 Summary

The dissociation between proper names and common nouns is clear in view of descriptive linguistics. They are phonologically different in the different sound patterns used. Powerful sounds are often used for male names and attractive sounds are frequently applied for female names. Morphologically, European proper names usually consist of one morpheme whereas common nouns can be further segmented. There are also some suffixes indicating the gender of personal names. In Chinese, personal names show a high degree of morphological freedom, compared to European personal names. The classification of proper names in the word class of substantive is also different between European languages and Chinese. Chinese geographical names are categorized as a subclass of place words while European place names, parallel to personal names, belong to proper names. Brand names are more controversial since they both have features from proper names and common nouns. Grammatically, the use of an article differentiates proper names and common nouns in European languages. Since the use of an article is not common in Chinese, the most important grammatical feature to differ these two word classes is to judge if the word can be an object of the preposition *dào* (to) or *zài* (in, at). The naming tradition provides an interesting aspect for comparison, since Chinese names exhibit more semantic transparency and this may influence the recognition of names.

3. Cognitive psychology of proper names

The first important issue concerning the cognitive psychology of proper names is the mental representation of the lexicon. Are proper names a distinct class in the mental lexicon? Do they differ from other lexical categories, for instance, common nouns? A further important issue considers mental processes required to recognize and recall proper names. Are there different processing routes between the production and perception of the proper names or do they utilize separate lexicons? Is there a common lexicon for perception and production? Does the processing of spoken and written names engage different mechanisms? Is there any more cognitive mechanisms involved except language processing?

This chapter is intended to give a brief review of the psycholinguistic studies of processing of proper names which will provide possible approaches to explain these proper-name-processing-specific questions.

3.1 Tip-of-the-tongue-state (TOT)

Assumptions about how language is organized are often based on the observations of daily language use. Most of us have probably experienced the situation in which we were not able to recall someone's name although we knew some other information about this person, for example, his occupation, his residence etc. One describes this feeling by saying that the name is 'on the tip of my tongue'. According to Brown and McNeill (1966), the definition of a tip-of-the-tongue state is that it "involves a failure to recall a word of which one has knowledge" and the recall must be felt to be "imminent" (p. 325). In many cases of word recall failure, the recall may not feel imminent, even though we believe we know the word. This is a case of word recall failure, not TOTs, because the recall may be "distant" (Valentine et al., 1996, p. 87).

By comparing whether TOT states of proper names are more frequent than common nouns used in everyday language, one may assume that there are differences between retrieval of these two word categories. This is one way to examine if proper names and common nouns are two distinctive categories in the mental lexicon. Empirical data supports that access to proper names is more difficult than access to common nouns. The evidence has come from self-evaluation studies, diary studies and experimental studies. Patient studies will be discussed in next chapter where neurological studies will introduced and examined.

3.1.1 Self-evaluation studies and diary studies

Young et al. (1985) conducted a diary study in which subjects documented their difficulties and mistakes in recognizing people. It was observed that recalling the individual details of a person was easier than recalling the names, and it was never the case that the name was reportable unless semantic information was available.

Cohen and Faulkner (1986), using a questionnaire in which subjects made self-evaluation about the retrieval difficulties of names in daily life, have found that elderly subjects experienced name blocks more frequently than other age groups. Most of the blocked names were rated as well known names and such retrieval difficulties occurred more often when trying to think or communicate about a person than when the person was physically present.

Burke et al. (1991) compared the occurrence of TOTs involving different word types: proper names, common nouns and abstract words in a dairy study of four weeks. Subjects reported more TOTs for proper names than other the two kinds of words. Furthermore, there was an age effect in TOTs for proper names. TOTs for proper names were more frequent for mid-age and older subjects (see also Cohen & Faulkner, 1986). TOTs for common nouns occurred more often for older adults than the other two age groups.

In general, diary studies and self-evaluation studies have indicated that tip-of-the-tongue-states occur more often for proper names. By comparing daily TOT states between bilinguals and monolinguals, a more recent study indicated that bilinguals reported the same number or fewer TOTs for proper names than monolinguals (Gollan et al. 2005). This result seems to be inconsistent to previous research which postulates that TOTs for proper names occur more often. According to the authors' interpretation, bilinguals' disadvantages in recalling other words might be due to multiple word forms for individual meanings. However, they demonstrated an advantage in proper naming recall because proper names have essentially the same form across the investigated languages (English and Spanish in this case).

3.1.2 General critique on investigation of TOT-states with diary studies

Investigating TOT states is considered as a good tool for understanding language production processes and memory structure. However, data from diary studies must be interpreted with caution. One reason for this relates to the so called paraphasia phenomenon (Valentine et al., 1996). Paraphasia is the term for an incorrect verbal production which substitutes the intended verbal production. Due to the semantic nature of common nouns, a word from the same category that replaces the intended word will not always change the meaning of the intended sentence sometimes. For example, saying *The child with the red cap is my son* may not make any difference to *The kid with the red cap is my son*. But substitution of an intended proper name may completely change the intended meaning, since proper names usually refer to one individual. For instance, saying *The name of that boy is Bill* instead of *The name of that boy is Bob* would cause a semantic mistake that the speaker would find easier to recognize. In other words, one will detect more semantic paraphasias for proper names than common nouns (Valentine et al., 1996). It raises the question whether observed TOT data, at least from diary studies, is representative, because the TOT state frequency does not necessary reflect the retrieval difficulties in the view of cognitive processing. Moreover, differences between age groups must be evaluated carefully because "different life styles may lead to different demands on the word retrieval systems" (Valentine et al., 1996, p. 93). For example, young students may meet new people more often than older people thus making more TOTs for this category.

3.1.3 Experimental studies

The first experimental study that investigated TOT states of proper names was carried out by Yarmey (1973). In this study, subjects received naming task in which faces of famous people were presented. When TOT states appeared, subjects were encouraged to guess or recall all they could about the person. Yarmey reported that there was high success rate when guessing the initial letters of the words of TOT states.

In order to investigate the functional model of face recognition (Bruce & Young, 1986), Hanley and Cowell (1988), using a TOT-inducing procedure, investigated the effect of cues on subjects' abilities to retrieve the names of famous faces that they had been unable to recall. There were three different types of cues: biographical information, name initials and a second photograph of the target person. When the subject already knew the occupation of the target person, the cue of biographical information didn't seem to elicit the name. When the subject only found the face to be familiar, the cue of biographical information was quite likely to resolve the retrieval difficulty. When the occupation was already known, name initials facilitated the name recall. The cue of a second photograph made no significant difference in eliciting names. Their findings generally support the view that successive but distinct stages are involved in face recognition (Hanley & Cowell, 1988). In a further experiment, the effect of a new photograph was compared with the condition in which the same photograph was presented twice. A new photograph had no effect on facilitating finding proper names when the biographic information was already known but when subject was unfamiliar with the face or only found the face familiar (Hanley & Cowell, 1988). These findings are interesting because they allow one to conjecture that there are at least three different processes that are related closely to each other when recalling names from face cues, i.e. access to person-specific semantics, access to lexical entries and access to face. This raises some interesting questions, for instance, which cognitive mechanisms are involved in the processing of proper names and are all these mechanisms automatically activated in parallel?

Brennen et al. (1990) induced TOTs by reading out definitions of famous people and landmarks to subjects. The study compared the ability of different cues to resolve TOT states of proper names and has confirmed that the initial letters of the target names can resolve TOTs, whereas the pictures of the referent can not. This advantage has been found for both people's names and names of landmarks. The authors concluded that there is a unitary store for proper nouns, because providing other cues may lead to a different store of information which does not facilitate the naming output. Only information directly concerning about the name can facilitate its retrieval.

Burke et al. (1991) carried out a study in which different age groups were investigated with knowledge question inducing TOTs. They tested five word types: abstract nouns, object nouns, adjectives and verbs, place names and names of famous people. The results showed that older subjects experienced more TOTs only for the names of famous people but not for other word classes (see also Maylor, 1990). Taking the frequency of response of the knowledge questions into consideration, older subjects were more likely to experience mental retrieval blocks for objects' names, adjectives and verbs, and names of famous people.

The age effect of TOT states for proper names in experimental studies did not reveal that older subjects have more retrieval difficulty for proper names than do younger subjects. Maylor (1995) compared the naming performance of younger and elder subjects and asserted that older subjects were less capable in object naming but not in person naming. Maylor explained that the age effect for proper names is probably an artifact because proper names, unlike common nouns, can not be paraphrased. Therefore, Maylor further differentiated the class of proper names in familiar people's names and unfamiliar people's names. The age effect was only found in naming familiar people's names but not in unfamiliar people's names and objects.

Along the same line, Dahlgren (1998), using general knowledge questions to induce TOT experiences, failed to find any significant age effect of TOTs for names when taking the knowledge level of subjects into consideration. However, the number of TOTs was positively correlated with the level of knowledge. The higher the level of knowledge was, the higher the TOT rate was. In addition, younger participants were able to identify the first letter of the target words more often than older subjects (see also Burke et al., 1991; Cohen & Faulkner, 1986). Dahlgren's results can only partially support a transmission deficit hypothesis (see 3.3.2 for more details) that a smaller amount of priming was reaching to the phonological nodes. It remains unclear, why more knowledge was unable to increase the summation of priming between different semantic networks.

It is still controversial if there exists an age-related effect in the retrieval of proper names. Recent face naming studies have provided evidence that the relative retrieval difficulty for proper names, compared with other words, is due to the loss of long-term memory rather than episodic memory (Evrard, 2002; Rendell et al., 2005). Rendell and colleagues manipulated the stimuli type in which old people had to name newly learned names of unknown faces and objects, familiar public people and objects. By naming newly learned names and objects, older subjects did not show any performance difference between these two categories. But by naming familiar people and objects, elder subjects showed an impairment in their ability to recall people's names whereas their object naming ability was uncompromised. Hence, it has been suggested that category-specified retrieval impairment for proper names is due to the weakening of long term memory. This result is consistent with the results of Cohen & Fauklner (1986) where there was no significant difference found between the naming of proper names and the naming of other kinds of information.

3.2 Priming and reaction time studies

3.2.1 Priming effect of proper names

Despite the question of whether proper names and common nouns share the same representation at a lexical level, a word that is both a proper name and a common noun must activate both name recognition units and word recognition units (Valentine et al., 1993; see 3.3.3 for more details).

In order to explore the relationship between common noun and proper name processing, Valentine et al. (1993) employed repetition timing technique. In one of their experiments, they used a familiarity decision task in the prime phase in which subjects were exposed to celebrities' full names. Some surnames in this condition were also normal English words (e.g. *Pat Cash*, *Max Wall*, *Charles Dance*). In the test phase, a lexical decision task was given in which subjects had to decide if the presented stimulus was a real word. Their results demonstrated that making a familiarity decision on a full name primes a lexical decision task that relates the word, originally a surname to the prime phase (familiarity task *Pat Cash* primes lexical decision task *cash*). In a further experiment, they demonstrated a repetition priming effect in a reversed pattern, i.e. making a lexical decision on a word primed familiarity decision in which the same words were surnames (lexical decision task *cash* primes familiarity task *Pat Cash*). These findings support the assumption that perception of a familiar letter string, regardless of whether it is encountered in the context of a common noun or a proper name, will increase the availability of lexical presentations.

In addition, following the same priming paradigm, Valentine et al. (1998) have found that the recall of a celebrity's name in response to seeking the celebrity's face primed the familiarity decision to the printed name of the same celebrity. Furthermore, in the familiarity decision test, auditory stimuli primed visual recognition of a celebrity's name. This cross-modality priming effect was not revealed in the lexical decision task.

As Valentine et al. (1996) proposed, there is a semantic lexicon common to the production and recognition of names, including the comprehension of people's names. According to their framework (for more description see 3.3.3) of face and name processing, it is predicted that production of a person's name in response to seeing his or her face will prime the recognition to his or her written name. Secondly, a semantic lexicon that is common to the recognition of auditory and visual presented word form predicts that the repetition priming effect of a familiarity test between different modalities will be the same as the effect among the same modality. These predictions are supported by the findings of Valentine et al. (1998). However, these predictions did not apply to the word recognition of common nouns, i.e., naming objects does not prime the recognition of the name of the object and the repetition priming effect is greater when common nouns are presented in the same modality than a presentation with different modalities. In this way, it is supported that the cognitive architecture of processing people's names is different from processing of common nouns (Valentine et al., 1998).

Age-specific priming effect

Comparable to TOT studies, some priming studies of proper names have also shown an age-specific effect. Burke et al. (2004) pointed out that prior production of a homophone (e.g. *pit*) of a name as the response to definition trial increased naming accuracy and reduced TOT states for a proper name (e.g. *Pitt*) in a later picture naming task. Interestingly, this priming effect was only shown by older subjects but not by young ones. The authors suggested that the representation of proper names is susceptible to weak connections. It leads to deficits in the transmission of excitation which causes an impairing of the retrieval of proper names (see 3.3.2 for more details).

In contrast, using a competitor priming paradigm, Cross and Burke (2004) did not induce an age-specific priming effect but a task-specific priming effect. In their experiment, young and old adults named famous characters in response to questions in the prime phase. In the test phase, subjects named a picture of a famous actor or actress depicting this famous character. Priming of a famous character did not seem to affect TOT states for the actor's name, neither by young subjects nor by older subjects. By both subject groups, the priming effect was found to reduce incorrect naming.

3.2.2 Temporal aspect of proper name processing

Most reliable findings in the literature indicate that the retrieval of proper names is more difficult than the retrieval of the semantic information of the names. It has been suggested that naming familiar faces is slower than categorizing the same face with respect to occupation (Young et al, 1986). Reaction time in a name classification task is longer than a semantic classification task (Young et al., 1988). However, this result could not apply to children. Scanlan and Johnston (1997) reported that children produced names of famous faces more quickly than the occupations. In a matching task, they were also faster in matching faces and names than matching faces and occupations.

In a study of Abdel Rahmen et al. (2004), the children demonstrated a reversed pattern to Scanlan and Johnston's finding when the stimuli were very familiar to them. On the other side, adults showed the same pattern as Scanlan and Johnston's finding when unfamiliar semantic facts were used in the categorization task. Based on those findings, Brédart et al. (2005) proposed that retrieval of very frequent proper names will occur faster than the recall of semantic information about those names although it is generally suggested that the production of proper names is more difficult than common nouns. Therefore, they presented two experiments in which participants were shown faces of their colleagues. In both semantic categorization tasks (highest degree obtained and nationality), the subjects were faster in naming task than in the semantic categorizing task.

Brédart et al. (2005) suggested that the main distinction between these personally familiar stimuli and celebrities is not the familiarity, but frequency of exposure to their names. This frequency provides the reaction time advantage for naming.

Investigating the perception of spoken proper names and common nouns in German, Werner and Müller (2001) used highly common people's names, geographical names and common nouns as stimuli. Subjects received a category decision task, in which they decided whether the presented word was a proper name or a common noun by pressing button. They observed that subjects responded faster to people's names than common nouns, even though the frequency of proper names was lower than common nouns. With the same experimental paradigm, this finding has been replicated in another study in Mandarin Chinese (Yen & Müller, 2003). Chinese native speakers responded to people's names and geographical names faster than common nouns. These results do not contradict the study of Brédart et al. (2005) in the sense that high word frequency can speed up the retrieval or processing. It also emphasizes, however, the importance of the exposure frequency for proper name processing. However, exposure frequency alone does not seem to explain the reaction time advantage of proper names relative to common nouns. Common nouns are more prevalent in daily life than proper names in general. One could predict that common nouns would be recognized faster than proper names. Experimental findings (Werner & Müller, 2001; Yen & Müller, 2003; Shoblag, 2005) did not support this prediction. Therefore, there must be other reasons that could explain the faster perception of proper names.

Concluding, the dissociation between proper names and common nouns can be supported by priming and reaction time studies as well. The advantage and disadvantage of processing time in the recognition and production of proper names still remain, however, an open question.

3.3 Retrieval difficulties of proper names: Some responding approaches

As the reviewed literature indicated, in healthy adults, mental blocks relating to proper name production occurs more often than common nouns. This section will propose three accounts explaining this phenomenon.

3.3.1 Semantic account

Cohen and Faulkner (1986), using recall tasks to test the memory of different proper names and common nouns, observed that the retrieval of people's first names and surnames are much more difficult than place names and descriptive attributes such as occupations and hobbies. Cohen and Faulkner suggested that it may be because names of well-known places are semantically richer than people's names. Furthermore, common nouns as well as well-known place names carry rich associated imagery. On the contrary, people's names have little or no associated imagery and may be difficult to recall.

Furthermore, "proper names have a frustrating propensity to be forgotten" because proper names are meaningless and arbitrary (Cohen and Burke, 1993, p. 249; see also Cohen, 1990). A proper name is said to be arbitrary because it conveys little or no information about the bearer, either because "it corresponds to a meaningless string of phonemes or because it corresponds to a word whose meaning does not describe any property of the bearer of this name" (Brédart & Valentine, 1998, p. 200). In this case, proper names are just tags that permit their bearer to be identified but they convey none of the properties of these bearers (Luchelli & De Renzi, 1992).

In order to test if the arbitrary property of proper names make them difficult to recall, Brédart & Valentine (1998) designed a face naming task in which retrieval blocks in naming characters bearing arbitrary names and naming characters bearing descriptive names were compared. They used cartoon and comic-strip characters as characters bearing descriptive names. From Cohen's hypothesis, such characters should elicit less retrieval blocks. The results of Brédart & Valentine showed a facilitatory effect of name descriptiveness on face naming using cartoon characters as stimuli. Therefore, Cohen's (1990) hypothesis of arbitrary semantics can be supported.

3.3.2 Node structure theory

Node structure theory was developed to provide a general model of the production and perception of language (MacKay, 1981, 1982, 1987). This model was used to explain TOT phenomenon of proper names by Burke et al. (1991). According to this theory, the memory system consists of a network of processing units called nodes. The nodes are organized hierarchically and represent different semantic and phonological knowledge. The nodes of the semantic system represents concepts and are connected to the phonological nodes which are types but not tokens. Two fundamental processes in this model are priming and activation. Burke and his colleagues postulated that type-based and hierarchical organization of phonological nodes and the differences between priming and activation are important for explaining the TOT-phenomenon of proper names.

Activation is necessary to retrieve information as a node represents and proceeds hierarchically and sequentially in production. It is either a fully prohibiting or a fully facilitating process and does not spread. Activation requires a special class of activating mechanism known as sequence nodes that connect every node in a domain. This domain is a set of nodes that all share the same syntactic function (e.g. noun) or order of occurrences in words and sentences (e.g. initial consonant group). On the contrary, priming prepares a node for possible activation and an activated node primes all connected nodes. It spreads both at higher and lower levels (Burke et al., 1991).

During word retrieval, the translation of thought into speech begins with the activation of a propositional node. Taking the production of the word *frisbee* for example (example taken from Burke et al., 1991), when one intends to say the word, the prepositional node such as *they were throwing a frisbee* is activated at the level of the semantic system. Activating this prepositional node primes the lexical node for *frisbee*, so that it becomes activated as the most primed node in its domain. Priming spreads from the lexical node to connected phonological nodes. The most primed phonological nodes in their domains will be activated and prime further muscle movement nodes in the articulation system. This procedure is illustrated in Figure 3 (Burke et al., 1991).

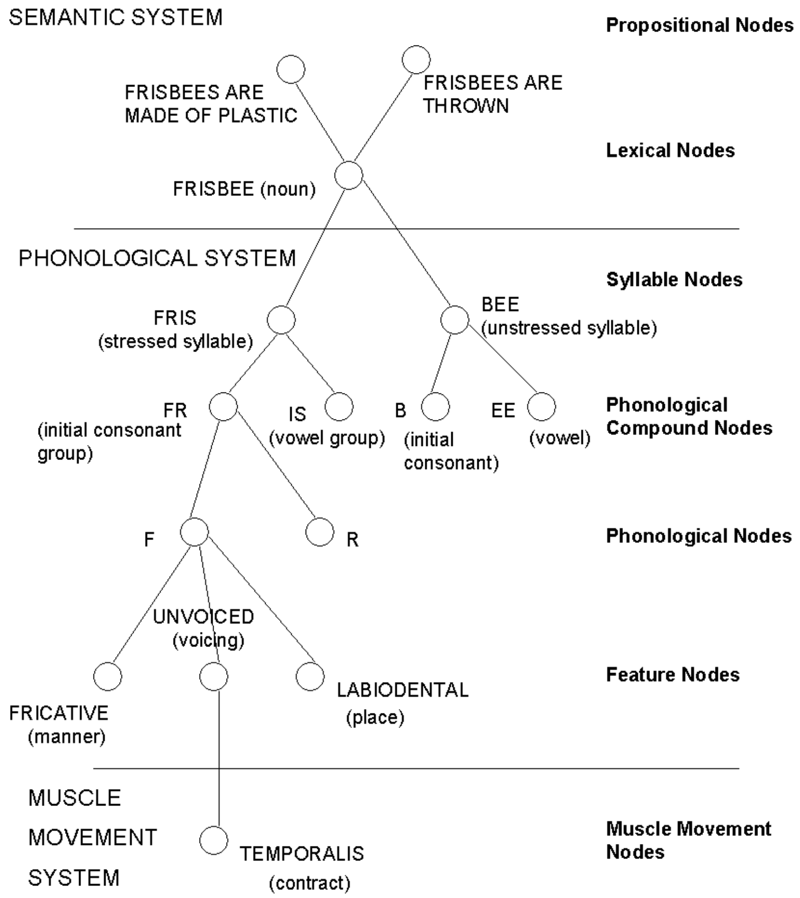

Figure 3: Nodes representing *frisbee* in the semantic, phonological, and muscle movement systems (taken from Burke et al., 1991, p. 544).

Transmission deficit hypothesis

In node structure theory, TOT phenomenon was considered as a deficit in the transmission of priming across critical connections that are necessary for target word production (e.g. Cohen & Faulkner, 1986). There are three factors affecting transmission deficit: frequency of use, recency of use and aging (Burke et al., 1991).

According to MacKay (1981, 1982), connections between nodes become stronger with use. When a node has been frequently activated, the rate and amount of priming transmitted across its connections increases. Frequency of use may explain why phonological speech errors and word substitution occur more often for low frequency words than high frequency words (Stemberger & MacWhinney, 1986; as cited in Burke et al., 1991, p. 545). Aging has been suggested to weaken the connections within the entire network nodes and reduce the rate and amount of priming transmitted across connections (MacKay & Burke, 1990). Compared with frequency and aging factors that determine the strength of connections, recency of use defines the decay of the strength of connections over time. Connections to phonological nodes that have not been used recently can become weak so that the transmitted priming will not be sufficient enough to enable the activation (Burke et al., 1991).

According to the node structure theory, Burke et al. (1991) predicted that TOT states will involve low frequency words more often than high frequency words. Moreover, TOT states will appear more for older subjects than younger subjects. Finally, recent use will influence the frequency of TOT states where words not recently used words induce more TOT states. Therefore, names of acquaintance who have been not contacted for more than three months (and much longer for older subjects) will evoke more TOT states. Those predictions have been confirmed in the study of Burke et al. (1991). They found a prevalence of proper name TOTs for all age groups and an age-related increase in proper name TOTs. This finding is consistent with the transmission deficit hypothesis. They clarified the effects of proper names on TOTs with an example in which the semantic representation underlying a proper name (e.g. *Baker*) and a common noun (e.g. *baker*) is compared. The occupation noun *baker* is connected to a large number of nodes representing semantic information about bakers, such as *bake bread*, *get up early* etc. whereas the proper name *Baker* is connected to semantic information only via lexical nodes for *John Baker* or other known individuals sharing the family name *Baker*. *John Baker* is connected to a large number of nodes representing semantic information of this person. However, the family proper name *Baker* does not have a set of connections representing information about this name, such as *Baker is an old English name*.

When one attempts to produce *baker*, the large number of connections linking the visual concept node for the person to the occupation noun will provide priming that leads to the activation of *baker* (occupation noun) and its connected phonological nodes. In contrast, when one attempts to greet an acquaintance named *John Baker*, no corresponding priming occurs at the lexical node for *Baker* (family proper name). There is only one connection linking the visual concept node to *Baker* via *John Baker*. Because *Baker* and its connected phonological nodes receive no convergent connections, they become vulnerable to transmission deficits and TOTs, even though the person is familiar to the speaker (Burke et al., 1991) (see Figure 4).

The transmission deficit hypothesis also predicts that the presentation of alternative words (blockers, persistent alternatives) will not increase the probability of TOTs because TOTs are caused by transmission deficits but not by interference. This prediction has been confirmed by a study of Cross and Burke (2004) in which prior production of a related character name did not affect TOTs.

Recent studies of James (2004) as well as Burke et al. (2004) have provided further evidence for transmission deficit hypothesis in which recall errors occurred more often for people's names and the phonological priming of proper names reduced the number of TOTs. It has been suggested that the single connections required for proper names, compared with the multiple connections existing to aid in learning and retrieval of common nouns, are more susceptible to transmission deficits (James, 2004). Even when the proper names and common nouns are the same words and only the label (syntactic class) is changed, the retrieval of proper names is still more difficult than common nouns. Aged-related difficulties in learning new names may be explained with this approach as well as where production of homophones of proper names strengthens phonological connections and an increase in the transmission of excitation of nodes and can facilitate the retrieval of proper names (Burke et al., 2004).

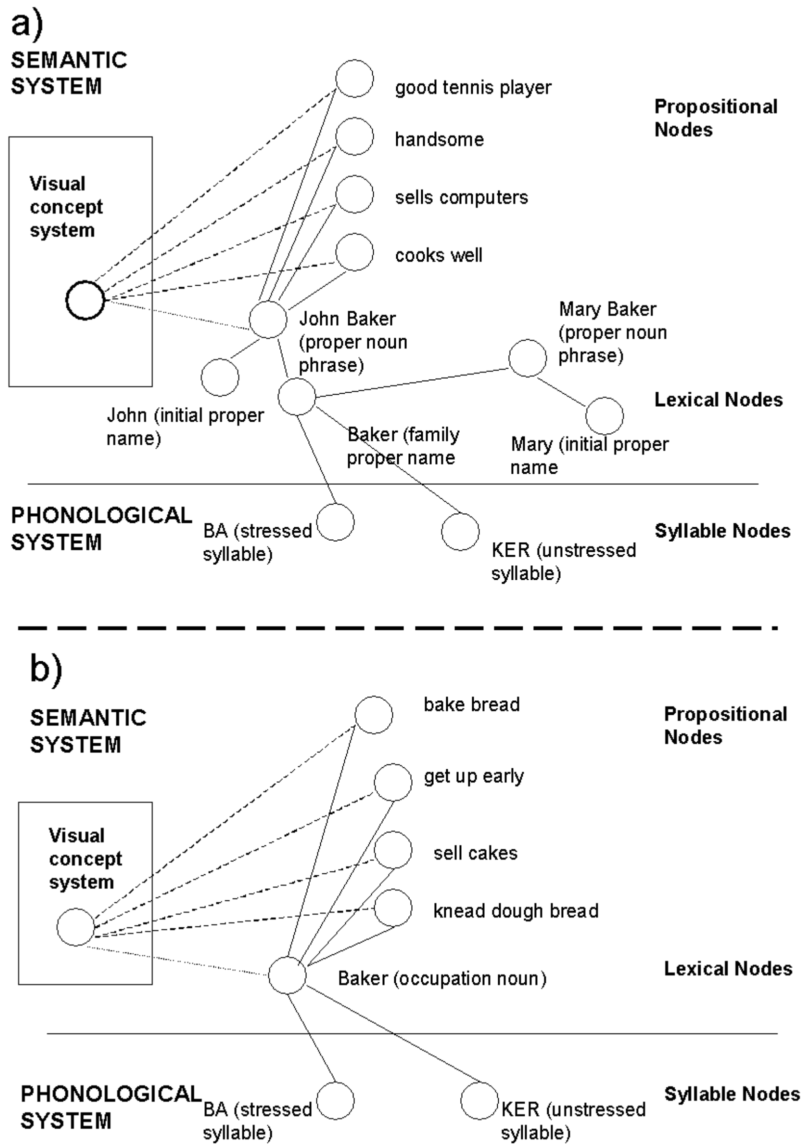

Figure 4: Examples of representations in the semantic, phonological and visual concept systems for a person with the proper name *Baker* a), and with the occupation *baker* b) (taken from Burke et al., 1991, p. 571).

3.3.3 Cognitive model of name, face, word and object recognition

Valentine et al. (1991, 1996) integrated the aspects of name recognition, face recognition, word recognition and object recognition and generated a functional model. This model is based on the framework proposed by Bruce and Young (1986; see also Burton & Bruce, 1992; 1993) which describes the different stages and aspects of face processing.

In this model (see Figure 5), it is suggested that the recognition of people's names is mediated by a set of recognition units. Word recognition units are connected to nodes representing the meanings of the relevant words. Name recognition units and face recognition units represent information about individual people. They serve as a storage function and can be activated by the input code. In this framework, identity-specific semantics have been separated from person identity nodes and have been included within the semantic system. The person identity node is a pre-lexical node which subsequently identifies a person. There is a gateway for access to the identity-specific semantics where biographical knowledge about a person is stored (Valentine et al., 1996).

The identity-specific semantics is closely interconnected to a general semantic system. For instance, recalling a person that is a musician may activate the general information about a musician. The model of Valentine et al. (1996) emphasizes a partition in the semantic system the different role that semantic memory plays in comprehending faces and names.

There is a single lexicon which is split into a semantic lexicon and a phonological lexicon (Brédart and Valentine, 1992). At the same time, this lexicon is shared by input and output. The person identity nodes also activate the lemmas for people's names. A lemma specifies the syntactic, semantic and pragmatic constraints under which words are selected. Orthography-phonology conversion strategies access the phonological lexicon but not the semantic lexicon. At the last stage of this model, the summation of activation of different systems leads to an articulation or naming response (Valentine et al., 1996).

The retrieval of common nouns is more robust than the retrieval of proper names because "multiple links from semantic systems converge on lemmas for common nouns" (Valentine et al., 1996, p. 179). In contrast, for proper names phrases, links from identity-specific semantics converging on person identity nodes are connected by a one-to-one mapping to lemmas. This makes the retrieval of proper names more vulnerable to deficit. This model is also able to explain why access to people's names is more difficult than access to identity-specific semantics. Again, the one-to-one link between person identity node and proper names phrase lemmas is the reason.

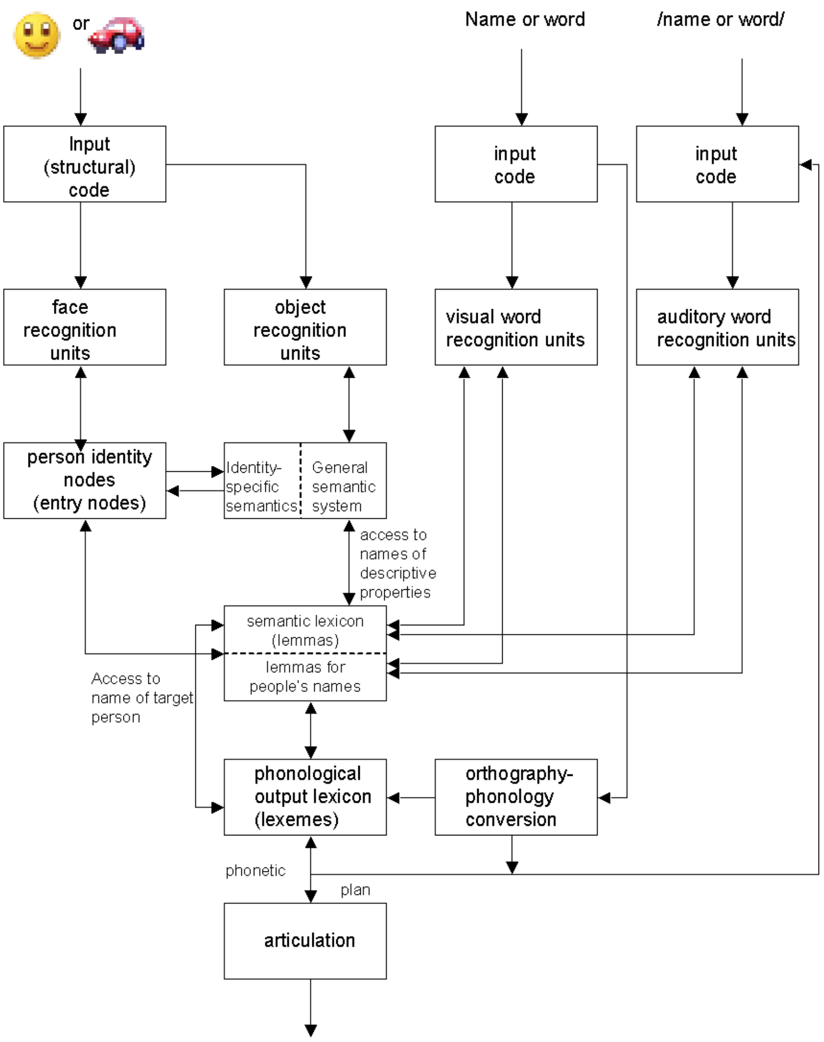

Figure 5: The framework for name, face, word and object recognition (taken from Valentine et al., 1996, p.172).

3.3.4 Conclusion

Generally, production of proper names is more difficult relative to production of common nouns. Evidence was found in different psychological studies such as diary studies, experimental studies, priming studies and reaction time studies. Different hypotheses have been developed to explain this phenomenon. Semantic accounts (Cohen & Faulkner, 1986; Cohen, 1990) suppose that the rich association and imagery of common nouns make them easier to recall than proper names, which are mono-referential and poor in semantic association. Node structure theory (Burke et al., 1991) suggests that the single connections required for proper names compared with the multiple connections existing to aid in learning and retrieval of common nouns are more susceptible to transmission deficits. The model of Valentine et al. (1996) provides a possibility with which different empirical data can be explained. For proper names, links from identity-specific semantics converging on person identity nodes are connected by a one-to-one mapping to lemmas. This insufficient connection makes the production of proper names more vulnerable to deficit.

Concluding, there is no single factor that makes proper names difficult to recall. Because of the unique reference of proper names, “activation must be passed by a single link from a token marker to a proper name phrase node” (Valentine et al., 1996, p. 192). One can say that the three mentioned approaches enunciate the same idea: the single link between proper names and their referents makes the recall of proper names difficult. Psycholinguistic studies have provided evidence for this idea which is postulated in philosophical linguistics and descriptive linguistics.

3.4 Summary

In this chapter, the dissociation between proper names and common nouns is introduced with the focus on the behavioral data of language users. In general, one may observe that tip-of-the-tongue-states occur more often for proper names than common nouns, in both experimental studies and daily life. There is no absolute relationship between recall failure and age. Priming effect of faces to names provides evidence for the existence of a common semantic lexicon for the production and perception of proper names and common nouns. Reaction time studies show different temporal aspects between proper name classification and common noun classification task. Some studies suggest that reaction time for semantic classification tasks is usually faster than name classification tasks whereas others suggest that identifying proper names is much more efficient than identifying common nouns by normal speakers. The frequency of exposure plays an essential role in expediting the identification of people’s names.

The following remarks are an attempt to briefly answer the questions posed at the start of this chapter. Empirical evidences allow one to assume that proper names and common nouns are two distinct classes in the mental lexicon and this distinction is enunciated in different aspects such as the behavior of TOT states, reaction time and priming effects. Valentine et al. (1996) have provide a model with which the dissociation between proper names and common nouns can be explained. According to this model, there is a common semantic lexicon for perception and production instead of separate lexica. This common lexicon is accessed by both visual and auditory word and name recognition and can be influenced by other cognitive mechanisms such as face recognition and person identity nodes. The semantic account (Cohen, 1990), the transmission deficit hypothesis (Burke et al., 1991) and the cognitive model of name, face, word and object recognition (Valentine et al., 1996) have offered some explanations for the retrieval difficulty of proper names. One may say that the single link between proper names and their referents is the main reason for the retrieval difficulty of proper names. That is, links from identity-specific semantics converging on person-identity nodes are connected by a one-to-one mapping to the lemmas of proper names.

4. Neuropsychology and neurolinguistics of proper names

The neural dissociation of proper names and common nouns has been corroborated by two kinds of studies. In the first case, patients with brain lesions were reported, who displayed selective disorders of proper names and common nouns. The simplest explanation for this phenomenon is that the human conceptual knowledge is more or less categorically 'organised' and processing of such categories may involve different brain structures and processes. A classical example is the dissociation between nouns and verbs (Caramazza, 1991). It has been claimed that the retrieval of the nouns depends on the left anterior and mid temporal lobe, whereas verb assessment involves the left prefrontal area (Damasio & Tranel, 1993; Daniele et al., 1993).

In the second type of study, experimental data provided neurological evidence of the cortical organization of word categories. For example, within the class of nouns, the EEG (Electroencephalography) experiment of Weiss and Rappelsberger (1996) provided neurophysiological evidence that concrete nouns show higher short-range coherence, whereas abstract nouns evoke higher long-range coherence. In addition, there are clear differences in the Beta1 band between the processing of the concrete words and abstract words with regard to the transfer between occipital and frontal as well as occipital and fronto-polar leads (Weiss & Müller, 2003). A further example is the ERP (event-related potential) evidence for dissociation between proper names and common nouns (Müller & Kutas, 1996). The study of Müller and Kutas revealed that N1 and P2 components are larger for spoken proper names than common nouns in a sentential context. In this chapter, both neuropsychological and neurolinguistic studies of proper names will be briefly reviewed with the focus on the functional anatomy of processing of proper names.

4.1 Functional anatomy of proper names: Evidence from aphasiology

4.1.1 Proper name anomia

Assumptions about the localisation of proper name processing were mainly derived from studying lesion patients. Proper name anomia has been reported most often compared with other selective disorders. Proper name anomia is defined as the difficulty in producing proper names or making associations between semantic content and phonological forms that is necessary for the retrieval. In the clinical reports, the most frequently affected category is personal names whereas the production of geographical names is often preserved. Therefore, in this section, a proper name will be used as an equivalent form to a personal name unless I specify otherwise.

According to the literature, proper name anomia has been caused by lesions in the following areas (RH = right hemisphere, LH = left hemisphere):

The LH basal ganglia (including amygdale)

Patients with lesions in this area showed difficulties in producing people's names (Fery et al., 1995; Hittmair-Delazer et al., 1994; Reinkemeier et al., 1997; Young et al., 1995). In the case of Hittmair-Delazer et al. (1994), the patient had problems in learning word pairs with arbitrary associations (such as *cabbage-pen*). Based on this finding, the authors suggested that the arbitrariness between proper names and persons they refer to, is the main reason why proper name anomia occurs more often. The deficit seems to occur prior to the input into the phonological and orthographic lexicons since the anomia showed the same pattern in both oral and writing modalities.

The LH thalamus

Patients with the lesion in the left thalamus also showed signs of impairment regarding proper name retrieval (Cohen et al., 1994; Lucchelli & De Renzi, 1992; Lucchelli et al., 1997, Reinkemeier et al., 1997). It has been proposed that the retrieval impairment is caued by the difficulty in activating the LH temporal lobe, in which proper names are stored (Cohen et al., 1994). The thalamus may be crucial for activating and coordinating left temporal lobe. Moreover, patients with this type of lesion tended to replace supposed proper names with other semantic paraphasia.

Reinkemeier et al. (1997) reported a case with lesions from the left media temporal lobe extended to this area who even failed to make semantic association about the persons that the names referred to. Therefore, the authors suggested that the LH thalamus was responsible for free association as the connection between names and persons.

The LH temporal pole

Lesions in the left temporal pole may be associated to proper name anomia (Damasio & Tranel, 1993; Damasio et al., 1996; Fukatsu et al., 1999; Tranel et al., 1997; Tranel, 2006; Yamadori et al., 2002). It is suggested that the left temporal pole is converging or intermediating the different components of a distributed representation of people in order to retrieve a name (Damasio & Tranel, 1993; Damasio et al., 1996). In contrast, Semenza et al. (1995) appealed that the hypothesis of Damasio's group must be treated with caution. The retrieval of proper names can not be attributed to the anterior temporal lobe with certainty since many anomia cases were presented with an intact anterior temporal lobe.

A new lesion study of Tranel (2006) suggests that the left temporal pole area is an intermediary structure for the naming of names of unique entities. The left temporal pole area triggers structures supporting conceptual knowledge and guides the implantation process executed by structures supporting the implantation of word forms. In this study, Tranel grouped patients according to their lesion sites (LH temporal pole, RH temporal pole, LH non-temporal pole and RH non-temporal pole) and tested their naming ability for names of unique landmarks. He found that patients with lesions in LH temporal pole were much more impaired in landmark naming. Furthermore, the same group also displayed deficits in naming famous faces. He concluded that the left temporal lobe contains systems that are important for retrieving the proper names of unique entities. However, the author also pointed out that one should not over generalize this idea. The specialization of the left temporal pole is centered on principles of not only unique (proper) naming but also the need to associate a proper name with a stimulus that is “part of a domain of items” that tend to be “numerous” and “visually similar” (p. 8). Naming difficulties of other proper name categories such as brand names, country names and city names did not necessarily involve lesions in the left temporal pole. More evidence for the involvement of the left temporal pole in proper name was provided by experimental data that will be introduced in 4.2.

The LH postero-temporal/occipital lobe

The left posterior-temporal and occipital cortex is also associated with proper name anomia (McKenna & Warrington, 1980; Reinkemeier et al., 1997; Semenza & Zettin, 1988; Yasuda & Ono, 1998). This lesion did not only cause proper name anomia but also a visual and auditory comprehension deficiency of proper names (Yasuda & Ono, 1998). The posterior temporal cortex was considered to be related to semantic processing (Gorno-Tempini et al., 1998). Both proper name and common noun processing engage this area, so it is difficult to explain the role of this area with a pure functional mapping approach. Moreover, the most reported cortical injuries were not restricted to one site, it would, hence, be more reasonable to hypothesize that the different procedures, in which different functional areas are involved, are participating processing of proper names and common nouns. Even though some of the functional areas may overlap, areas which are relatively important for one category may selectively cause the category-specific impairment.

The LH frontal lobe and the LH parietal lobe

The patient with lesions in left anterior frontal lobe and left parieto/occipital lobe also showed deficits in the production of people’s names (Semenza & Zettin, 1988; Semenza et al., 1998). The case of Semenza et al. (1998) provided some important aspects of this phenomenon. First, the patient's memory for autobiographical facts and his recollection of public events was good, where the retrieval of personal names was not concerned. When he was provided solely with a name, he was able to access all relevant information about a person. Second, the patient showed good performance in face recognition. However, he could not match semantic information to faces that he was able to judge as familiar and whose features he had no problem in remembering. No other cues were able to help him access semantic information of a person. The authors explained this disorder with the theory of Valentine et al. (1996) in which common nouns are directly activated by attributes in the semantic system and proper names are only indirectly activated via a simple person identity node.

Moreover, this case is also useful to assist in understanding the role of the right hemisphere in name retrieval. Some studies have claimed that the right hemisphere supports proper name recognition (see 4.1.4). This patient's inability to match names and faces came from a lesion limited to the left hemisphere. Specific linguistic mechanisms subserving proper name recognition are stored exclusively in the left hemisphere, whereas the right hemisphere most likely processes "stimulus qualities" like personal familiarity and emotional relevance (Semenza et al., 1998, p. 52).

Other subcortical areas

Otsuka et al. (2005) reported a patient with proper name anomia who had a lesion restricted to the subcortical region along the upper bank of the superior temporal sulcus. This patient could retain semantic knowledge regarding people, countries and racehorses. In addition, phonological cueing improved the performance of matching photos with their corresponding names. This finding suggested that the output lexicon was preserved in this patient. The disconnection between the output lexicon and semantic knowledge seems to cause proper name anomia. Other subcortical areas, such as internal capsule (Fery et al., 1995; Lucchelli & De Renzi, 1992; Lucchelli et al., 1997) and hippocampus (Reinkemeier et al., 1997) were found to be relevant for proper name anomia. The patient with a lesion in his or her hippocampus was able to describe the person that he could not name. Naming of other proper name categories was still intact. Naming difficulty decreased when the initial phoneme was provided. The authors suggested that the impairment for making semantic association to the referred persons was the main reason for proper name anomia.

4.1.2 Capability of proper name production

Compared with proper name anomia, preservation of proper name production was seldom reported. Semenza and Sgaramella (1993) described a patient capable of proper name production (names of friends and famous people in spontaneous speech and naming task supplied with first sound of the names) in spite of production deficits of other linguistic categories. A left parieto-occipital lesion could be demonstrated via computer tomography (CT).

Cipolotti et al. (1993) reported a patient with a left posterior fronto-parietal low density lesion and two additional small low density areas in the left frontal lobe (CT). The patient's MRI showed an abnormal signal in the left posterior temporal and parietal lobes. Different from the case described by Semenza and Sgaramella (1993), whose speaking was not impaired, this patient's ability to write proper names (names of countries and famous people) was superior to her ability to write object names. The authors suggested that the deficit occurs in the common noun computational procedures involved in both accessing semantic and activating orthographic representations.

A much more clear case of double dissociation with proper names anomia was reported by Lyons et al. (2002). Their patient, with a low attenuation in the left frontal lobe, showed an entire preservation of recalling names of people although he was impaired in the retrieval of common nouns and geographical names. His ability to name familiar people from famous faces and from verbal accounts of their occupations was as good as healthy controls. The patient was able to access detailed conceptual knowledge about people, but his semantic knowledge about objects was impaired. These investigations showed that he was suffering from a semantically based anomia rather than a purely expressive deficit. The reason for this was that he made more semantic errors about objects he was not able to name.

Cases of selective naming impairment do not occur simply because people's names are more difficult to retrieve than common nouns. Instead, this double dissociation is consistent with the domain-specific hypothesis of semantic memory (Caramazza & Shelton, 1998). The study of Lyons et al. (2002) provides further support for the claim that semantic knowledge is categorically organized in the brain and that different types of semantic information are represented in brain locations that can be selectively impaired by injury. The fact that the patient could retrieve people's names but not geographical locations suggested that the semantic system that represents geographical knowledge seems to be distinct from the semantic system that represents knowledge about people, although they are both categorized as proper names (Lyons et al., 2002). However, this case does not constitute evidence that separate output lexicons are involved in the production of people's names and common nouns. It only reflects damage to neurally and functionally distinct components of the semantic system (Brédart, 1997; Lyons, 2002).

Recently, a case of proper name sparing that was caused by a defect in post-semantic level activation (Schmidt et al., 2004) was reported. In contrast to the case of Lyons et al. (2002), this patient knew the meaning of the objects that he could not name. Together with the case of Lyons et al. (2002), one may assume that there are separate phonological output lexica for proper names and common nouns (see Figure 6). The claim that semantic knowledge about people and objects are stored separately gains more support with case reports of proper name anomia and sparing of proper name production.

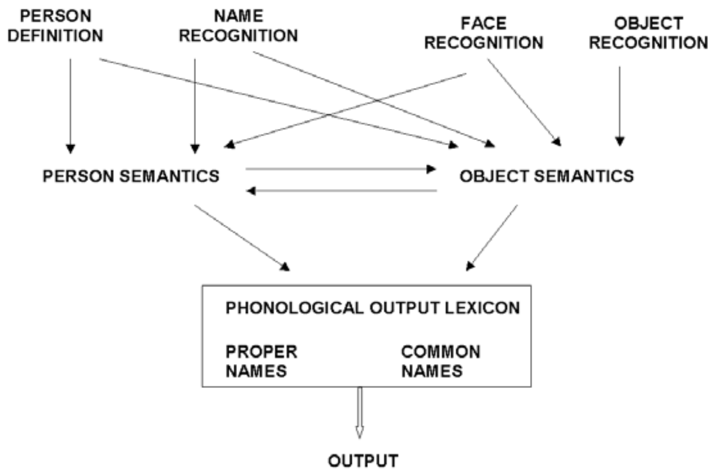

Figure 6: A model of proper name processing derived from neuropsychological investigations (taken from Schmidt, 2004, p.9)

4.1.3 Disorder in proper name perception

Patient data indicates that the perception of proper names seems to be determined by the right hemisphere. After a right anterior temporal lobectomy, a patient was not able to memorize people's names (Ellis et al., 1989). This case is more than a disorder at a purely perceptual level. It is also a a disorder in semantic memory. The patient complained that names were often meaningless for her and rated her memory in anything regarding people, for instance, recognizing faces, remembering where she has met people before, their occupations, their names, their voices and what they like, as poor. Ellis et al. (1989) judged this case not simply as a modality-specified prosopagnosia but suggested that her central store of semantic information about people (or access to it) is impaired. Since the patient's problem extended beyond familiar people to famous animals, buildings and products, the authors proposed that she had suffered damage to a semantic system which could be characterized as storage of information about “singular objects” (p. 1481). That is, the patient has no problem in understanding objects of a basic level, for instance, a building, a cat, etc. Problems occur when she has to recall information about singular objects or people. This case also implies that successful storage and recall of autobiographical memories requires a complex synthesis of memory for episodes and general semantic memory. As to the implication for the neural areas for memorizing information concerning people, it has been indicated that damage to the right temporal lobe and left temporal lobe causes perceptual disorder of personal names (Bennet-Levy et al., 1980; Kapur et al., 1986).

In contrast, Schweinberger (1995) investigated the performance of left- and right-brain-damaged patients in recognizing personal names. His study revealed that overall impairments in name recognition were observed in both patient groups, but the left-brain-damaged patients showed more difficulties in name recognition than right-brain-damaged patients. This finding suggested that the recognition of names is more dependent on the functioning of the left hemisphere. On the other hand, only right-hemisphere-damaged patients showed differences between the associative priming of faces and names. Name primes showed an increased effect while face primes did not. This may be related to impaired overt face recognition in right-hemisphere-damaged patients (Schweinberger, 1995).

4.1.4 Preservation of proper name perception

Yasuda and colleague’s investigation (for a review see Yasuda et al., 2000) has revealed that global aphasia patients as well as severely aphasia patients had less problems in the comprehension of common nouns and names of famous people. The superior comprehension of people’s names over common nouns has been also reported in further global or severe aphasia patients (McNeil, 1994; Van Lancker & Klein, 1990; Van Lancker et al., 1991, Van Lancker & Nicklay, 1992; Warrington & MacCarthy, 1987; Yasuda & Ono, 1998).

Familiar personal names, despite their greater length and complexity, were easily recognized by patients diagnosed with global aphasia secondary to ischemic left-hemisphere infarction (Van Lancker & Klein, 1990). Since global aphasia patients showed deficits in many linguistic categories, not including the comprehension of proper names, the view that the processing of proper names is more difficult does not hold. Van Lancker et al. (1991) have proposed that proper names can be processed holistically, thus, linguistic complexity is irrelevant. As people’s names do not have classical lexical features, hemispheric asymmetry may provide a possibility to explain the performance difference between the processing of proper names and common nouns (Van Lancker et al., 1991).

However, there are contradictory findings regarding hemispheric dominance. On one hand, there are studies which support the left-hemisphere-approach (Hay, 1982, Schweinberger, 1995, 2002a); on the other hand, the right hemisphere is able to recognize people's names (e.g. Saffran et al., 1980). For example, in spite of extensive damage to the left hemisphere, the preserved comprehension of people's name of global aphasia patients may be due to their intact right hemisphere (Van Lancker et al., 1991; Yasuda et al., 2000).

Yasuda and Ono (1998) have provided an alternative explanation of the problem of hemispheric dominance. According to Yasuda and Ono, common nouns consist of hierarchically organized concepts. Semantic meaning of a common noun is obtained analytically in this hierarchy. The left hemisphere is characterized by its analytical abilities and mediated the semantic processing of common nouns. In contrast, proper names do not have such hierarchical organization but require reference to a specific individual directly. The right hemisphere is more favorably disposed to the referential processing of proper names due to the non-semantic processing and holistic properties of them (see also Van Lancker et al., 1991). Yasuda and Ono's data confirmed this hypothesis. Hence, by comparing lesions for the impaired-personal-name-group and the spared-personal-name-group, they discovered that lesions for the impaired-personal-name-group were extended into the left occipital lobe. In contrast, for the spared-personal-name-group, the left occipital lobe and left posterior inferior temporal gyrus were relatively unaffected. The finding of this double dissociation may indicate that these regions are important for comprehension of personal names. Whether proper names are processed unilaterally, is still a topic of debate.

4.1.5 Cerebral processing of geographical names

Global aphasia patients were often superior in auditory comprehension of geographical names than common nouns. They were also superior in pointing out major cities on a map (e.g. McNeil et al., 1994; Wapner & Gardner, 1979; Warrington & MacCarthy, 1987; Yasuda et al., 2000). The superior comprehension of geographical names was related to the visuo-spatial capabilities of patients' intact right hemisphere (Wapner & Gardner, 1979).

On the other hand, a representative study of more than one hundred patients suggests that the left hemisphere may play an important role in the comprehension of geographical names (Goodglass & Wingfield, 1993). Aphasic patients, who often have left parieto-teomporal lesions, have shown difficulties in pointing to locations on maps when they were confronted with the geographical names. Therefore, it is suggested that semantic memory for locations is associated with the left temporoparietal area.

Studies of naming difficulties of geographical names do not seem to be consistent with comprehension studies. McKenna and Warrington (1978) described a patient with a left temporal lobe tumour (extending posterior to the parietal lobe) that suffered from a severe anomia. This patient's naming ability of countries in both visual and verbal modality was consistently better than that of any other explored categories. A similar case was reported by Warrington and Clegg (1993) in which the patient preserved the semantics and naming ability of geographical names. These two cases showed impaired personal name retrieval, whereas the retrieval of geographical names was intact. Therefore, the authors suggested that there may be an ordered organisation within the categories of proper names and there may be a structural basis to the word meaning system. But the role of left temporo-parietal region for naming and comprehension of geographical names still needs to be determined.

Even more, there may be a dissociation of impairment within the category of geographical names. Crutch & Warrington (2003) reported a patient with lesions in the left parietal, temporal and posterior frontal regions, who showed a disorder of semantic processing of geographical names. The patient's ability to identify country or city names was significantly worse when selecting geographically close rather than distant places. This finding reveals a fine-grain organization in this domain of semantics. Since the information about geographical proximity can be encoded in purely verbal or visual terms, the authors proposed that there is a separate module of spatially encoded information within conceptual knowledge.

4.1.6 Dissociation between subcategories of proper names

One interesting phenomenon is that there seems to be a dissociation within the category of proper names. Some of the patients appeared to have problems in producing names of people, whereas others have difficulties with the retrieval of all types of proper names. There are two different explanations. One is stated by Carney and Temple (1993) who proposed that face-specific anomia would suggest a specialized brain mechanism for the processing of names of faces. The alternative is the different retrieval difficulty between names of faces and other types of proper names. It was proposed that retrieval of geographical names is easier than the retrieval of people's names (Hittmair-Delazer, 1994; Lucchelli & De Renzi, 1992), because they belong to a closed class with a limited number of names and geographical names share some properties of common nouns, for example, they can be adjectivized and used to indicate people living in a certain country. Therefore, the extension of the impairment to other proper names categories correlates with its severity.

Challenging this notion, Milders (2000) has proposed that this approach can not explain why, for instance, names of buildings can be spared by patients with people's name anomia, although names of buildings are never used as adjectives. He investigated the retrieval of people's names and names of buildings in healthy and closed-head injured subjects and suggested that these subcategories of proper names are equally vulnerable to brain injury.

Hanley and Kay's meta-analysis (1998) of patients with proper name anomia supports the hypothesis of Lucchelli & De Renzi (1992) and showed that recall difficulties for patients with naming problems, including other categories of proper names, also scored lower when naming famous faces. Patients with only selective naming problems were able to name a higher percentage of famous faces. Although Hanley & Kay's analysis does not support the idea of a specialized brain mechanism for the processing of names of faces, however, it does not exclude the possibility that geographical naming and face naming are involved in some overlapping and some differential brain structures which are responsible for the selective disorder within the category of proper names.

4.1.7 Conclusion

Radiologically confirmed lesions causing proper name anomia were widely dispersed throughout the left hemisphere. The most common lesion sites are the left medial temporal lobe (e.g. Reinkemeier et al., 1997), the anterior portion of the left temporal lobe (e.g. Fukatsu et al., 1999; Saetti et al., 1999), the ventroanterior portion of the left thalamus or the left internal capsule (e.g. Cohen et al., 1994; Fery et al., 1995; Lucchelli & De Renzi, 1992; Lucchelli et al., 1997), the lateral portion of the left frontotemporal lobe and the left frontal lobe (Carney et al., 1993; Hittmair-Delazer et al., 1994; Saetti et al., 1999, Semenza & Zettin, 1989). The variety of symptoms and lesions regarding selective impairment and preservation of proper name production and perception has suggested that complex cortical networks may subserve retrieval of proper names (Otsuka et al., 2005).

Comprehension of proper names seems to rely more on the right hemisphere. Patients with lesions in the right anterior temporal lobe displayed difficulties in the comprehension of proper names (Ellis et al., 1989). Global aphasia patients with intact right hemisphere can generally understand proper names well (Van Lancker & Klein, 1990; Van Lancker et al., 1991; Yasuda et al., 2000). However, there was also patient data challenging the view that the right hemisphere is superior to the left hemisphere regarding process proper names (Schweinberger 1995).

It seems to be impossible to localize the processing of proper names based on patient studies alone because inconsistent statements were continuously found. For example, global aphasia patients showed superior comprehension of geographical names that is attributed to the visuo-spatial capabilities of the patients' intact right hemisphere (Wapner & Gardnder, 1979), whereas a patient with a spared left parietal lobe displayed the ability to recall geographical names (De Renzi & Lucchelli, 1993). Lesions in the left temporal lobe and left thalamus are associated with the impairment in proper name retrieval (Cohen et al., 1994; Harris & Kay, 1995) on one hand and the preservation of proper name retrieval on the other (Cipolotti et al., 1993).

Second, lesion areas are usually diffuse and vague so that it is quite difficult to determine which element is essential for the disorder. For example, not only lesions in the temporal lobe but also damage to left parietal lobe and occipital lobe may cause proper name anomia (Cubelli et al., 1991; Miozza & Cappa, 1995, as cited in Semenza et al., 1995, p. 185; Semenza & Zettin, 1988; Semenza et al., 1998). Damasio (2004) and Tranel (2006) explained the paradoxical findings of proper name anomia with an individual probability driven approach. In their framework, the structures involved in word retrieval, including structures that support conceptual knowledge, structures that support the implementation of word forms and intermediary structures are not conceptualized as rigid centers. They are rather "flexible, probability-driven system components" (Tranel, 2006, p. 9). Therefore, lesions in the same structures do not necessarily cause the same deficits.

The third problem relates more or less to interpretation of the findings. One may ask whether the findings are contradictory or whether they are a question of representation of different modalities or task-specific correlates. Is there a general model for proper name processing which requires an accessory procedure rather than common word processing? In order to understand the processing of proper names, it is necessary to look at the data of normal subjects which will be discussed in 4.2.

4.2 Neural correlates of proper names: Evidence from neurolinguistic studies

4.2.1 Naming and retrieval

In general, naming people is supposed to evoke activations in the left temporal pole. This hypothesis is also supported by experimental findings on normal subjects. Damasio et al. (1996) used a PET (Positron Emission Tomography) to investigate brain activations determining proper name retrieval (here: famous personal names). They revealed that the retrieval of words denoting visually presented entities activates the left temporal pole and the left inferior temporal regions. In addition, the retrieval of words from distinct conceptual categories activates separate sectors of the left temporal pole and the left inferior temporal regions. The retrieval of persons evokes activations in left temporal pole. Furthermore, retrieval of people involves the right temporal pole and right inferior temporal regions. The authors defined those areas as "intermediary or mediational" (p. 503) areas rather than modules or centers, since they see this structure and operation as "being acquired and modified by learning" (p. 504). A further fact that supports the notion of mediational system is that patients, who fail to recall specific words can still access the pertinent word forms in other condition, e.g. phoneme cuing. In connection with this topic, Grabowski et al. (2001) found that left anterior temporal area is also activated during the name retrieval from famous landmarks and famous faces. This finding supports the view that the activity in this area is related to the level of specificity of word retrieval rather than the conceptual class to which the stimulus belongs.

The findings relating to the left anterior temporal area were also replicated by an ERP (Event-related Potential) study of Proverbio et al. (2001). They used ERP spatio-temporal mapping to localize proper name and common noun retrieval. The task for subjects was to retrieve the target words when presented with a definition and to decide whether the upcoming syllable was a part of the target word. In this study, proper name retrieval yielded a strong activation of the anterior temporal area whereas common noun retrieval involved visual areas greatly. The authors suggested that memory retrieval of common nouns involves sensory integration establishing semantic representation of nouns and therefore evokes activation in the occipital lobe. As to the role of the left anterior temporal lobe for proper name retrieval, the authors explained this with the intrinsic properties of proper names. The left anterior temporal area was found to be associated with the retrieval of similar material and tasks involving episodic memory. Episodic memory retrieval, in contrast to semantic memory retrieval, may be defined as the retrieval of unique information linked to precise spatio-temporal coordinates. This property of episodic memory is similar to proper names in the view that proper names "refer unique individuals depending on a high contextual complexity" (Proverbio, 2001, p. 824).

Recently, Yamadori et al. (2002) carried out an fMRI investigation into the retrieval of famous names in comparison with the retrieval of their occupations. Their results, confirming the findings of Damasio et al. (1996), show that name retrieval activates the anterior pole of the left superior temporal gyrus (BA 38) and the medial frontal lobe adjacent to the anterior cingulate gyrus (BA 32). Since the stimuli and subjects' verbal behavior did not differ between the name-retrieval and the occupation-retrieval and the task difficulty was always the same, this extraction can reflect a neuro-psychological process associated with the retrieval of proper names (here: famous persons' names) from the semantic store. Proper names can be considered a relatively "independent category", since their retrieval engages a different, wider neural network (p. 143).

4.2.2 Comprehension and recognition

In perception modality, different neuro-physiological patterns were also observed for proper names and common nouns. Dehaene (1995) used event-related potentials (ERPs) to investigate the time course of visual word processing of different categories such as animal names, verbs, numerals, proper names and meaningless consonant strings of normal participants. Category-sepecific ERP differences appeared around 260 ms from word onset. For proper names, there was a left inferior temporal negativity. This may be related to the involvement of left and right inferior temporo-occipital areas in "face processing" (Dehaene, 1995, p. 2157). Also with ERPs, Müller & Kutas (1996) investigated the comprehension of spoken nouns and proper names and one's own name that were provided at the beginning of spoken sentences with different syntactic structures. Their results revealed an amplitude difference in the ERPs to the first words of sentences as a function of whether they began with a proper name or common noun as early as 125 ms after onset of articulation. Both N1 and P2 components were larger for the proper names than nouns.

Another EEG study (Müller et al., 1999) indicates that proper names elicit higher synchronisation at left fronto-temporal sites within the theta band and right posterior sites within the alpha-2 band. The processing of proper names evoked differences in cortical interaction depending on the frequency band and the topography. In addition to the activation in the language dominated left hemisphere there was also activation in the right hemisphere.

There are some theories which assume that proper name processing must involve the right hemisphere. One of the assumptions is that the semantic meaning of proper names, unlike common nouns, does not have a hierarchical and analytical organization but a more holistic one, since they refer only to individuals (mono-referential). These properties lead to the conclusion that the right hemisphere is more favorably disposed to the referential processing of proper names (for a review see Yasuda & Ono, 1998). A further assumption is that the autobiographical memory is stored in the right hemisphere (e.g. Ellis et al., 1989) which can be considered as the semantic lemma of people's names. Except for patient studies reviewed in 4.1.4, experimental findings on normal subjects (Ohnesoege and Van Lancker, 1999; 2001) support the approach that the right hemisphere is able to process personal names as successfully as left hemisphere. The authors compared responses to familiar proper names and common nouns presented to left visual fields or right visual fields to investigate the cerebral processing of proper nouns. Their results showed that proper names were correctly categorized more often than common nouns. The subjects' identification of proper names did not differ by hemisphere, whereas subjects' identification of common nouns differed significantly in favor of the left hemisphere. The results support the claim that proper names are cerebrally represented differently from common nouns and both hemispheres can process proper names successfully. In addition, the right hemisphere can process personally relevant stimuli (Van Lancker et al., 1991).

Using split-visual field method, Schweinberger et al. (2002a) did not find any advantage for the right hemisphere in the comprehension of familiar proper names. In their study, both reaction times and error rates of proper names revealed strong advantages for the right visual field and the left hemisphere as the common nouns did. Van Lancker and Ohnesorge (2002) explained this opposite finding primarily with the methodological point of view. Furthermore, they hold the view that familiar-intimate and familiar-famous proper nouns, have strong and "intense emotional, contextual, historical, biographical, iconic, imagistic and auditory associations, which serve as semantic properties, and which, in addition, make proper nouns prime candidates for right hemisphere processing" (Van Lancker & Ohnesorge, 2002, p. 128).

ERP findings of name and face recognition tasks suggest that semantic information about people is stored in an abstract way and "independent of the precise perceptual input" and that the same brain systems and cognitive processes mediate the "semantic" level of person recognition (Schweinberger et al., 2002b, p. 2070).

Applying PET scans, Gorno-Tempini et al. (1998) investigated if there was a functional dissociation between the visual recognition of faces, proper names and common nouns. The processing of faces relative to names showed enhanced activity bilaterally in fusiform gyri (particularly in the right) and right lingual gyrus. Processing of names relative to faces engendered activations in left posterior middle temporal gyrus and left superior temporal sulcus. Both famous names and faces revealed extensive activations in the medial frontal cortex and precuneus. Furthermore, both proper names and common nouns engaged the same left temporoparietal junction (BA 39), bilateral temporal poles and posterior cingulated cortex. Activation in the left anterior middle temporal region extended more laterally for famous proper names than for common nouns. The authors consider this area as a "people-specific" (Gorno Tempini et al., 1998, p. 2115) area, which should be more active for proper names, since phonology was involved in all conditions and the visual input was the same, in that proper names and common nouns were presented. Moreover, the anterior temporal cortex has been proposed to play a role in the identification of famous faces (Gorno-Tempini et al., 2000) and semantic process by identification tasks without naming (Gornot-Tempini, 2001).

In a fMRI study (Tsukiura et al., 2003), face-name recognition tasks of previously learned face-name pairs were utilized to investigate functional anatomy subserving name retrieval from faces. Subjects were scanned immediately after they had learned face-name associations and then again two weeks later. Activation in the left anterior temporal lobe was observed in both an immediate recognition task and a delayed recognition task, whereas the activation in right anterior temporal lobe was reduced significantly in the delayed recognition task. This finding provides evidence that the left anterior temporal lobe plays an essential and stable role in face-name associative learning and the right anterior cortex has a time-limited role. Activation in the left temporal polar region was evoked during the retrieval of familiar and newly-learnt people's names. Right superior temporal and bilateral prefrontal cortices were activated during the retrieval of newly-learnt information from face cues. These data, consistent with their patient data, provide new evidence that the left anterior temporal region is crucial for the retrieval of people's names irrespective of their familiarity (Tsukiura et al., 2003). The data also showed that the right superior temporal and bilateral prefrontal areas are crucial for the process of associating newly-learnt people's faces and names.

Tsukiura et al. (2006) investigated the effect of repeated learning and person-specific semantics in face-name association in a further fMRI study and provide more information about the role of the right and the left anterior temporal lobe. In their study, left anterior temporal lobe was significantly activated in the retrieval of people’s names encoded with person-related semantics. Right anterior temporal lobe was engaged in the retrieval of people’s faces encoding with person-related semantics. Repeated learning of face-name association may reduce the activation in left anterior temporal lobe. The authors suggested therefore that faces, names and person-related semantics can be mutually mediated by the bilateral anterior temporal lobe and sufficient learning of face-name association may decrease the involvement of the left anterior temporal lobe. The role of left and right anterior temporal lobe is “dynamically organized “according to the level of “consolidation” of face-names associations (p. 625).

The involvement of the bilateral anterior cortex for the comprehension of proper names was also observed in the spoken language processing of Mandarin Chinese (Yen et al., 2005 a,b). The processing of spoken Chinese proper names not only activated the language-specific left hemisphere but also brain regions such as the precentral gyrus, superior temporal gyrus, lingual gyrus and some subcortical areas in the right hemisphere. The activation in the right hemisphere may indicate that other cognitive processes such as, for example, face recognition, are involved in addition to language processing.

Douville et al. (2005) investigated the medial temporal lobe activity for recognition of recent and remote famous names with an event-related fMRI and observed a temporal gradient of activity in the right hippocampus and right parahippocampal gyrus: recent famous names showed greater activation relative to remote names. Increased bilateral medial temporal lobe activity can be seen by both recent and remote names. This study has provided an alternative aspect to explain the dissociation between proper names and common nouns. According to the activation patterns they found in lateral middle temporal lobe, the authors suggested that memories for famous names may not have a purely semantic component that is common to most people, but also a significant "autobiographical, episodic component that is specific to each individual" (p. 700, see also Westmacott et al., 2004).

4.3 Summary

In order to determine the functional anatomy of the processing of proper names, one needs, firstly, to make a clear definition of the term ***processing***. Concerning the discussion in this dissertation, processing is used to indicate the process in which natural language input is comprehended or language output is generated. It includes both reception and production. In most studies, the term ***retrieval*** and ***access*** is often used to refer to the connection between semantic processing and phonological processing, hence it is mostly associated with language production. However, the term retrieval is sometimes used to refer to a recognition task (e.g. Tsukiura et al., 2003) since a basic preposition for word processing is the existence of a mental lexicon where words are categorically stored and the retrieval to this lexicon is necessary for both production and comprehension. With regard to the neuroimaging studies, one may be able to find brain areas that may be involved in processing of specific categories, but a differential functional definition for each involved area is difficult due to methodological limitations. As Gorno-Tempini et al. (2001) argued, distinction between the neural correlates of recognizing entities and naming them is extremely difficult because it is difficult to prevent naming during recognition tasks. Thus, the following summary will be presented irrespective of this distinction, that is, whether they were recognition tasks or naming tasks.

Surprisingly, in spite of task form, neuroimaging studies found a concord conclusion regarding to proper name retrieval. That is, the involvement of the left anterior temporal lobe extended to the left middle temporal region. In contrast, findings of patient studies appear to be widely divergent. This inspires a better way to explore the brain areas involved in proper name processing: combining data from experimental and patient studies. Patient data presents a partial area of a distributed network whereas neuroimaging studies reveal the essential area of this network.

Patient data, as well as experimental findings, show that left temporal pole, plays an important role in proper name processing. Furthermore, data of global aphasia patients show that the right hemisphere provides key functions in processing proper names because the spared right hemisphere is able to support proper name comprehension (e.g. Van Lancker et al., 1991). The involvement of the right hemisphere is not excluded by experimental findings. Supports for the role of right hemisphere come from neuroimaging studies (e.g. Damasio, 1996; Yen et al., 2005a, b, Tsukiura et al., 2006), neurophysiological studies (e.g. Müller et al., 1999) and behavioral studies (e.g. Ohnesorge & Van Lancker, 1999). Obviously, the approach of a dominant hemisphere for proper name processing is inappropriate. A network distributing in both hemisphere must be utilized for proper name processing since both language-specific and identification-related mechanisms are important for the successful access to a mental lexicon.

5. Using fMRI to investigate human language processing

The fMRI (functional magnet resonance imaging) technique is becoming more and more important for the investigation of human language processing. It enables a non-invasive and detailed exploration of the human brain processing and makes the detection of on-line processing accessible. This chapter is intended to provide a simple overview of fMRI which includes its physical and physiological basis, its application in researching on-line language processing and its contribution to understanding language organization.

5.1 An introduction to fMRI

5.1.1 Physical and physiological basis of fMRI

Unlike electrophysiological methods such as EEG (Electroencephalography), fMRI does not measure the neuronal activities during cognitive processes e.g. language processing directly, but the changes of the metabolic mechanism which accompanies this process. The metabolic changes in neurons and glia that accompany a neurotransmitter release require energy. Most of this energy is used at or around synapses. Thus, there is a greater local demand for the delivery of oxygen within a region of increased synaptic activity. The local blood flow increases to meet this demand and causes a small increase in local blood volume. This small metabolic change provides the basis for functional magnet resonance imaging. The most popular fMRI-technique used to investigate the brain function is blood oxygenation level dependent (BOLD) fMRI in which the imaging contrast arises as a consequence of the higher ratio of oxy- to deoxyhaemoglobin in local draining venules and veins that accompanies neuronal activation (Ogawa et al., 1993). Compared to other techniques such as perfusion fMRI, BOLD fMRI provides much better signal-to-noise sensitivity (Matthews, 2001/2002).

Basically, the magnet resonance comes from the interaction of atomic nuclei which have a magnetic moment with an applied magnetic field. Atomic nuclei with an odd number of neutrons, in this case one proton (1H), have a nuclear spin which can be observed. They behave as a simple magnetic dipole and can assume either a high-energy state (against applied magnet field) or a low-energy state (aligned with applied magnet field). Transitions between the two energy states are accompanied by the absorption or emission of energy in the radiofrequency range (Matthews, 2001/2002). With the use of small magnet field gradients, which is called B1 (e.g. 2.5-4.0 G/cm), that are superimposed on the larger homogeneous static magnet field, which is called

B0 (typically 1.5 T)[1], it is possible to image the location of resonating nuclei. When the B1 field is switched off, excited nuclear spin can relax to low-energy state by the emission of radiofrequency energy. This is called the relaxation of spins.

The different time constants of the duration of the spin relaxation are called T1 and T2. T1 is the so called ***spin-lattice relaxation time***. Excited spins regain 66 % of their equilibrium magnetization over one T1 period and about 100 % over five T1 periods. The more rapidly excitation pulses are applied by which one does not allow the full relaxation, the less spins that can be excited and the less resonance signal can that be detected. T2 relaxation time is so called ***spin-spin relaxation time***; it is an intrinsic property of nuclei in a particular environment. By increasing the delay before signal detection, the signal from tissue with a longer T2 (e.g. brain grey matter) will be increased (Matthews, 2001/2002, p. 7).

In BOLD fMRI, variations in the relative concentration of water protons and differences in the relaxation times of the excited proton nuclei provide contrast images. We can use different ***pulse sequences*** to change the way in which the spins are excited and observed (e.g. a 'T2-weighted spin echo pulse' sequence). Contrast differences can be generated by varying three parameters of pulse sequences. The first parameter is the energy per pulse of the radiofrequency excitation energy, which is called ***flip angle***, "a measure in notional degrees of the extent to which the net magnetization vector of the nuclear spins is tipped away from the equilibrium with the applied magnetic field" (Matthews, 2001/2002, p. 7-8). The more energy that is used, the more time required for full relaxation. The second parameter is the rate at which these pulses are applied. This rate increases as the ***TR*** (repetition time) intervals (measured in seconds between pulses become shorter. The faster the rate is, the less time that is left for T1 relaxation. The third parameter is the time between the excitation and the detection of resonance signals, referred to as ***TE*** (echo time, measured in milliseconds). The longer the TE is, the less signal nuclei that have a shorter T2 are created.

Another important mechanism for generating contrast of functional MRI is ***T2* relaxation***. Due to microscopic molecular interactions (pure T2) and local magnet field inhomogeneities, the coherence of nuclear spins becomes lower. This leads to signal decay. The rate of the signal decay in the presence of local magnet field inhomogeneities (as molecules move into different regions) is so called T2* relaxation. In regions of rapidly changing local magnetic fields (e.g. in tissue adjacent to a blood vessel filled predominately with paramagnetic deoxyhaemoglobin), the T2* can be shorter than the T2 (Matthews, 2001/2002).

[1] 1 Tesla = 10000 Gauss; Earth's magnetic field = 0.5 Gauss.

Concluding, protons in the brain are excited by the emission of radiofrequency energy. When the pulse sequence is off, the relaxation of nuclear spins from different tissues provides the basis of signal contrast. After the spatial coding with the help of gradients and 2-D Fourier transforms, the contrast can be generated into an image. The metabolic changes in neurons and glia that accompany neurotransmitter release require energy. This leads to a small increase in local blood volume. The increase in total oxygen delivery (increase of oxyhaemoglobin) exceeds the increase in the oxygen utilization of neurons. This reduces the proportion of deoxyhaemoglobin in the activated areas. Since deoxyhaemoglobin is a paramagnetic material (Pauling & Coryell, 1936, as cited in Matthews, 2001/2002, p. 11), the applied magnetic field is attracted into the material which leads to a distortion of the magnet field, i.e. loss of signal. In the activated areas, the proportion of deoxyhaemoglobin decreases, i.e. the signal increases. This is the reason why one can make distinctions between activated areas and resting areas (for an illustration concerning the basics of fMRI see Figure 7).

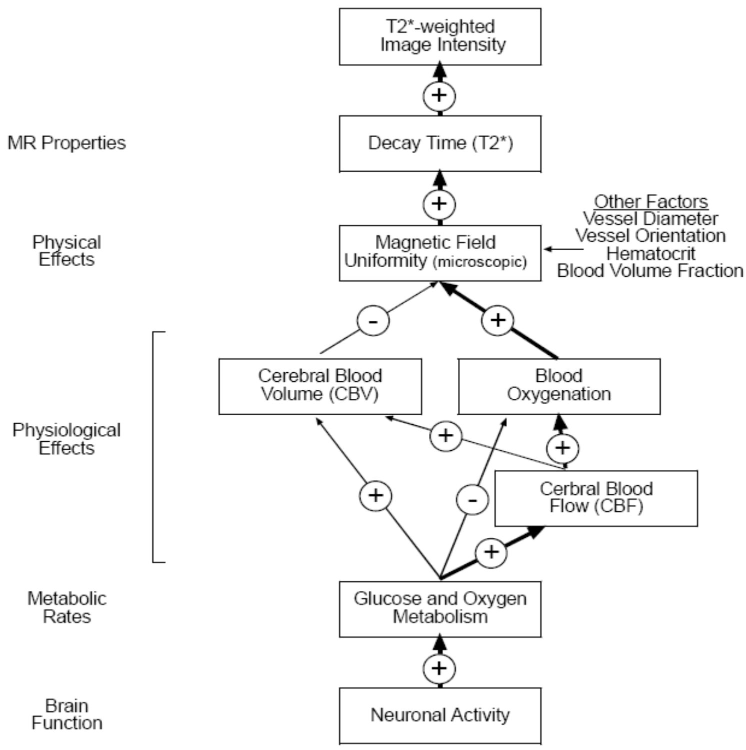

Figure 7: An illustration of the formation of the BOLD siganl (taken from Noll, 2001, p.8).

5.1.2 Paradigm design

Block design

The most commonly used experimental design is the blocked design (categorical, subtractive design). In this kind of design, a series of trials under one set of conditions are presented during a discrete period of time. The signal acquired during blocks of one conditions is compared to blocks of other conditions. In a typical study, the duration of task blocks ranges from 16 seconds to one minute. In a single fMRI run (continuous period of data acquisition), multiple task blocks, including experimental blocks and control blocks, are presented to allow the contrast of fMRI signals between blocks.

The crucial questions in a fMRI study are how to design the task comparisons in the best way and how closely matched should the different tasks be, since the fMRI methods are limited to finding relative changes between task comparisons. Regarding this question, a distinction between "tight" and "loose" comparison can be made (Donaldson & Buckner, 2001/2002, p. 179). Tight comparisons are made in order to hold as many extraneous variables as possible constant across tasks. By the loose comparison, the tasks are not closely matched, for instance, a visual fixation could be used as a baseline task. There are several merits to employ both tight and loose comparisons. In contrast to tight comparisons which only reveal regions that differ between tasks (common regions are subtracted), loose comparisons can provide a complete view of shared areas. Loose comparisons can also identify the entire network of brain regions active in a given task. This is important, because one can examine whether the experiment is successful and can control of the overall quality of the data. Furthermore, the same reference task can serve multiple sets of conditions and even studies.

Event-related design

Using event-related fMRI, the separate signal contribution of different trial types can be compared directly (D'Esposito et al., 1999). Rather than a temporally-integrated signal of blocked paradigms, individual trial events (or subcomponents of trial events), for example, the presentation of a visual stimuli, fixation, non-verbal response such as button pressing, are measured in event-related paradigms. An important merit of event-related paradigms is that trials can be presented randomly. Random presentation prevents subjects from suffering from fatigue and boredom. Unlike by the blocked design, subjects are not able to develop strategies for a special type of stimuli. The original event-related design allows time for blood flow responses to reach a baseline before proceeding to the next. This makes each task longer (about 12 to 16 seconds) due to the slow haemodynamic response.

Newly developed approaches present stimuli more rapidly. This is a contribution of the following development (Donaldson & Buckner, 2001/2002): first, the sampling rate of fMRI-measures is improved so that the total TR (repetition time) can be acquired in as little as 2 seconds on current commercial systems. Second, the fMRI-signal is highly sensitive, even a very short period of neural activity elicits a measurable signal change. In addition, the shape of the BOLD haemodynamic response to a given period of stimulation is predictable and stable. Even of the initial response has not decayed, the same response will be evoked, i.e. the haemodynamic response summates in a “linear fashion” (p. 182).

Mixed design

In general, the blocked design and the event-related design are sensitive to different signal changes. Event-related paradigms are sensitive to transient changes that are time-locked to events of interest, whereas the blocked designs are additionally sensitive to sustained signal changes that exist across extended periods of time. Therefore, Buckner and Donaldson suggested a mixed design in which both the blocked paradigm and the event-related paradigm are used. Only with “mixed” designs is it possible to explore the role of both “transient” and “sustained” activity in supporting cognitive processing and any potential interplay between the two (Donaldson & Buckner, 2001/2002, p. 193).

5.1.3 Presentation of results

Functional MRI is usually used to find the neural correlate of the cognitive functions. The results are usually shown either in so called functional maps or tables in which activated clusters are listed with the anatomical labels, coordinates, mapped brodmann areas and statistic power. Nearly all fMRI and PET studies report results in Talairach coordinate space (Talairach & Tournoux, 1988). This system was called “the universal language of brain mapping” (Bookheimer, 2002, p. 155). In the Talairach system, all locations within the three-dimensional space of the brain are represented as a number from left (negative x value) to right (positive x value), from anterior (positive y value) to posterior (negative y value) and from inferior (negative z value) to superior (positive z value). In this way, a three-number coordinate defines the spatial location of any point in the brain (e.g. right fusiform face area: 44, -46, -20). Either the highest peak of the activation in a region or the geometric center of a three-dimensional blob of activity is presented. This system makes it possible to compare brain activation across centers, imaging modalities and subjects (Bookheimer, 2002).

5.2 Application to language research

Since fMRI allows non-invasive mapping of human cognitive functions, it has become an important tool for understanding human language function. In this section, a brief review about the cortical organization of language processing that is yielded from functional MRI studies will be given. The aim is not to give a complete review, however, only relevant important findings in the context of this study.

5.2.1 Word recognition

With regard to the language comprehension and production, word recognition is the most researched area using an fMRI. Cabeza and Nyberg (2000) published a relatively complete empirical review of 275 PET and fMRI studies in which the data from healthy young adults were analyzed. Regardless of input modality and form of response, activation in areas 21 and 22 in temporal cortex has been consistently found. This activation for spoken word recognition tended to be bilateral whereas visual word recognition evoked rather the activation in the left hemisphere (e.g. Binder et al., 1994). The traditional view states that Wernicke's area is associated with word comprehension whereas Broca's area/left inferior prefrontal cortex is linked to word production. The involvement of the left temporal gyrus confirms this view partially; however, other left temporo-parietal regions may be more critical for the comprehension of auditory and visual material at a linguistic-semantic level (Binder et al., 1997). By comparing the conditions of responses, i.e. spoken response vs. non spoken response, Cabeza and Nyberg (2000) did not suggest that the left inferior prefrontal region was involved when spoken responses were required in the studies. Instead, spoken responses activate cerebellum to a higher extent. Ackerman et al. (1998) provided evidence that cerebellar activation may play an important role by speech production at an articulatory level.

Actually, it is too simple to assume that there is a dual mapping in which the Wernicke area is responsible for the speech perception and Broca area is linked to the speech production. What the fMRI studies revealed with regards to the role of the Broca area is that it is not only involved with the word production but also the word perception (e.g. Price et al., 1996; Binder et al., 1997). It has been suggested that the left inferior frontal activation deals with semantic processing (Price, 1998). Neural correlates of semantic processing and the function of the left inferior frontal region will be introduced later.

Another issue concerning word recognition is whether different input modality evoke different neural networks. It would be interesting to investigate if there is any components which are independent from input modality. Buchel et al. (1998a,b) suggested that the left temporal region (BA 37) is a multimodal language region. The activation in this region was found by tactile and visual reading by blind subjects and visually unimpaired subjects. It was proposed that this area may not store linguistic codes but promote activity in other areas that utilize lexical or conceptual access. Cabeza and Nyberg (2000) speculated this finding because activation in the Brodmann area 37 (BA 37) occurs commonly in the visual word recognition studies but not in any spoken word recognition studies. Cohen et al. (2004) investigated the word recognition circuits organized in the left temporal lobe and clarified the difference between auditory and visual word processing streams. The so called visual word form area in the left occipitotemporal sulcus appears as a visual unimodal area. However, there is a second lateral inferotemporal which is multimodal and an auditory word form area which located in the left anterior superior temporal sulcus.

Another interesting issue of word recognition is the word frequency effect. There is evidence supporting dual-model word processing (e.g. Fiebach et al., 2002). Low-frequency words, compared to high-frequency words, begot greater activation in the superior pars opecularis (BA 44) of the left interior frontal gyrus (IFG), in the anterior insula and in the thalamus and caudate nucleus. In addition, pars triangularis (BA 45) and the left inferior frontal gyrus are also involved by low-frequency word processing.

5.2.2 Syntactic processing

When trying to investigate the neural correlate of syntactic processing, control conditions may influence the interpretation of data. By an extreme control condition in which only the resting status was provided, the so-called syntactic processing may include some lexical and sublexical processing (Indefrey, 2003). In contrast, using a simple syntactic task as a control condition may only reflect the neural correlate of the complexity of syntactic processing. Therefore, it is important to consider the findings concerning syntactic processing that is independent of design and input modality. That is, for both difficult and simple syntactic processing as well as for spoken sentence processing and written sentence processing (Indefrey, 2003).

Indefrey (2003) published a meta-analysis about the neural correlate of syntactic processing in which twenty-eight PET or fMRI studies were analyzed. In all, the rearward part of the bilateral frontal lobe, the back section of the left middle frontal gyrus, the middle part of bilateral superior temporal gyri, the front and back part of superior temporal gyrus and the middle and back area of the middle temporal gyrus are the essential regions involved in syntactic processing.

As shown in the meta-analysis, it was suggested that the Broca-area is related to syntactic processing despite the complexity of the sentences. This is a rather general area because this area is not only involved with comprehension of normal sentences but also pseudo-sentences (Friederici et. al., 2000a; Indefrey, 2001). Interestingly, activation in the homologue area at the right hemisphere was found when difficult sentence processing was compared to simple sentence processing. There are several approaches to explain this phenomenon; first, the right homologue area offers a kind of compensatory function that supports the processing of more difficult sentences (see also Just et al., 1996). The question is, whether this area alone supports the processing of sentence or if it serves as additional non-syntactic cognitive resource. Indefrey (2003) suggested that activation in this area was due to the experimental task in which subjects performed, not only a syntactic, but also non-syntactic, for instance, a phonological judgment task. A further activation area, which was independent from the presentation mode and experimental design, is the posterior part of the left superior temporal gyrus. This area belongs to the classical language area, Wernicke area.

The finding, that the Broca-area as well as the Wernicke-area is essential for sentence processing, is quite consistent with the clinical studies. Patients with brain lesions in these areas often suffer from grammatical disorders (Caplan et al., 1996). In addition, the left caudate nucleus and insula is involved in syntactic processing (Moro et al., 2001).

5.2.3 Semantic processing

IFG-Hypothesis

More and more neuroimgaing studies have identified the small brain regions within the inferior frontal gyrus (IFG) that respond to specific aspects of language. In a PET study, Petersen et al. (1988) found that the anterior and inferior portion of the IFG was selectively activated when subjects generated a semantic association task to a presented noun. This region is in the junction between the pars triangularis and pars orbitalis of the left IFG (BA 47). It represents a unique brain region involved in processing semantic relationship between words or phrases or in retrieving semantic information. This finding was confirmed by studies with different experimental designs, such as specifics of task demands, input modality and types of stimuli (for a review see Bookheimer, 2002).

By most accounts, this area is neither modality specific nor is it content specific. The anterior IFG is rather important for “executive” aspects of semantic processing, i.e. semantic working memory, directing semantic search, drawing comparisons between semantic concepts in working memory, etc (Bookheimer, 2002, p. 168). On the other hand, it was suggested that IFG performs a more general function such as making comparisons or judgments among information held in working memory (e.g. Thompson-Schill et al., 1997; Muller et al., 2001). As mentioned in former sections, IFG is also associated with phonological processing and syntactic processing. Bookheimer (2002) suggested that there is network within the IFG consisting highly interactive and compact modules which enable human language processing.

Content-specific organization of semantics

Apart from content-independent semantic region in inferior frontal gyrus, there is increasing evidence showing that semantic content is categorically organized and spatially segregated. Dissociations between for example, living *vs*. non-living categories (e.g. Smith et al., 2001) or concrete *vs*. abstract words (e.g. Jessen et al., 2000) are supported by fMRI-studies. According to Bookheimer (2002), there are some problems when interpreting fMRI-data of research for category-specific dissociation. Do category-specific findings imply distinct modules of those categories or do these categories just form a continuum of information across the cortex? And do those effects reflect organization based on features of categories or semantic knowledge of those categories? Regarding the first question, Ishai et al. (1999) found that the activation of each category in distinct regions is only reliable within subjects but not across stimulus types. Therefore, they suggested that there are not independent modules for a single category. The neural representations of categorical information overlap. As to the second question, there is evidence that the organization of semantic categories is not random but reflects sensory and motor associations within one of the conceptual categories (e.g. Martin et al., 1996). Information about natural and specific categories distributes diffusely in sensory and cortical areas. This distribution may differentiate from culture to culture and is bound together by an executive semantic system in the left frontal lobe (Bookheimer, 2002).

5.3 Summary

Using fMRI to explore cognitive functions was a revolutionary step in the research of cognition since it is an non-invasive method and offers very high spatial resolution. It is also an important tool to confirm language processing theories which result from lesion studies. Due to the nature of this method, there is no so-called optimal design. Different experimental paradigms and statistical analyzing approaches may evoke gradually different findings. Applying fMRI in understanding language function, the most researched area is word recognition. The old view of Broca’s area and Wernicke’s area must be corrected that both of them are engaged in language perception as well as production. Besides, these two areas are essential for the syntactic processing in spite of sentence complexity, presentation mode and experimental design. As to the semantic processing, fMRI data does not support a unique categorical system of semantic organization. The information of different categories is more likely to spread diffusely in the brain regions associated with their sensory-motoric as well as linguistic features.

Part II Experimental Investigation

In the theoretical part, linguistic and cognitive aspects of proper names across languages have been explored. As chapter one to chapter four have showed, the dissociation between proper names and common nouns can be observed in philosophical linguistics and descriptive linguistics. Cognitive models of the processing of proper names also suggest that those linguistic features can be reflected in different processing routes of these two word categories. A great number of studies on Indo-European languages have provided behavioral evidence, for instance in recognition time, for this hypothesis. Words in Mandarin Chinese, unlike Indo-European languages, possess different features respective of phonological and morphological characteristics. The first research question will concern the recognition time of proper names and common nouns. Is there a difference in recognition time for proper names and common nouns in Mandarin Chinese? Can the advantage or disadvantage of processing proper names be replicated in Mandarin Chinese?

Furthermore, patient data as well as experimental data imply that there may be a further differentiation among the subcategories of proper names. Is there any behavioral or neuroimaging evidence for this approach? The second question concerns the neural correlates determining the comprehension of proper names and common nouns. What are the neural correlates underlying proper name and common noun processing? Is there any category difference between proper name processing and common noun processing in brain activation? What implications do they provide for the theory development? Is the neural correlate of category specific processing of proper names universal for languages? According to the theories of proper names, proper names and common nouns differ in the degree of meaning. Proper names contain less systematic meaning whereas common nouns are linked to rich associative features. The same idea is used in the cognitive model of the processing of proper names (Valentine et al., 1996) in which the semantic system is differentiated into general semantic systems and identity-specfic semantics. It would be interesting to see if there is any neuroimaging evidence supporting this theory. Will differences regarding the semantic processing be reflected in the neural correlates?

Two studies which includes one behavioral study and one fMRI study were designed to explore the aforementioned research questions. They will be described in chapter six and chapter seven.

6. A behavioral study on processing of proper names

This study aims to investigate the temporal aspect of the comprehension of proper names. The study consisted of three parts: a gating task, a visual category decision task and an auditory category decision task.

6.1 Methods

The gating paradigm is often applied to explore the on-line processing of language comprehension. The process of word recognition is divided into two different perspectives. According to one perspective, the semantic access is permitted after the phonological information is completely identified (e.g. Forster 1976; Morton 1969). The language processing system is made of modules that are functionally autonomous. Another alternative is that those processing modules interact and share information across levels (e.g. Marslen-Wilson & Tyler, 1980; Marslen-Wilson, 1987; McClelland& Elman, 1986; Norris, 1994; Norris et al., 1995). Under this perspective, the output of a module can be influenced by information from other modules. The interaction models provide the advantage that higher-level constraints are allowed to guide lower-level processes.

In the cohort model (Marslen-Wilson & Tyler, 1980) of word recognition, the input signal is equalized with a set of word candidates. As the hearer perceives the first phoneme, he activates all words with this word initial in his mental lexicon. This group of word candidates is the so called word initial cohorts. At the same time, not only the lexical form is activated but also the semantic codes (Marslen-Wilson, 1987). The more the hearer perceives the word, the less word candidates there are, which are compatible with the acoustic input. Taking American English for example, within 200 milliseconds (ms) of word-onset, there would be more than about 40 words still compatible with the available input (Marslen-Wilson, 1984, as cited in Marslen-Wilson, 1987, p. 74). Incompatible words are removed in this process until the last word candidate is identified as the target word.

The so called gating procedure (Grosjean, 1980) is based on the cohort model. In the gating procedure, acoustic gates of a language stimulus with gradually increasing length are presented. For example, 30 ms of the stimulus word (measured from the word onset) is presented at first. The length of the stimulus is added gradually trial by trial. In the second trial, longer gates (e.g. 60 ms) of the stimulus word is presented. In the third trial, the 90 ms gates are presented. The procedure is then repeated until the listener can recognize the target word. The listener should recognize what the target word is and say whether they are confident in their guess by each presentation of gates.

As a result, the temporal procedure of the lexical access can be explored. According to Grosjean (1980, p. 268), one has to differentiate the ***isolation point*** and the ***recognition point***. The isolation point indicates the time point (measured from the beginning of the stimuli) in which the correct target word can be isolated from other word candidates. The isolation point is gating-procedure-specific and describes the time that the listener needs to identify the correct target word form without changing his decision after listening to the rest of the stimuli. At this point, the listener is able to isolate the target word but his or her confidence may not be very high because other word candidates are still activated. At the isolation point, the meanings of words are also activated although the process of word identification is not finished yet. The recognition point (this term is often used in word shadowing tasks) refers to the time point in which the listener identifies the target word completely and is definitely confident about his other decision (Grosjean, 1980). By using gating procedure, one may observe the temporal process of word recognition and confirm that words can be recognized before they are perceptualized completely.

The second procedure used in the present experiment is reaction time measurement. It is used as one of the standard methods in psycholinguistics. The reaction time is defined as the time in which experiment participants react to a giving task (Grimm, 1981).

6.1.1 Participants

Twenty male and twenty female Mandarin Chinese native speakers participated in this experiment. Their mean age was 27.6 (SD = 3.4). All of them were right-handed according to Edinburgh Handedness Inventory (Oldfield, 1971). According to their statement, they did not have any history of neurological disease and hearing problems. None of them were taking medical treatment which might influence task-related cognitive ability. Participants with bilingual background in the sense of a foreign language were not included in this experiment.

6.1.2 Material

There were a total of 360 different words used in three sessions, including common nouns and proper names. Semantically comparable words within the same word category were selected as stimuli. For the category of common nouns, 120 high-frequency words which reflect concrete physical forms, e.g. *baby*, *flower*, *air plane*, were used. The most common nouns were selected from Sinica Corpus (http://www.sinica.edu.tw/SinicaCorpus/). High-frequency words were those in which frequency of occurrence was at least 19 per million. The second source for stimuli was taken from Mandarin Chinese textbooks used in Taiwanese elementary schools (http://www.sinica.edu.tw/wen/textbooks/intro.html).

As to the representatives for the proper names, the proto-typical class, i.e. personal names, were presented. There were 60 male first names and 60 female first names used for three sessions, which were taken from the list of accepted pupils that participated in the university/college entrance examination of Taiwan, 2002. In this list, there were 79027 complete personal names altogether. Despite the different surnames, there were a total of 39419 first names entities. Firstly, the gender of the names was judged according to their general semantic features (see 2.4.1 for patterns of personal naming). For instance, names constituted of *líng* (=玲, tinkling of jade) are usually female names. Semantically neutral names or names without a clear semantic gender marker were deleted from the candidate list. The frequency of the absolute appearance of each name was calculated. The most frequent first name had an absolute frequency of 295 (3732 per million). Selected stimulus names had an absolute frequency which was higher than 24 (303 per million). These names provided the advantage that they must have been more familiar for our subjects, since the subjects were approximately in the same generation.

Besides personal first names, 80 geographical names and 40 brand names were also included in the category of proper names. Under the category of geographical names, there were 20 country names, for example *rì běn* (=日本, Japan); 10 province names, for example *sì chuān* (=四川, Sichuan); 30 city names, for example *tái běi* (=台北, Taipei), and 20 city zone names, for example, *běi tóu* (=北投, Beitou). Not only Taiwanese or Chinese geographical names were included but also some international geographical names, for example *Paris*, *New York*. Under the category of brand names, there were 20 brand names for abstract products such as bank and insurance services, for example, *kúo tài* (=國泰, Cathay) and 20 brand names for concrete products such as soft drink or computer, for instance, *hóng jī* (=宏碁, Acer). Internationally famous brands such as *Kodak*, *Mercedes* which have a popular translation in Mandarin Chinese, together with some local brand names, were applied for our reaction time sessions.

Proper names that are homophones or homographs to common nouns were excluded to avoid the ambiguity and difficulty of the interpretation. Furthermore, all words were matched respectively with the number of syllables and initial phonemes. Both common nouns and proper names were two-syllable words and the initial phonemes of these two categories were controlled to be equally distributed. In a pretest, several native speakers of Mandarin Chinese all have judged stimulus words as familiar words.

In order to maintain the properties of natural spoken language, all auditory stimulus words were embedded in a sentential context for recording purpose. These sentences were also taken from the Sinica corpus (http://www.sinica.edu.tw/SinicaCorpus/). Connected speech provides the advantage, that the natural prosody and temporal features can be better preserved than isolated speech. In addition, for recording purposes, target words were listed at the beginning of the sentences so that the co-articulation effect could be minimized by editing. Several filler-sentences were mixed with the target sentences in the speaker’s list so that the speaker would not be aware of target words. All sentences were in indicating form in order to avoid an emotional speech. After sentence recording, isolated target words without any sentential context were recorded for the fMRI experiment.

The speaker for the auditory stimuli was a young native Mandarin speaking woman. The stimuli were recorded with a DAT-recorder in a sound-reduced chamber. They were edited with Sound-Edit program 1.6. Target words were cut out from the whole sentences. The mean length of the words, independent of word category, was 449.20 ms (SD = 92.7 ms). The mean length of proper names was 459.1 ms (SD = 88.9 ms). The length of common nouns was 432.7 ms (SD = 97.1 ms). The mean length of proper names, including personal names, geographical names and brand names, was significantly longer than the mean length of common nouns (t = 2.03, df = 212, $p <$ 0.05).

Visual stimuli words were different from the auditory stimuli and were presented in standard characters on a computer monitor for 500 ms. All visual items comprised two characters. The characters were ordered from top to bottom in order to avoid the effect of reading direction, since it is possible to read Chinese characters from right to left as well as from left to right. The possibility of a reading direction from bottom to top does not exist. An example for auditory stimuli and visual stimuli is shown in Figure 8 and Figure 9.

Table 1 shows the details of stimulus words. There was a significant difference of word length for the auditory reaction time session {$F (3, 130) = 10.175$, $p < 0.001$}. A post hoc test according to Scheffé’s procedure showed that there was a significant difference of word length between groups. Regarding the ariculatory length of words, there was a significant difference between personal names and common nouns {$p <$ 0.01}, personal names and geographical names {$p < 0.01$} as well as personal names and brand names {$p < 0.001$}. There was no significant difference between common nouns and geographical names {$p = 0.994$}, common nouns and brand names {$p =$ 0.339} as well as geographical names and brand names {$p = 0.250$}.

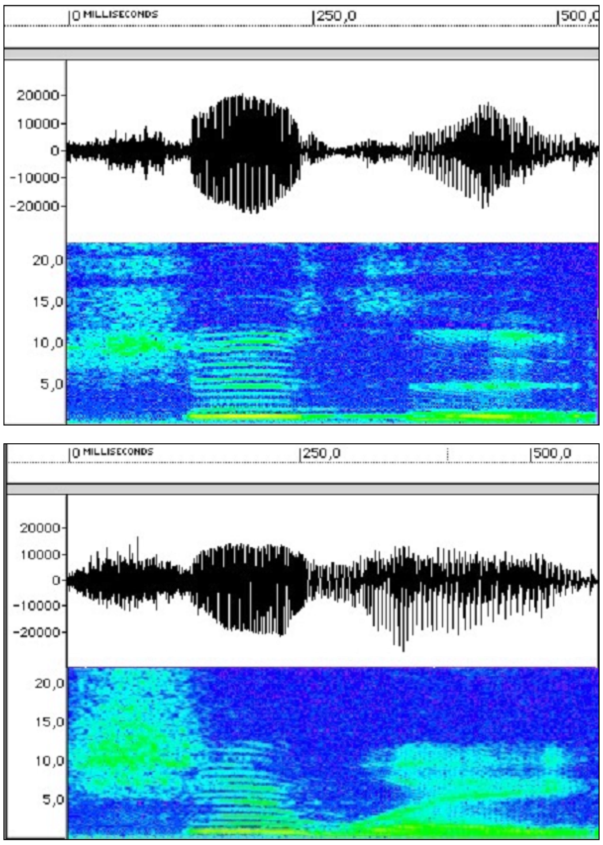

Figure 8: Example of auditory stimuli. Upper: *shī zi* (= 獅子, lion), lower: *shì wěi* (= 士偉, male first name).

Figure 9: Example of visual stimuli. Upper: *yă huì* (female first name), lower: *yăn jīng* (eye).

Table 1: An overview of experimental stimuli. Word length = articulatory length in connected speech.

experiment	word category	subcategory	number of items	mean length (ms)	SD (ms)
Gating	proper name		40	482.2	75.0
	common noun		40	443.1	97.2
Audio	proper name	first name	40	499.3	78.0
		geographical name	38	427.6	91.7
		brand name	16	375.3	56.1
		total	94	449.2	92.8
	common noun		40	422.2	97.0
Visual	proper name	first name	40		
		geographical name	40		
		brand name	20		
		total	100		
	common noun		39		

6.1.3 Procedure

Preparation session

In the pre-experimental session, participants made statement about their personal background and handedness by filling out questionnaires. The basic questionnaire aimed to elicit information about the participants' language proficiency in Chinese dialects, hearing ability, history of medical treatment and neurological diseases. In the handedness questionnaire, subjects reported their preferentially used hand they for a specified action, such as using scissors, throwing a ball etc.

The experimenter gave an instruction about the experiment procedure and gave the definition of proper names and common nouns. This was achieved by giving concrete word examples for each word category. Before the experiment began, participants got some test items presented through head phones for adjusting proper sound volume. The order of the session was gating, visual choice reaction time session and then auditory choice reaction time session.

Session one

The task for participants was to make a category decision, either proper name or common noun, after each presented stimulus. There were 80 target words including 40 common nouns and 40 personal names. There was no time limitation for making decisions. Each trial consisted of a double presentation of a short gate (100 ms) and a double presentation of a long gate (160 ms). The decision for short gates should be independent of the decision for long gates. Participants could name a word concretely if they had a proper word candidate in mind after listening to the presentation. Answers were documented for further evaluation.

Session two

The visual stimuli were randomly presented in standard characters on the computer monitor. The participants' task was to make a category decision, either proper name or common noun, by pressing a button with the right or left forefinger. There were two buttons for answers, one for each word category. The buttons were positioned for the right hand and the left hand. Half of the participants pressed the right hand button for the decision of proper name whereas the other half were required to press the left hand button for the same answer. A signal tone was presented after finishing each task. The reaction time of category decision was measured from the onset of the stimuli until pressing the button. The inter-stimulus-interval for reaction time sessions were alternated between 1200, 1300 and 1600 ms in order to prevent the participants from predicting the stimuli onset time unconsciously. With this variation, participants had to concentrate more on the tasks than on the fixed interval.

Session three

The auditory stimuli were randomly presented through a head phone. The participants' task was to make a category decision, either proper name or common noun, by pressing a button with the right or left forefinger. The same design as in session two was adapted for this purpose.

Stimuli rating

A stimuli rating questionnaire about the connotative meaning of the target words or personal relationship to them, scaled from 1 to 3, was provided for further evaluation. The experimenter explained how participants should rate the stimulus words. For example, a stimulus word could be scaled with one, if the stimulus word was the name of a friend, which evoked much emotional association, irrespectively if it evoked a positive or negative feeling. Words which could not evoke any emotional association should be scaled with three. If the stimulus could evoke an emotional association, but one that wasn't as strong as a scale one, then it should be scaled with a two.

6.2 Hypotheses

6.2.1 Hypotheses for gating session

Proper names and common nouns contain distinctive linguistic features (see chapter 2). Furthermore, interactive models of spoken word comprehension (e.g. Marslen-

Wilson, 1978) predict that a word can be recognized before the phonological processing is finished. One may hypothesize that top-down information, such as word category information, can be also recognized at an early point in time. It has been suggested that German normal speakers are able to recognize word category information very early in the category decision task, about 100 to 120 ms from word onset (Werner & Müller, 2001; Schuth et al., 2002). This is even earlier than the word recognition point, approximately 170 to 200 ms in context (Marslen-Wilson & Welsh, 1978; Grosjean, 1980). If information of word category can be recognized in an early point in time and the advantage of early recognition is universal, then the same results as in the German and English studies must be replicated by the speakers of Mandarin Chinese.

First, it would be interesting to know if the frequency of the correct answers differs with different word categories. If the word category has an effect on the frequency of the correct answers, the next step is to look whether the proper name and common nouns can be recognized at an early point in time. If they can be recognized at an early point in time, then the percentage of correct answers should be higher than a random distribution. Otherwise, the correct answers would not be more frequent than expected by chance. Three hypotheses are stated as following:

1. If the word category is related to the frequency of the correct answers, the percentage of correct answers for proper names will be different from the percentage of correct answers for common nouns.
2. If proper names can be recognized at an early point in time, the frequency distribution of correct answers to presented proper names will be higher than a random distribution.
3. If common nouns can be recognized at an early point in time, the frequency distribution of correct answers to presented common nouns will be higher than a random distribution.

6.2.2 Hypotheses for visual choice reaction time session

Psycholinguistic models (see chapter 3) predict different processing routes based on the semantic and referential features of proper names and common nouns. Proper names are considered as mono-referential and must be processed holistically while common nouns can be processed hierarchically. This experiment aims to test whether this distinction can be reflected in category choice reaction time. There were three types of proper names used: personal names, geographical names and brand names.

These three categories are treated as proper names for the a priori hypotheses. Three hypotheses are stated as following:

1. If personal names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for personal names.
2. If geographical names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for geographical names.
3. If brand names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for brand names.

6.2.3 Hypotheses for auditory choice reaction time session

The same assumptions for the visual choice reaction time session are made for the auditory choice reaction time task.

1. If personal names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for personal names.
2. If geographical names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for geographical names.
3. If brand names and common nouns are two distinctive categories, the reaction time for common nouns will be significantly different from the reaction time for brand names.

6.3 Results

6.3.1 Gating

Chi-square-tests (Pearson) were used to test the hypotheses. Figure 10 shows the absolute frequency of answers for the presented stimuli of different gates.

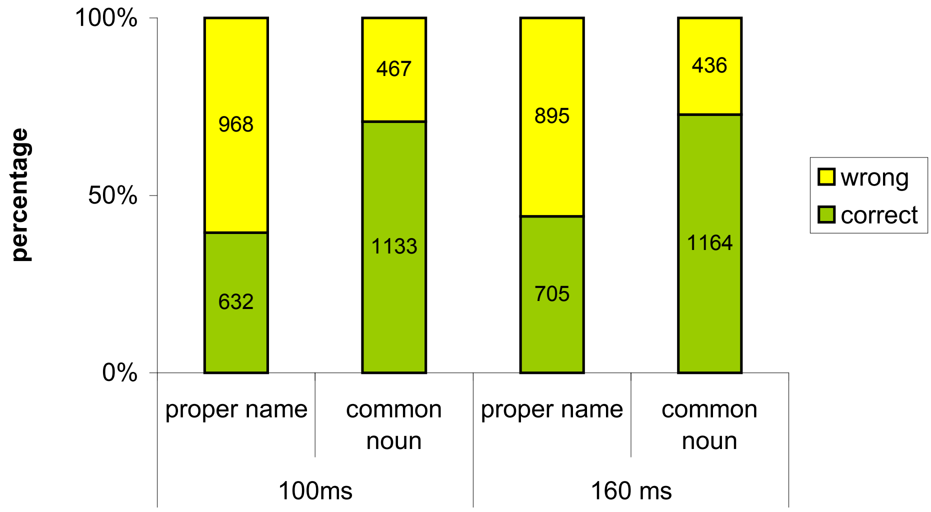

Figure 10: The distribution of answers for different word categories with different gate length (the number in the bar is the absolute frequency of the answers).

A 2x2 χ^2 test was performed to test the contingency between the word category and the frequency of answers for presented stimuli. For the 100 ms gates, the percentage of the correct answers for proper names was significantly different from the percentage of the correct answers for common nouns {χ^2 [1] = 317.124, p < 0.001}. For 160 gates, the percentage of the correct answers between proper names and common nouns was significantly different {χ^2 [1] = 271.012, p < 0.001}.

A 1x2 χ^2 test was performed to test whether proper names can be recognized at an early point in time. The theoretic random distribution is 50:50 if one assumes that the participants would either say "this is a proper name" or "this is a common noun". Theoretically, they had a 50:50 chance to answer the questions correctly. With a random distribution of 50:50, the number of correct answers for presented proper names was not higher than random frequency, neither for 100 ms gates {χ^2 [1] = 70.56, p < 0.001} nor for 160 ms gates {χ^2 [1] = 22.563, p < 0.001}.

A 1x2 χ^2 test was performed to test whether common nouns can be recognized at an early point in time. With the same random distribution, the percentage of correct answers for presented common nouns was higher than the number of correct answers following a random frequency, both for 100 ms gates {χ^2 [1] = 277.223, p < 0.001} and 160 ms gates {χ^2 [1] = 331.240, p < 0.001}.

In order to compare rating scores between different word categories, the median value of word categories was calculated for each participant. A Wilcoxon test shows that there was no difference of connotative meaning between proper names (personal names) and common nouns {Z (1) = -1.745, p = 0.081}. The rating median for proper names (here only personal names) was 3.00 and the rating median for common noun rating was 2.00. The stimulus words used in the gating session did not evoke strong emotional association.

A posteriori analysis of the frequency of gating stimuli was done to explore if there was any correlation between character frequency and accuracy of word category recognition task. Since 100 ms gates and 160 ms are not as long as a complete speech sound, one may use frequency of the first character of the stimuli words to calculate the correlation. A Spearman test shows that there was no correlation between the frequency and accuracy of the word category recognition task, neither for proper names {R = 0.057, p =0.727 for 100 ms gates; R = 0.024, p =0.881 for 160 ms gates} nor for common nouns {R = 0.118, p =0.468 for 100 ms gates; R = 0.007, p =0.966 for 160 ms gates}.

6.3.2 Visual choice reaction time session

ANOVAs were performed on reaction time data, using both subject and item means. Only correct responses were evaluated. Both the test by subject and the test by item revealed a significant effect of word category on the choice reaction time {Subject: F (3, 117) = 7.508, p < 0.01; Item: F (3, 135) = 14.809, p < 0.001} (see Figure 11 and Figure 12). There was no subject-gender-specific effect.

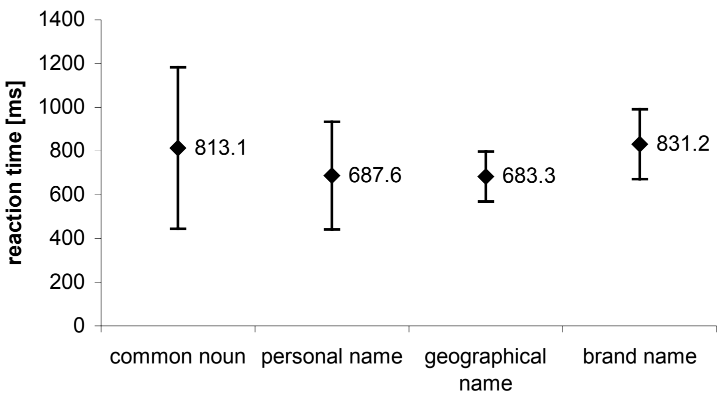

Figure 11: Comparison of mean reaction time of the visual session by subject.

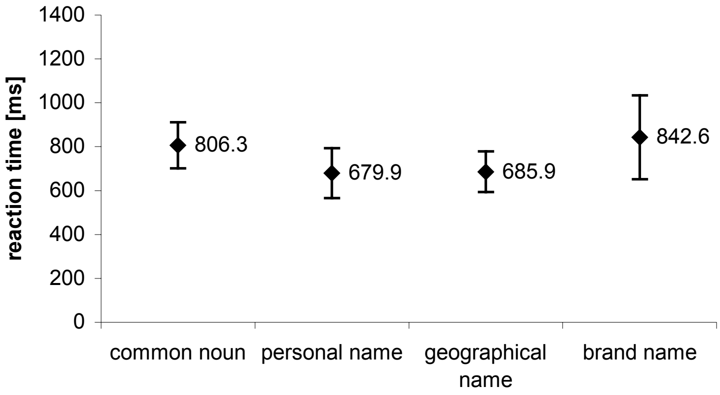

Figure 12: Comparison of mean reaction time of the visual session by item.

A post hoc comparison (Bonferroni) of subject effect showed that there was a significant difference in the reaction time between personal names and brand names {$p < 0.001$} as well as geographical names and brand names {$p < 0.001$}. There was no significant difference of reaction time between personal names and common nouns {$p = 0.132$}[2]; personal names and geographical names {$p = 1.000$}; common nouns and geographical names {$p = 0.078$}[3] and common nouns and brand names {$p = 1.000$}.

A post hoc comparison (Bonferroni) of item effect showed that there was a significant difference of reaction time between common nouns and personal names {$p < 0.001$}; between common nouns and geographical names {$p < 0.001$}; between personal names and brand names {$p < 0.001$}, and between geographical names and brand names {$p < 0.001$}. There was no significant difference in the reaction time between common nouns and brand names {$p = 1.000$} as well as between personal names and geographical names {$p = 1.000$}.

As the Friedman test showed, participants judged four word categories (personal names, common nouns, geographical names and brand names) differently in the sense of their connotative meaning {$\chi^2_r(3) = 15.974$, $p < 0.01$}. The rating median of personal names was 2.75, the rating median of common nouns was 2.00, the rating median of geographical names was 2.00 and the rating median of brand names was 2.00. Because the rating median of these four word categories were all between two and three, visual stimulus words did not evoke strong emotional associations.

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[2] A post hoc comparison (LSD) revealed a significant subject effect in the choice reaction time between personal names and common nouns {$p < 0.05$}.
[3] A post hoc comparison (LSD) revealed a significant subject effect in the choice reaction time between geographical names and common nouns {$p < 0.05$}.

6.3.3 Auditory choice reaction time session

ANOVAs were performed on reaction time data, using both subject and item means. Only correct responses were considered in data analysis. Both the test by subject and the test by item revealed a significant effect of word category on the choice reaction time {Subject: F (3, 117) = 22.718, $p < 0.001$; Item: F (3, 130) = 5.544, $p < 0.01$} (see Figure 13 and Figure 14). There was no subject-gender-specific effect.

A post hoc comparison (Benferroni) of subject effect showed that there was a significant difference in the reaction time between common nouns and personal names {$p < 0.001$}; between common nouns and geographical names {$p < 0.001$}; between personal names and brand names {$p < 0.001$}, and between geographical names and brand names {$p < 0.001$}. There was no significant difference of reaction time between common nouns and brand names {$p = 1.000$} as well as between personal names and geographical names {$p = 0.443$}.

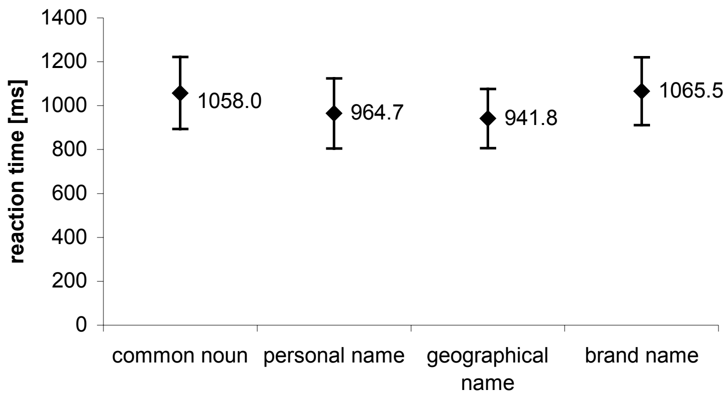


Figure 13: Comparison of mean reaction time of the auditory session by subject.

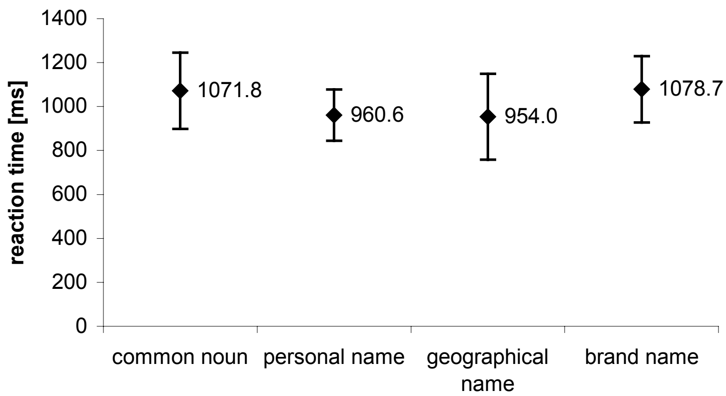


Figure 14: Comparison of mean reaction time of the auditory session by item.

A post hoc comparison (Bonferroni) of item effect showed that there was a significant difference of reaction time between common nouns and personal names {$p < 0.05$}; common nouns and geographical names {$p < 0.05$}. There was no significant difference in the reaction time between personal names and geographical names {$p = 1.000$}; personal names and brand names {$p = 0.094$}[4]; common nouns and brand names {$p = 1.000$}; and between geographical names and brand names {$p = 0.069$}[5].

For the auditory choice reaction time session, the Friedman test showed that subjects ranked four word categories (personal names, common nouns, geographical names and brand names) differently in the sense of their affective content { $\chi^2_r(3) = 19.906$, $p < 0.001$}. The rating median of personal names was 3.00, the rating median of common nouns was 2.00, the rating median of geographical names was 2.00 and the rating median of brand names was 2.00. Auditory stimulus words did not contain strong emotional associations or personal relevance for the subjects.

6.3.4 Concrete suggestions for presented items and strategies

In this experiment, subjects seldom recognized presented stimuli concretely as words. For 100 ms gates: only 0.38 % of all stimuli were recognized as target words; 1.38 % of all stimuli were not recognized as target words correctly. For 160 ms gates: only 2.63 % of all stimuli were recognized correctly as target words; 2.97 % of all stimuli were not recognized as target words. Retrospection of subjects indicated that about half of the participants did not use explicit strategies but just “guessed” the answer according to their instinct. Four participants said that they chose common noun if they did not have a concrete word candidate, whereas two participants chose proper name in the same situation. Four participants used distinctive phonological features for two word categories to support for their decisions. Six participants made morphological associations to select a word candidate and then categorized the word category information. Three participants expressed explicitly that they were able to recognize common nouns because they could find a word candidate for the presented sound very quickly.

6.3.5 Summary of behavioral results

Participants could recognize better common nouns than proper names. However, they were not able to recognize proper names with the provided auditory gates (100 ms &

[4] A post hoc comparison (LSD) revealed a significant item effect in reaction time between personal names and brand names {$p < 0.05$}.
[5] A post hoc comparison (LSD) revealed a significant item effect in reaction time between geographical names and brand names {$p < 0.05$}.

160 ms). The word category had an effect on the choice reaction time. In general, participants responded significantly faster to proper names (personal names and geographical names) than common nouns. The reaction time of brand names was similar to common nouns. These results were independent of modality.

6.4 Discussion

6.4.1 Interim discussion for the gating session

In the gating session, the temporal aspect of word processing was investigated. Word processing consists of interactions between top-down processing, such as information about word categories and world knowledge as well as bottom-up processing, such as analyzing the input phonemes and other phonological features. The focus of this session is whether one can recognize word category information of a proper name or a common noun with the provided auditory gates. As the results showed, the percentage of correct answers was not independent of word category. For both 100 ms and 160 ms gates, the percentage of correct answers for the proper name items was not higher than a random distribution; on the contrary it was lower. For both gate lengths, the percentage of correct answers for the common noun items was higher than a random distribution.

Both percentage of correct answers for proper names and common nouns did not follow a random distribution. This implies that the participants did not 'guess' the word category by chance but applied some strategies, which could lead to success or failure of the word category judgment task. One can observe that relative to the random value, there were more wrong answers for proper names while there were more correct answers for common nouns. The advantage for common nouns and the disadvantage for proper names were independent from the length of gates. Obviously, the participants were not able to identify word category information within the provided gates, at least for proper names.

As to the accuracy for common noun items, it is somehow difficult to interpret without a control condition. It remains unclear, whether the participants really recognized the presented words as common nouns or whether they just preferred to select the answer common nouns. In the post-experimental interview, some participants indicated that they always guessed common nouns if they did not know how to decide.

On the other hand, one may predict that participants better recognized the words as common nouns than they did as proper names for two reasons, namely, frequency effect and 'morphological dependence'. Firstly, high frequency of use which characterizes common nouns may probably explain the observed result. When one is confronted with a phoneme, which is a word initial of several word candidates, the dominant word-cohort with higher frequency of exposure, may lead the ongoing phonological processing. However, the posteriori analysis did not support this point of view. The results showed that there was no correlation between the frequency of the first character of target words and the accuracy of answers. One still must treat this issue with caution since the frequency used for the analysis was related to the written language.

Furthermore, morphological dependence of Chinese proper names on Mandarin Chinese may explain why participants could not recognize proper names at an early point in time. As mentioned in 2.2, Chinese proper names are not morphologically independent, since morphemes from all word categories can be used as proper names. This dependency may make the word category judgment task for proper names difficult, if there are not enough distinctive phonological or morphological features available in the 160 ms gates. Prosodic features are very important to activate the meaning of the words because Mandarin Chinese is a tonal language. It has been suggested that tonal information can be used to identify word meaning within 200 ms of word onset (Brown-Schmidt & Canseco-Gonzalez, 2004). It has also been revealed that Mandarin Chinese speech and tonal information can be correctly identified with 200 ms gates (Wu & Shu, 2003). However, it is critical if 160 ms from word onset can provide efficient tonal information. The cognitive system is occupied with primary phonological processing and the capacity for interaction between other information, such as meaning, word category, etc. is limited. This approach may explain why English and German speakers are able to recognize word category with 120 ms or 100 ms gates in word category judgment task with the same gating paradigm (Müller & Kutas, 1997; Werner & Müller, 2001) and why Mandarin speakers failed in the same task. 160 ms gates may contain efficient phonological information which is helpful for the judgement of word category for German speakers and English speakers, whereas the same gate length don't provide enough tonal information for Chinese speakers.

6.4.2 Interim discussion for the visual choice reaction time session

In this session, the reaction time of visual category decision task was measured. As the results show, the reaction time of category decision task differed with word categories. This holds for both the subject level and item level. However, results of post hoc comparisons of item effect and subject effect were not quite consistent. The test of item effect showed a very clear dissociation between proper names (personal names and geographical names) and common nouns whereas the test of subject effect only revealed a significant difference in reaction time between personal names and brand names as well as geographical names and brand names.

According to the results, one can clearly observe that brand names function similar to common nouns in the sense of the choice reaction time. In the sense of reaction time, visual brand names may not be categorized as a class of proper names. This holds for the test by subject and the test by item.

Regarding the first hypothesis, which postulates that personal names and common nouns are two distinctive categories, then the item effect (but not the subject effect) supports the dissociation between personal names and common nouns. One may say that the dissociation between personal names and common nouns, in the sense of reaction time, generally exists at the language level and the information of word category can be differentiated by speakers of the language (LSD post hoc comparison supports this view). But the information of word category is probably not the most important element contributing visual word recognition, since the Bonferroni post hoc comparison can not provide convincing evidence.

Regarding the second hypothesis, which postulates that geographical names and common nouns are two distinctive categories, then the item effect (but again not the subject effect) supports the dissociation between personal names and common nouns. One may say that there is a great difference of the reaction time between geographical names and common nouns at language level since the item effect is significant. Furthermore, participants may respond faster to geographical names than common nouns, at least for most speakers of Mandarin Chinese.

Regarding the third hypothesis, which postulates that brand names and common nouns are two distinctive categories, then both the test by subject and the test by items failed to provide any indices. The behavior in sense of evoked reaction time in category decision task is similar between brand names and common nouns. Moreover, as predicted, there is no distinctive choice reaction time between personal names and geographical names since they both belong to the class of proper names. This is supported by the test by subject and the test by item.

6.4.3 Interim discussion for the auditory choice reaction time session

In this session, the reaction time of the auditory category decision task was measured. The main result is that different word categories had a significant effect on the reaction time. This holds for both subject level and item level.

Both the test of subject effect and the test of item effect support the dissociation between personal names and common nouns. Mandarin Chinese speakers can recognize personal names faster than common nouns. Personal names and common nouns can be classified into two different word categories in the sense of the auditory choice reaction time. The first hypothesis is supported at the language level and at the level of language users.

Also, the dissociation between geographical names and common nouns is supported according to the test of subject effect and the test of item effect. The choice reaction time for spoken Chinese geographical names was faster than the choice reaction time for Chinese common nouns. Both post hoc comparison of subject effect and item effect can not support the view that brand names and common nouns are two distinctive categories. No reaction time difference between was observed between common nouns and brand names. Common nouns and brand names can be classified in the same word category in auditory modality whereas spoken personal names and geographical names can be considered as equivalent due to statistical evidence.

The data of brand names is somehow complicated since there were some inconsistent results between subject effect and item effect. One may still say that grouping brand names and common nouns in the same word category is more plausible, although the more strict statistical analysis does not allow one to make a generalization of this statement.

7. An fMRI study on processing of proper names

This study aims to investigate the neural correlates for comprehension of proper names. One auditory and one visual experiment using different words were included to study the question of the dissociation between proper names and common nouns. An interim discussion will be provided at the end of the chapter as preparation for the general discussion which will be presented in the next chapter.

7.1 Methods

7.1.1 Participants

Twelve participants (6 female, 6 male) participated in the fMRI study. They gave informed consent in accordance with guidelines set by the Chang Gung Hospital Medical Center in Taiwan. One female subject was excluded from further data analysis due to an uncorrectable motion artefact. All participants were native Mandarin Chinese speakers ranging in age between 21 and 25 years. Before the experiment started, they filled out a questionnaire including personal background, language learning history and handedness. No history of neurological diseases or brain lesions was reported, and they were all predominantly right-handed (mean laterality index was 96%) according to the Edinburgh Inventory of Handedness (Oldfield, 1971). However, the results of the handedness test do not guarantee that right-handed persons show left-hemispheric dominance by language processing. Knecht et al. (2000) showed that only 96% of right-handed people show a left-hemispheric dominance. In order to make sure that all participants had the same hemispheric-dominance by language processing, a verbal fluency test using fMRI (Woermann et al., 2003) was performed. The test revealed a left-hemispheric dominance of language processing for all participants.

7.1.2 Material

Auditory stimulus

One hundred and twenty words, including forty personal names, forty geographical names and forty common nouns as isolated speech were used (mean articulatory length = 626 ms, SD = 89 ms). These were the same words as in the auditory reaction time experimental session and were matched according to psycholinguistic criteria such as frequency, length and phonological features (see 6.1.2 for more details). The mean articulatory length of the personal names was 631 ms (SD = 102 ms). The average length of the geographical names was 620 ms (SD = 88 ms) and the common nouns had an average length of 626 ms (SD = 78 ms).

Pseudo-speech stimuli (Müller et al., 1997; Müller & Weiss, 2006) were created as a control in order to subtract language specific processes. An artificial complex signal was created by modulation of a carrier wave (200 Hz, sinusoidal) with synthesized 500 Hz, 2000 Hz and 5000 Hz sinusoidal waves to eliminate the sound analyzing part of language comprehension. A deviation of 4, 20 and 50 Hz was used to add a jitter to this artificial signal aiming at adapting the artificial signal to a "real" speech signal. Subsequently, length adapted chunks of the resulting complex wave became an "envelope clone" of the real stimuli used in this experiment: the real stimulus provided the amplitude 'template', which was superimposed on the artificial signal. This led to a completely artificial, but complex, amplitude and frequency modulated signal, which was comparable in complexity and length to the real speech signals and was called “pseudo-speech” (Müller et al., 1997; Müller & Weiss, 2006).

Visual stimulus

One hundred and twenty words, including forty personal names, forty geographical names and forty common nouns were used for the visual experiment. These were the same words as in the visual reaction time experimental session and were matched according to psycholinguistic criteria such as frequency, length and phonological features (see 6.1.2 for more details). All words consisted of two characters. They were presented vertically in the standard Chinese font characters (see Figure 9). In addition, Arabic words in vertical order (see Figure 15) were presented as the control condition.

Figure 15: An example of Arabic word as the control condition for the visual experiment

7.1.3 Design

Two experiments were conducted in this study, a visual experiment and an auditory experiment. Half of the participants performed the visual task first and the auditory task later, and vice versa for the other half. A rating of stimuli with regard to the connotative meaning was provided after the fMRI scans.

Auditory paradigm

A block design was conducted for the auditory experiment. There were four task conditions, namely, personal names, geographical names, common nouns and pseudo-speech. Each task block lasted 30 seconds and consisted of ten trials with one experimental condition. Each of the four experimental conditions was repeated four times and their order of presentation was randomized according to the Latin-square table. A 15-second-silence-block was presented between the task blocks. Before the first condition block and after the last condition block, one 30-second-silence-block was presented (see Figure 16 for experiment paradigm). Target word onset occurred 1000 ms after the onset of the trails (ISI = 3 s). By doing this, one could minimize the interference of the EPI noise on the delivery of auditory stimuli.

Visual paradigm

The same paradigm as used in the auditory experiment was adapted for the visual experiment. Each trial consisted of a word presented for 500 ms, followed by visual fixation on a crosshair for 2500 ms (ISI = 3 s).

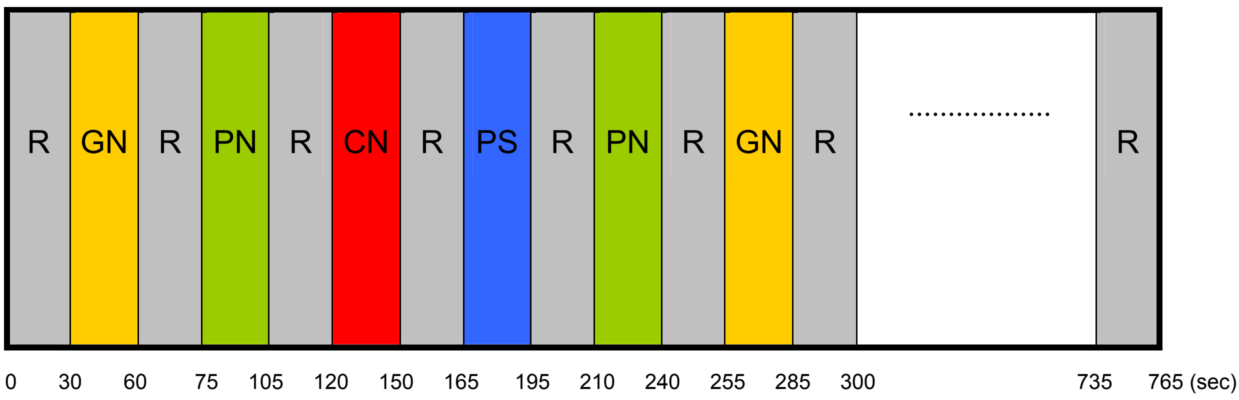


Figure 16: fMRI paradigm; GN = geographical names, PN = personal names, CN = common nouns, PS = pseudo-speech (auditory) or Arabic word (visual), R =Rest, presented as silence or fixation crosshair.

7.1.4 Procedure

Before starting the experiment, participants read the instruction about the experimental procedure. The experimental task was to comprehend the presented words and they should keep the eyes closed during the auditory experiment. No behavioral response was requested since language comprehension was highly automated even though there was no behavioral control.

The participants were visually familiarized with the procedures to reduce their anxiety before the fMRI scans began. A test-run was carried out to allow adjustment to a suitable sound intensity and visual exposition. After familiarization, the subject lay supine on the scanning table and was fitted with plastic ear-canal molds. The subject's head was immobilized by a tightly fitting, thermally molded, plastic facial mask which extended from the hairline to the chin (Fox et al., 1985) (see Figure 17 for set-up). After the set-up was completed, participants were presented the auditory and then the visual tasks, or vice versa, during the fMRI scans.

A further fMRI scan with a verbal fluency task employing common nouns was used to verify that all participants' language processing was of left-hemispheric dominance. The two kinds of verbal fluency task were evenly distributed between participants, with half of them only performing one of the tasks.

In the post-experimental debriefing, participants answered a rating regarding affective association or personal relevance (a scale from one to three) and imageability of the stimuli (scale one to seven) to assess the influence of the their personal emotions and the effects of word imagery (Schwibbe, 1994; Wippich & Bredenkamp, 1979). A one signalized that the target item was very familiar (e.g. the name of parents) in the rating test of affective association and personal relevance. In the rating test of imageability, a seven signalized very clear imageability (e.g. apple), the smaller the number was, the less the imageability.

7.1.5 Apparatus

The paradigms used in the experiment were generated from a personal computer running SuperLab (Cedrus Corporation, San Pedro, CA, USA). The auditory stimulus was delivered via headphones and the visual stimulus was presented through goggles.

The fMRI experiment was performed on a 1.5 T Magnetom Vision MRI scanner (Siemens, Erlangen, Germany). The auditory stimuli were delivered by headsets (Resonance Technology Inc., Northridge, CA, USA). A single shot T2*-weighted echo planar imaging sequence (EPI) was used for fMRI scans, with the slice thickness = 5 mm, in-plane resolution = 3.3 mm x 3.3 mm, and TR/TE/θ = 3000 ms/60 ms/90° . The field of view was 211 mm x 211 mm, and the acquisition matrix was 64 x 64.

Twenty-four contiguous axial slices were acquired to cover the whole brain. For each slice, 255 images were acquired with a total scan time of 765 s for the experiment. In the subsequent verbal fluency task 80 images were acquired with a total scan of 240 s. The anatomical MRI was acquired using a T1-weighted, 3D, gradient-echo pulse sequence. This sequence provided high solution images (1 mm x 1 mm x 1 mm) of the entire brain.

Figure 17: Experiment set-up; the tightly fitting, thermally molded, plastic facial mask which extended from the hairline to the chin was used to avoid a head motion.

7.1.6 Data analysis

Analysis of imaging data was conducted using the software SPM99 (Wellcome Department of Cognitive Neurology, London, UK). Each participant's T2*-weighted images were realigned with the first image of the series using the rigid-body transformation procedure and resliced using sinc interpolation while adjusting for residual motion-related signal changes. A mean image was created from the realigned and unwarped time series data. The mean T2*-weighted image was spatially normalized via nonlinear basis functions to the EPI template image, the stereotaxic space of which was based upon the Talairach and Tournoux system. The nonlinear transformations for the mean T2*-weighted images were subsequently applied to the realigned fMRI time series data. The data sets were then spatially smoothed by convolution with a three-dimensional Gaussian kernel (FWHM = 8 mm). Data were analyzed by modeling the experimental conditions using boxcar functions convolved with a hemodynamic response function in the context of the general linear model employed by SPM99. The resulting time series data across sessions were high-pass filtered with a cut-off of two block cycles to remove low frequency drift. The effect of global differences in scan intensity was removed by scaling each scan in proportion to its global intensity. The contrast between conditions was examined by voxel-specific t-tests (SPM{t}) for all the participants. The t-statistics were subsequently transformed to

Z statistics to create a statistical parametric map (SPM{z}) of the contrast. The SPM{z} map was then interpreted by referring to the probabilistic behavior of Gaussian random fields. Unless otherwise indicated, the regionally specific difference with an uncorrected threshold of $p \leq 0.001$ and cluster size ≥ 50 voxels was considered statistically significant. For comparisons with the control condition, a threshold of corrected $p \leq 0.05$ and cluster size ≥ 20 voxels was considered statistically significant. Activation maps were overlaid on the normalized T1 structural template image, and the maxima were labeled using the nomenclature of Talairach and Tournoux by means of the TD database (Research Imaging Center, The University of Texas Health Science Center, San Antonio, TX). Anatomical label (lobes, gyri) and Brodmann area (BA) designations were applied automatically using a three-dimensional electronic brain atlas (Lancaster et al., 1997).

7.2 Results

7.2.1 Auditory results

Difference between proper names and common nouns can be shown in the contrasts relative to the control baseline pseudo-speech as well as in the direct comparisons between word categories. When the baseline was pseudo-speech, then personal names, geographical names and common nouns showed activation mainly in the right hemisphere (Figure 18). All three word categories engaged the middle temporal cortex and the occipital cortex. Proper names, including personal names and geographical names, activated additionally the right premotor cortex. When proper names and common nouns were compared with each other, proper names showed significant activation in precuneus, bilateral anterior cortices and premotor areas, whereas common nouns yielded significant activation in the left posterior temporal cortex and bilateral visual cortices. The following sections describe the results in more details.

Activation for different word categories

Anatomical visualization of these three word categories relative to baseline pseudo-speech is shown in Figure 18. In contrast to the pseudo-speech, bilateral occipital activation was found in all word categories. The occipital activation for common nouns was most extended, the less extended activation was observed for personal names.

Regarding the temporal activation, personal names induced significant activation in both hemispheres, whereas geographical names and common nouns predominantly evoked right hemispheric activation. Listening to personal names was associated with activation in bilateral inferior temporal gyri (BA 20) and middle temporal gyri (BA 21).

Temporal activation for common nouns included right inferior temporal gyrus (BA 20) and bilateral fusiform gyri (BA 37, 19 at left side; BA 19 at right side). Significant temporal activation for geographical names was found at the right inferior temporal gyrus (BA 20) and middle temporal gyrus (BA 21).

Activated areas in the frontal region can be divided into two classes: both personal names and geographical names activated right precentral gyrus (BA 6), whereas common nouns did not evoke significant activity in frontal regions.

Parietal activation was also shown for all conditions and located in postcentral gyrus and precuneus. Variations were found in the involved hemisphere side. Listening comprehension of personal names was associated with activation in bilateral postcentral gyri (BA 3) and right precuneus (BA 7); common nouns was associated with activation in bilateral precuneus (BA 7) and left postcentral gyrus (BA 3); geographical names was associated with activation in bilateral precunes (BA 7) and right postcentral gyrus (BA 3).

Dissociation between proper names and common nouns

<u>Characteristics of proper names</u>

Compared with common nouns, personal names yielded a bihemispheric involvement in the precentral gyri (BA 6, 4) and anterior superior temporal gyri (BA 38; BA 22 only at the left side). The activation peak was shown in anterior precuneus (BA 7). A right hemispheric involvement was found in the medial frontal gyrus (BA 6, 8), postcentral gyrus (BA 3), and other areas such as the caudate, parahippocampal gyrus (BA 27), insula (BA 13) and thalamus (see Figure 19 and Table 2 for more details).

Geographical names, in contrast to common nouns, evoked greater activity in several frontal areas such as the middle frontal gyrus (BA 6) and superior fronal gyrus (BA 6, 8) in both hemispheres. The activation in the medial frontal gyrus (BA 6) was only seen in the right hemisphere. Bilateral activation was also observed in anterior superior temporal gyri (BA 38) and superior occipital gyri (BA 19). The parietal activation was strongly right-lateralized and located in regions such as the angular gyrus (BA 39) and inferior parietal lobule (BA 40) (see Figure 20 and Table 3 for more details).

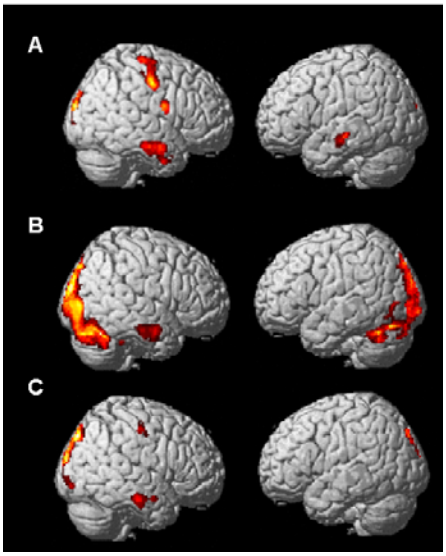
<u>Characteristics of common nouns</u>

An increased level of activation for common nouns was located in the occipital lobe when the baseline was personal names. The significant activation in the temporal region was shown in posterior part of left superior temporal gyrus (BA 22) and middle temporal gyrus (BA 21). Furthermore, right inferior frontal gyrus, right inferior parietal lobule (BA 40), right postcentral gyrus (BA 3) and left posterior precuneus (BA 7) were involved in processing common nouns (see Figure 21 and Table 4 for more details).

Common nouns showed significant activation in the bilateral occipital region (BA 17, 18, 19) in contrast to geographical names. The main temporal activation was located in the left middle temporal gyrus (BA 21). Further tiny activation clusters were found in left superior temporal gyrus (BA 22), right inferior temporal gyrus (BA 20) and bilateral fusiform gyri (BA 19). Details of this contrast is shown in Figure 22 and Table 5.

Stimuli Rating

The results indicate no significant difference between all word groups with regard to affective association and personal relevance {X^2r (2) = 4.00, p = 0.135}. With regards to the imageability of word groups, there was a significant difference in rating {X^2r (2) = 18.513, p < 0.001}. Common nouns appeared to produce more mental images than personal names {Z = -2.971, p < 0.01} and geographical names {Z = -2.823, p < 0.01}. Personal names evoked the lowest imageability which was even significant smaller than geographical names {Z = -2.132, p < 0.05}.



R **L**

Figure 18: Brain activation maps for (A) personal names *vs*. pseudo-speech (B) common nouns *vs*. pseudo-speech (C) geographical names *vs*. pseudo-speech in the auditory experiment. An occipital activation is revealed in all contrasts.

Table 2: Regions of significant activation for comprehension of spoken personal names *vs.* common nouns.

Region		Side	X	Y	Z	T
Frontal Lobe	Medial Frontal Gyrus	R	6	-22	58	4.98
		R	24	37	41	3.88
	Precentral Gyrus	R	61	-6	39	4.27
		R	34	-24	56	3.91
		L	-14	-28	64	3.65
		L	-20	-18	65	3.36
Temporal Lobe	Superior Temporal Gyrus	R	46	1	-12	4.06
		L	-46	-8	-8	3.86
		L	-44	7	-19	3.83
Parietal Lobe	Anterior Precuneus	L	0	-59	32	7.24
	Postcentral Gyrus	R	24	-26	60	3.21
Other areas	Parahippocampal Gyrus	R	16	-35	0	3.58
	Insula	R	42	-4	-5	3.67
	Thalamus	R	24	-22	18	3.97
	Caudate	R	18	-22	27	3.48

Significant at $p < 0.001$, uncorrected.

Table 3: Regions of significant activation for comprehension of spoken geographical names *vs*. common nouns.

Region		Side	X	Y	Z	T
Frontal Lobe	Medial Frontal Gyrus	R	6	-22	58	4.21
	Middle Frontal Gyrus	L	-22	22	56	4.26
		R	28	22	54	3.54
	Superior Frontal Gyrus	L	0	13	62	3.84
		R	4	-3	65	3.25
		R	24	29	45	3.83
Temporal Lobe	Superior Temporal Gyrus	R	42	1	-15	4.29
		L	-38	5	-17	3.52
Parietal Lobe	Angular Gyrus	R	51	-64	36	3.96
	Inferior Parietal Lobule	R	51	-32	57	3.64
Occipital Lobe	Superior Occipital Gyrus	L	-36	-80	35	5.67
		R	44	-74	37	4.81

Significant at $p < 0.001$, uncorrected.

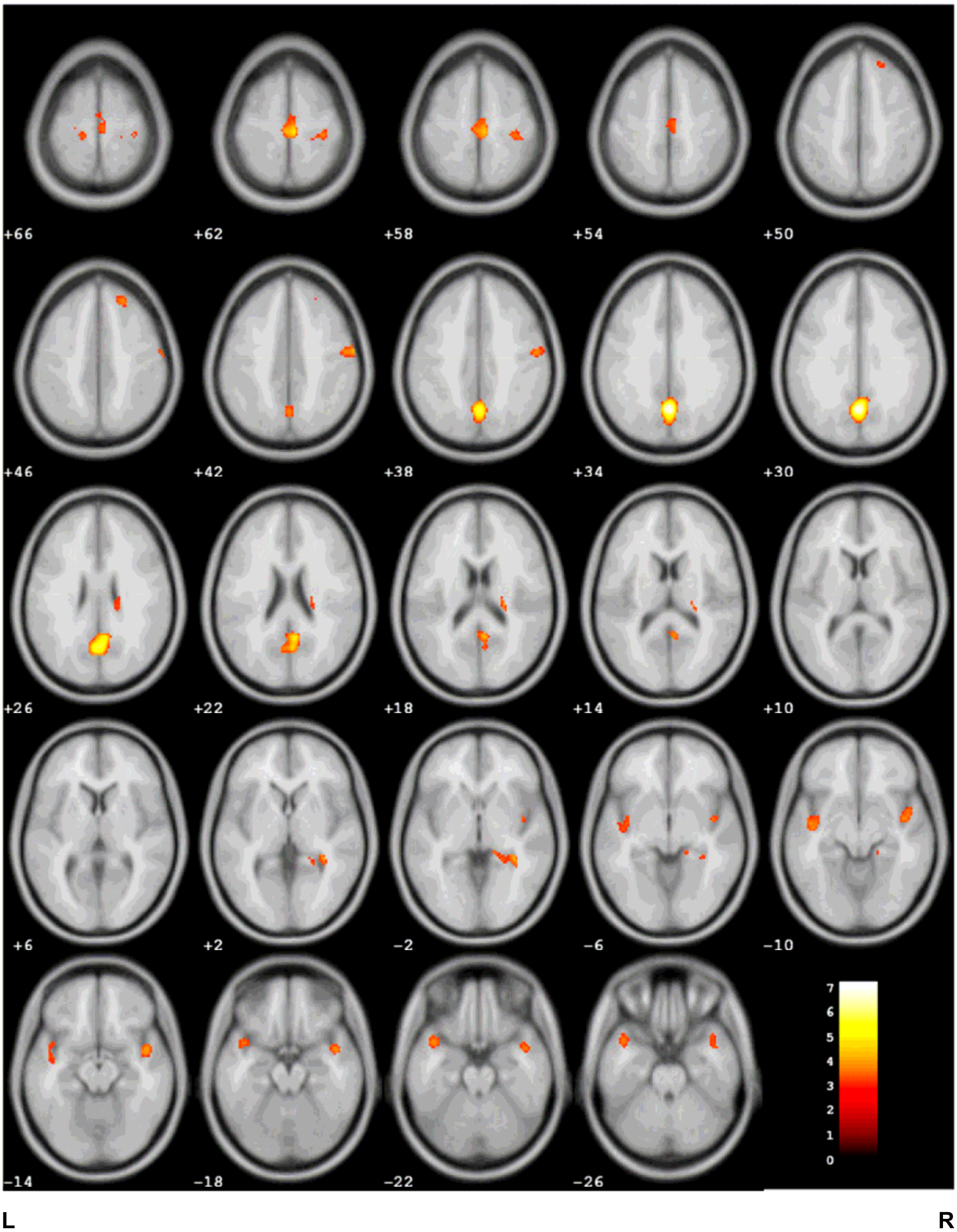


Figure 19: Activation map (4mm slices, *t*-value in color bar) for auditory personal names *vs.* common nouns. The activation is shown in the premotor area, bilateral anterior temporal cortices and the anterior precuneus.

Table 4: Regions of significant activation for comprehension of spoken common nouns *vs.* personal names.

Region		Side	X	Y	Z	T
Frontal Lobe	Inferior Frontal Gyrus	R	42	52	1	4.66
Temporal Lobe	Superior Temporal Gyrus	L	-51	-59	18	4.70
		R	65	-36	15	3.47
	Middle Temporal Gyrus	L	-59	-50	1	4.47
Parietal Lobe	Inferior Parietal Lobule	R	53	-35	37	3.92
	Postcentral Gyrus	R	57	-30	20	3.70
	Posterior Precuneus	L	-10	-79	48	4.48
Occipital Lobe	Middle Occipital Gyrus	L	-32	-82	-11	4.43
		R	10	-95	12	4.15
		R	28	-89	10	3.20
	Lingual Gyrus	R	8	-84	-4	5.54
		L	-8	-82	-3	5.12
	Inferior Occipital Gyrus	R	34	-84	-14	4.53
	Fusiform Gyrus	L	-28	-84	-14	4.60
	Cuneus	R	12	-97	7	4.21
		L	-8	-97	0	4.16

Significant at $p < 0.001$, uncorrected.

Table 5: Regions of significant activation for comprehension of spoken common nouns *vs.* geographical names.

Region		Side	X	Y	Z	T
Frontal Lobe	Superior Frontal Gyrus	L	-8	52	-3	4.02
	Medial Frontal Gyrus	R	10	48	-7	4.01
Temporal Lobe	Superior Temporal Gyrus	L	-51	-59	20	4.94
	Middle Temporal Gyrus	L	-61	-45	2	4.56
	Inferior Temporal Gyrus	R	34	-6	-35	4.43
	Fusiform Gyrus	R	48	-67	-15	3.63
		R	46	-63	-19	3.33
		L	-46	-65	-15	3.31
Occipital Lobe	Middle Occipital Gyrus	L	-38	-82	-9	3.98
		L	-26	-87	6	3.91
		R	14	-96	16	3.33
	Lingual Gyrus	R	8	-84	-4	5.06
		L	-10	-95	0	4.33
		L	-8	-70	3	3.35
		L	0	-87	4	3.30
	Inferior Occipital Gyrus	R	28	-88	-11	4.63
	Fusiform Gyrus	L	-24	-67	-13	5.41
		R	22	-79	-16	4.70
	Cuneus	R	8	-81	6	4.38
		L	-22	-84	23	3.96
Other areas	Uncus	R	30	-6	-33	4.49
		L	-30	-4	-32	4.49
	Cingulate Gyrus	L	-10	-43	30	3.78

Significant at $p < 0.001$, uncorrected.

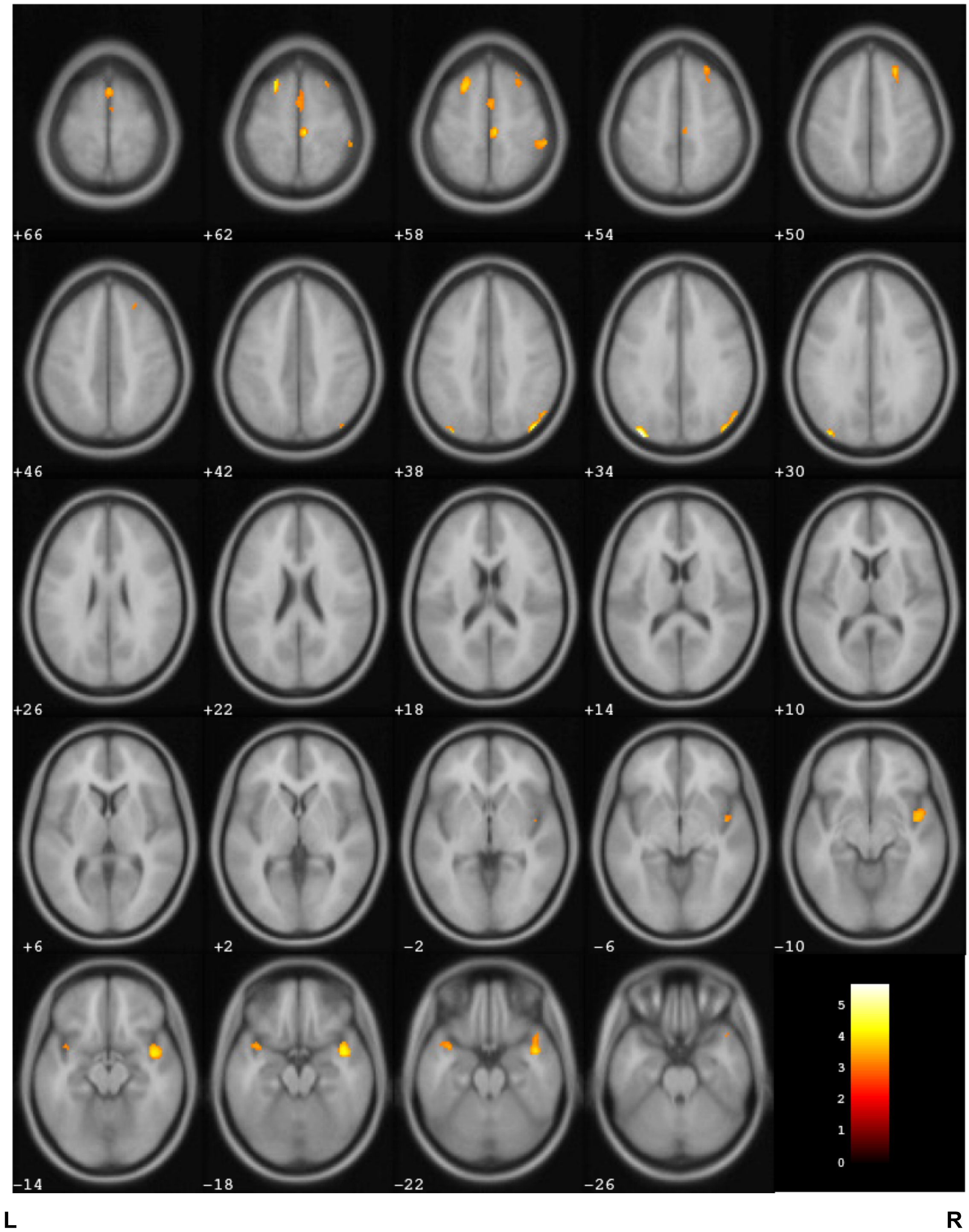
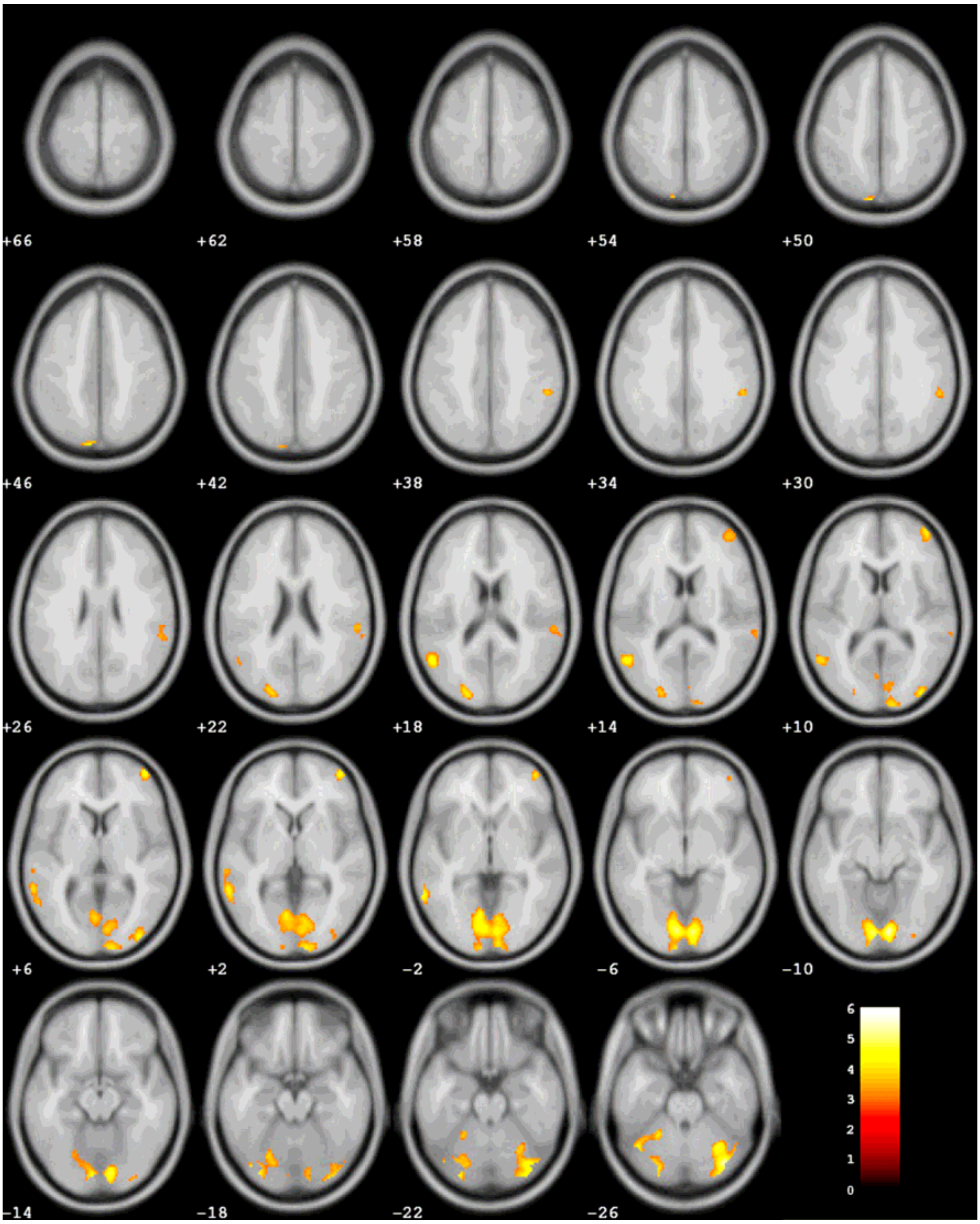
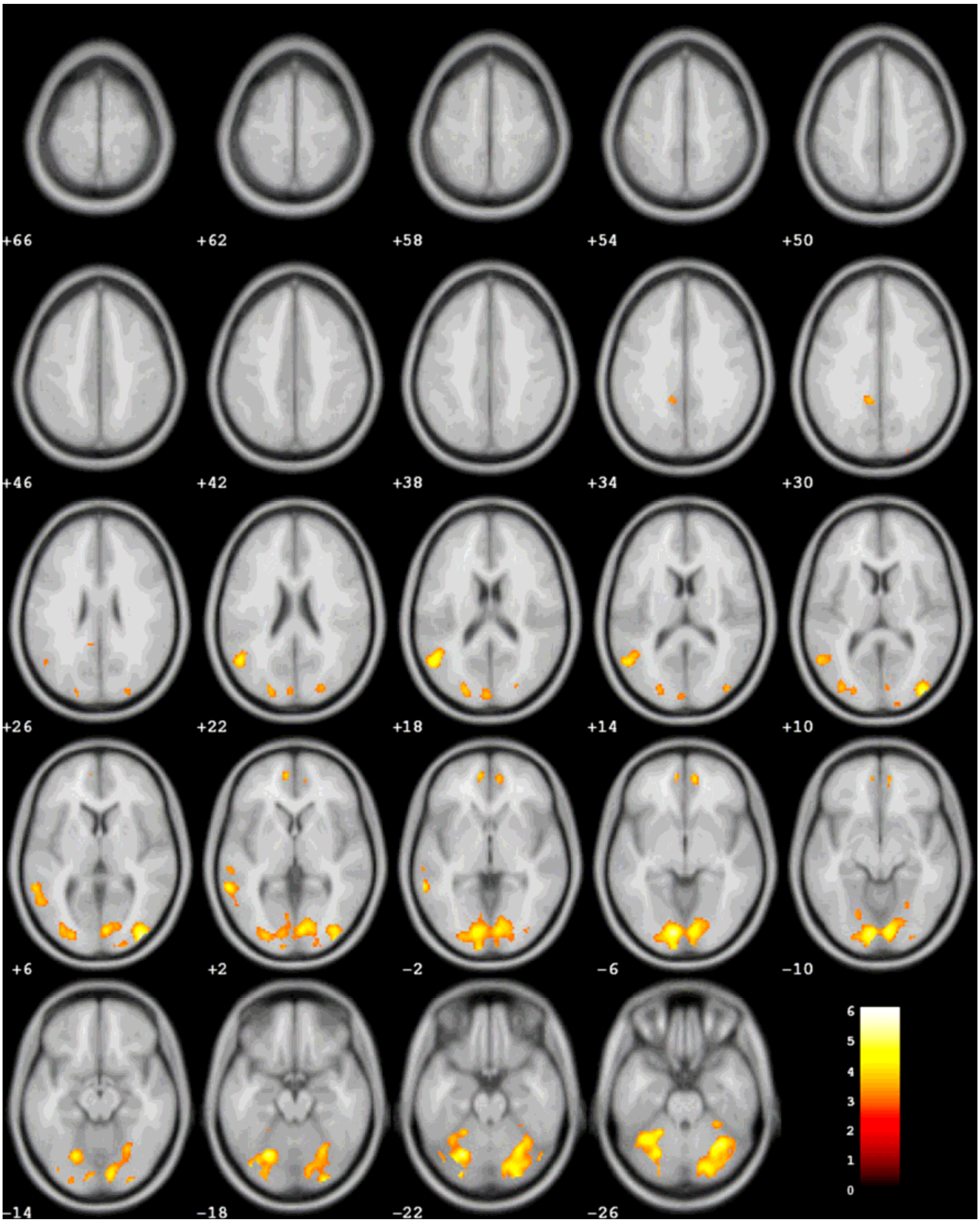


Figure 20: Activation map (4mm slices, *t*-value in color bar) for auditory geographical names *vs*. common nouns. The activation is shown in the premotor area and bilateral anterior temporal cortices.



L **R**

Figure 21: Activation map (4mm slices, *t*-value in color bar) for auditory common nouns *vs*. personal names. The activation is mainly located in the visual cortex and the left posterior temporal cortex.



L R

Figure 22: Activation map (4mm slices, *t*-value in color bar) for auditory common nouns *vs.* geographical names. Significant activation is shown in the bilateral occipital region and the posterior part of the left middle temporal gyrus.

7.2.2 Visual results

Word-category-specific differences were observed in the contrasts to the control (Arabic words) (see Figure 23) and in the contrasts between word categories (proper names *vs*. common nouns and vice versa). When compared with Arabic words, personal names mainly evoked activation in the left frontal area. Common nouns involved the ventral frontal cortex and the central sulcus. Geographical names engaged predominantly the left middle temporal cortex. When proper names and common nouns were compared with each other, proper names, including personal names and geographical names, showed significant activation in the frontal lobe including the frontal eye fields and premotor areas, whereas common nouns yielded significant activation in the left posterior temporal cortex and temporo-parietal areas. The following sections describe the results in more details.

Activation for different word categories

Anatomical visualization of these three word categories relative to baseline Arabic words is shown in Figure 23. Relative to Arabic words, reading personal names evoked activation mainly in left inferior frontal gyrus (BA 46, 47). Furthermore, activity in bilateral cuneus and right precuneus (BA 7) was observed. There was no activation in the temporal lobe.

Reading common nouns, instead, was associated with activations in bilateral superior temporal gyri (BA 22), left middle temporal gyrus (BA 21) and left fusiform gyrus (BA 19). Furthermore, activation in the bilateral anterior frontal area and central sulcus was revealed. Parietal activation for common nouns included bilateral inferior parietal lobules (BA 40) and left postcentral gyrus. Other involved areas were caudate, clustrum, thalamus in the right hemisphere; parahippocampal gyrus, insula in the left hemisphere. Activation was also demonstrated bilaterally in the anterior cingulates, lentiform nulceus and cingulate gyri.

Reading geographical names caused more stimulation in right orbitofrontal area (BA 11) and right dorsolateral area (BA 9, 10). Further frontal activation included right cingulate gyrus (BA 32) and left precentral gyrus (BA 6). Regarding the temporal lobe, the involved area in the left hemisphere was larger than the right (a small cluster in the superior temporal gyrus). Furthermore, bilateral activation in the inferior parietal lobules was also observed.

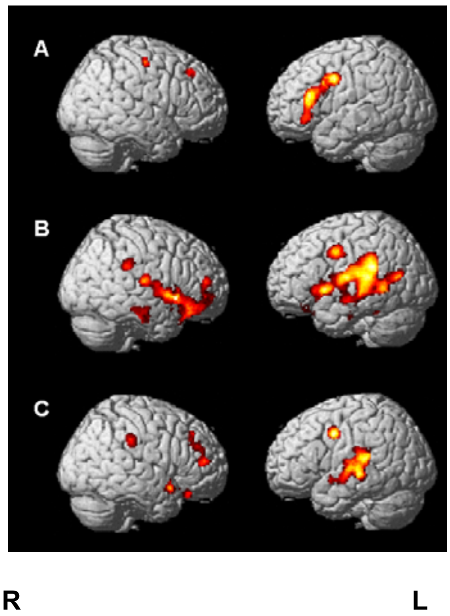


Figure 23: Brain activation maps for (A) personal names *vs*. Arabic words (B) common nouns *vs*. Arabic words (C) geographical names *vs*. Arabic words in the visual experiment.

Dissociation between proper names and common nouns

<u>Characteristics of proper names</u>

Personal names, compared with common nouns, significantly activated bilateral middle frontal gyri (BA 8, 46), superior frontal gyri (BA 9, 10) and right paracentral lobule (BA 5) and right precentral gyrus (BA 4). Activation in the temporal lobe was only found in the right temporo-occipital junction, namely in middle temporal gyrus (BA 21) and superior temporal gyrus (BA 22). Parietal activation was also right dominated, main activation patterns were found in inferior parietal lobule (BA 39), postcentral gyrus (BA 3, 5) and precuneus (BA 31, 7). Occipital activation included the left lingual gyrus (BA 19) and bilateral cuneus (BA 19). Other areas, such as bilateral posterior cingulate, were also associated with reading personal names (see Figure 24 and Table 6 for more details).

Reading geographical names relative to common nouns caused significant stimulation in frontal and parietal area. Activation in the frontal area included bilateral medial frontal gyri (BA 6), paracentral lobule (BA 5), precentral gyri (BA 6, 4) and superior frontal gyri (BA 9, 6). Activation in the middle frontal gyrus was only found in the right hemisphere (BA 8) (see Figure 25 and Table 7 for more details).

<u>Characteristics of common nouns</u>

Reading common nouns, in comparison with personal names, stimulated significantly the parieto-temporal area and the area near anterior temporal sulcus, which includes bilateral superior temporal gyri (BA 22, 38), inferior parietal lobules (BA 40), postcentral gyri (BA 1, 2), right transverse temporal gyrus (BA 42), right middle temporal gyrus (BA 21) and left supramarginal gyrus (BA 40). Frontal activation occurred dominantly in the right hemisphere: inferior frontal gyrus (BA 47, 44) and middle frontal gyrus (BA 10). The only left frontal activation occurred in precentral gyrus (BA 6). Other areas included left insula, bilateral cingulated gyri (BA 32) and left anterior cingulate (BA 32) (see Figure 26 and Table 8 for more details).

Reading common nouns relative to geographical names evoked activation in the bilateral ventral medial frontal area and the superior frontal gyrus (BA 10). The posterior part of temporal lobe was also activated, whereas the activation in the left hemisphere was more extended than the right side (see Figure27 and Table 9 for more details).

Stimuli Rating

The results indicate no significant difference between all word groups with regards to affective association and personal relevance {X^2r (2) = 2.00, p = 0.368}. Concerning the imageability of word groups, there was a significant difference in rating {X^2r (2) = 18.474, p < 0.001}. Common nouns appeared to produce more mental images than personal names {Z = -2.986, p < 0.01} and geographical names {Z = -2.829, p < 0.01}. Personal names evoked the lowest imageability which was even significant smaller than geographical names {Z = -1.997, p < 0.05}.

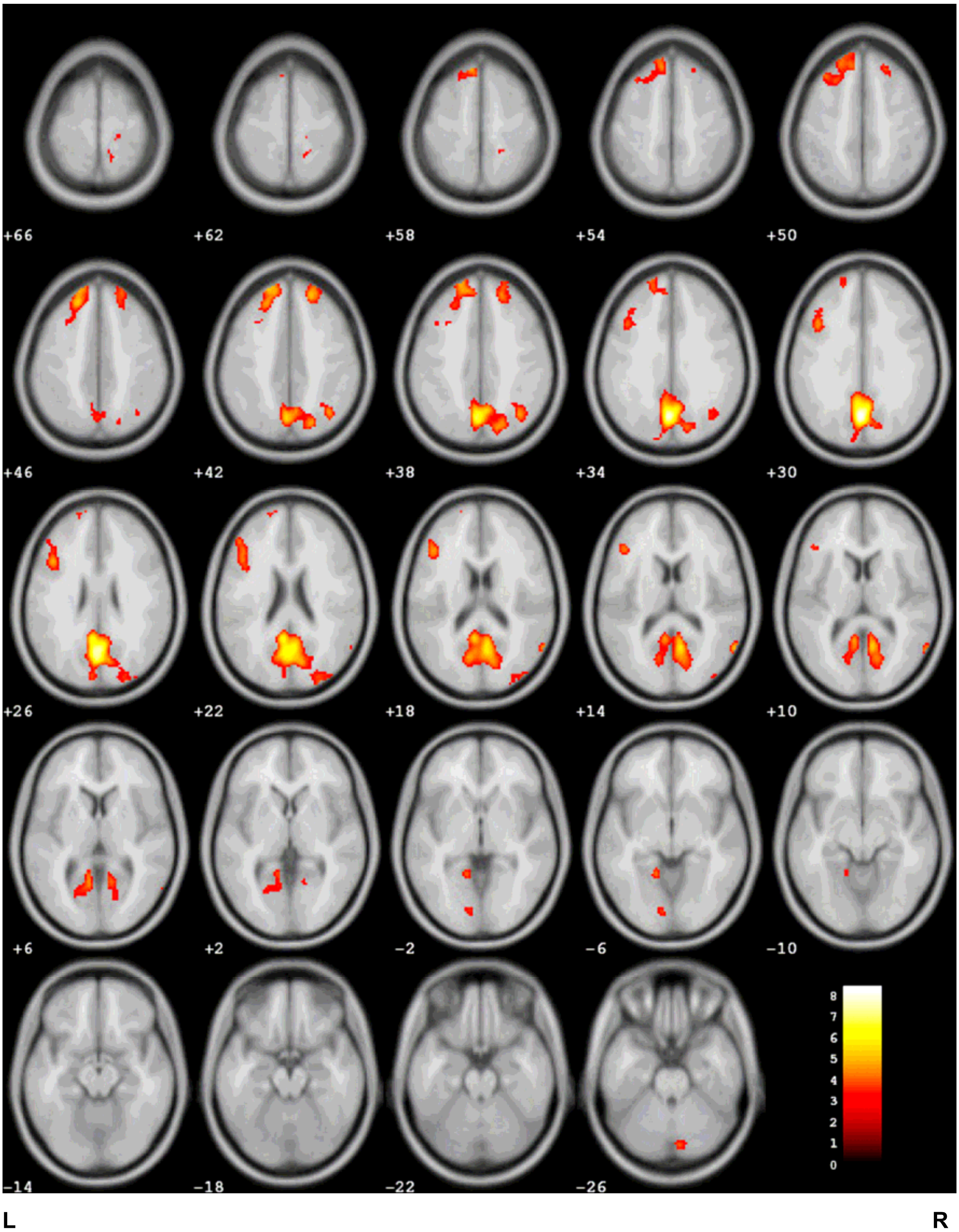


Figure 24: Activation map (4mm slices, *t*-value in color bar) for visual personal names *vs*. common nouns. The activation is mainly located in the frontal area.

Table 6: Regions of significant activation for comprehension of written personal names *vs*. common nouns.

Region		**Side**	**X**	**Y**	**Z**	**T**
Frontal Lobe	Inferior Frontal Gyrus	L	-44	26	15	4.73
	Middle Frontal Gyrus	L	-42	17	25	4.85
		R	26	25	43	3.13
	Paracentral Lobule	R	18	-40	57	3.44
	Precentral Gyrus	R	18	-26	60	3.30
	Superior Frontal Gyrus	L	-18	49	38	5.26
		R	20	43	37	5.07
		R	22	33	44	3.97
Temporal Lobe	Middle Temporal Gyrus	R	42	-83	19	3.90
	Superior Temporal Gyrus	R	59	-59	16	5.14
Parietal Lobe	Inferior Parietal Lobule	R	38	-60	40	4.84
	Postcentral Gyrus	R	10	-34	66	3.70
		R	12	-45	63	3.37
	Precuneus	R	10	-69	22	5.05
		R	20	-70	40	4.80
Occipital Lobe	Lingual Gyrus	L	-14	-49	-1	4.25
	Cuneus	L	-2	-64	31	8.46
		R	28	-88	25	3.97
Other areas	Posterior Cingulate	L	-6	-51	25	6.41
		R	8	-59	16	5.80

Significant at $p < 0.001$, uncorrected.

Table 7: Regions of significant activation for comprehension of written geographical names *vs*. common nouns.

Region		**Side**	**X**	**Y**	**Z**	**T**
Frontal Lobe	Medial Frontal Gyrus	L	-2	-11	59	4.23
		R	6	-9	61	3.99
	Middle Frontal Gyrus	R	28	27	45	5.18
	Precentral Gyrus	L	-26	-14	60	4.01
		L	-16	-32	62	4.04
		R	30	-22	56	3.39
	Superior Frontal Gyrus	R	22	17	60	3.23
		L	-22	48	34	4.55
Parietal Lobe	Inferior Parietal Lobule	R	40	-66	40	4.77
	Paracentral Lobule	L	-4	-38	63	4.19
	Postcentral Gyrus	R	32	-32	61	4.02
		L	-32	-34	57	3.76
	Precuneus	L	-6	-72	40	4.83
		R	8	-50	54	4.23
Other areas	Cingulate Gyrus	L	-4	-33	37	3.60
	Posterior Cingulate	L	-4	-56	12	4.21

Significant at $p < 0.001$, uncorrected.

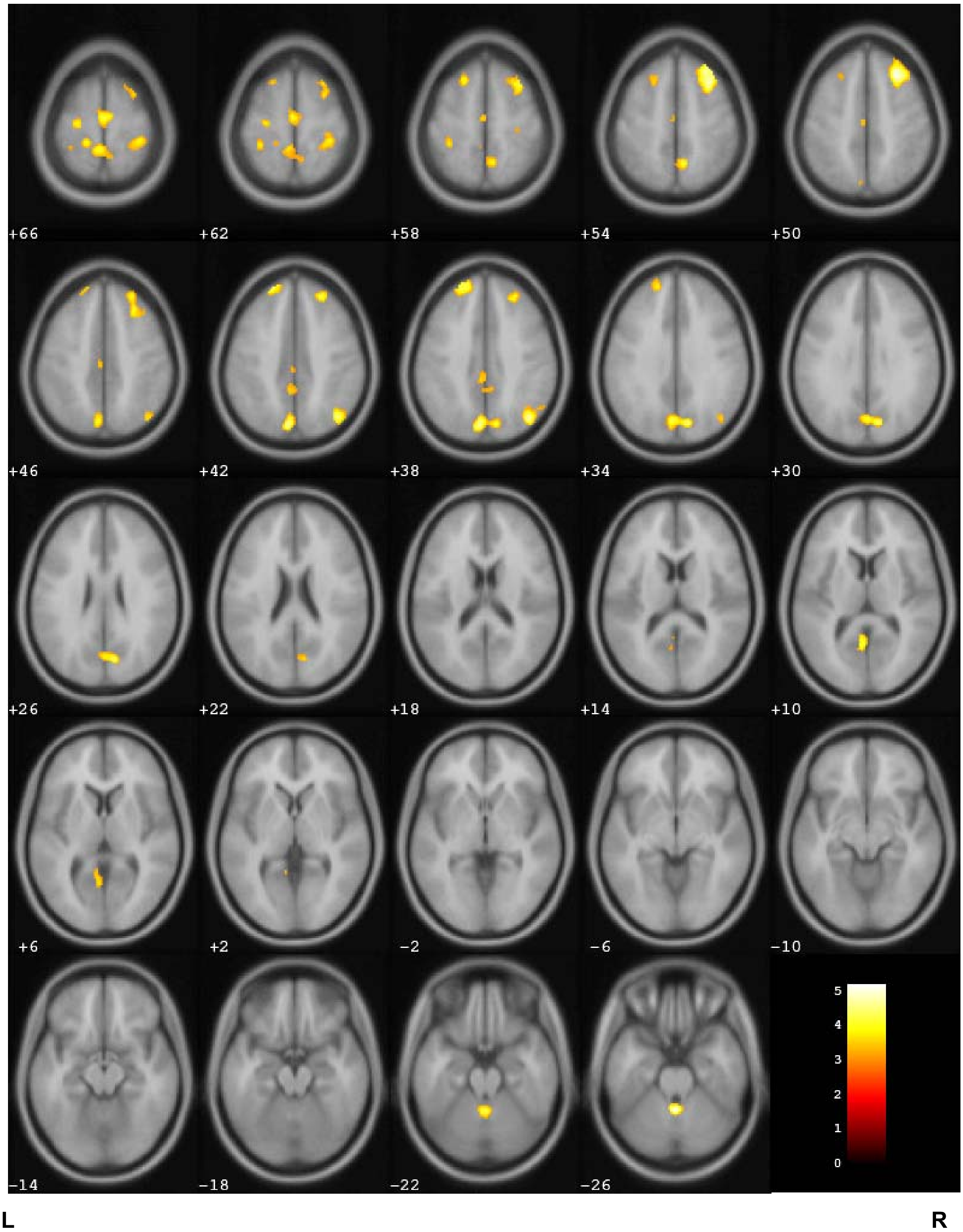


Figure 25: Activation map (4mm slices, *t*-value in color bar) for visual geographical names *vs.* common nouns. Significant activation is shown in the frontal and parietal area.

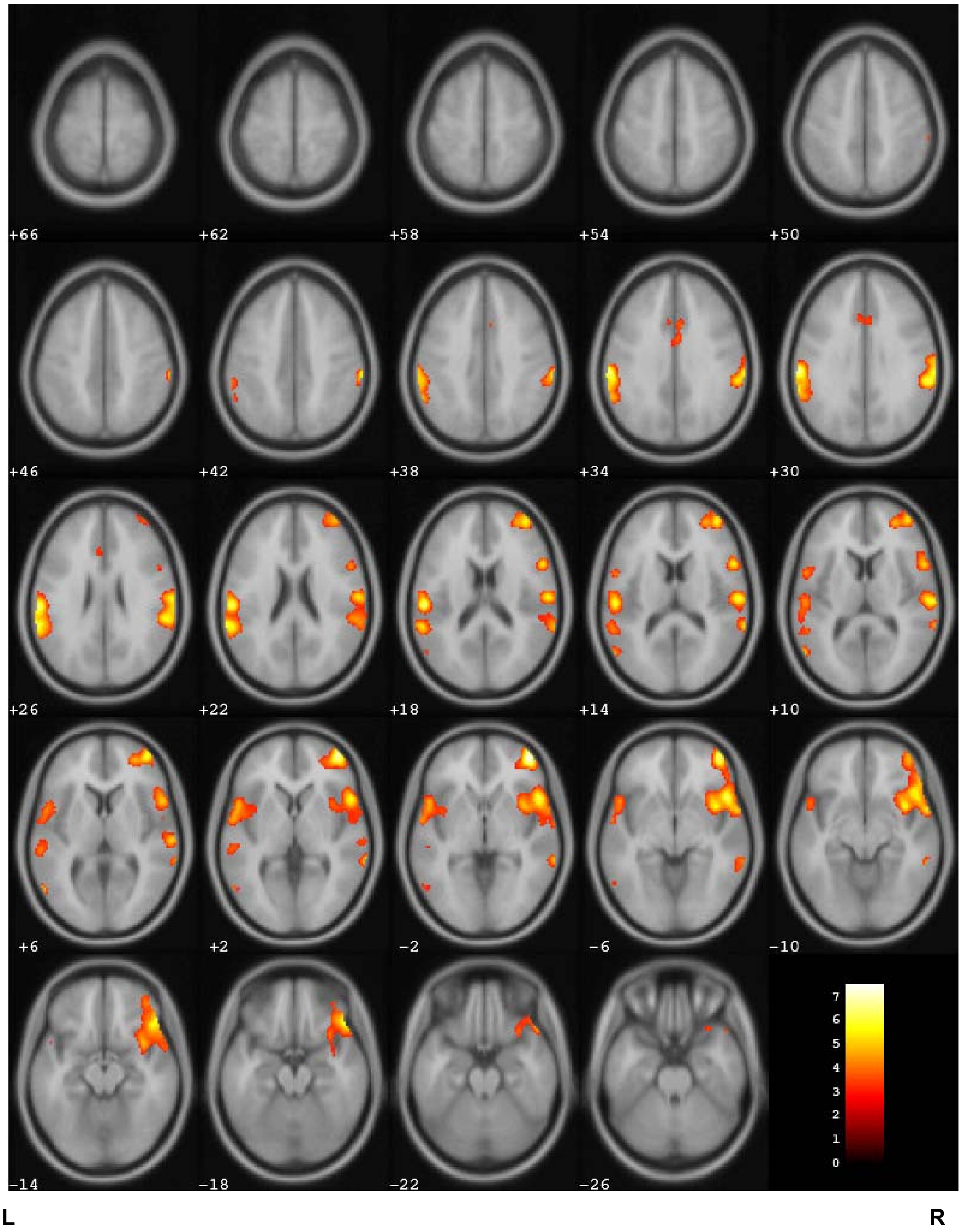


Figure 26: Activation map (4mm slices, *t*-value in color bar) for visual common nouns *vs.* personal names. Significant activation is shown in the right temporo-parietal junction and the left posterior temporal cortex.

Table 8: Regions of significant activation for comprehension of written common nouns *vs*. personal names.

Region		**Side**	**X**	**Y**	**Z**	**T**
Frontal Lobe	Inferior Frontal Gyrus	R	50	17	-6	6.33
	Middle Frontal Gyrus	R	42	50	-4	7.51
	Precentral Gyrus	L	-55	4	9	4.25
Temporal Lobe	Transverse Temporal Gyrus	R	59	-17	14	5.99
	Superior Temporal Gyrus	R	57	5	-7	5.39
		L	-59	-31	7	4.27
		L	-51	12	-1	4.95
	Middle Temporal Gyrus	R	65	-39	2	4.93
		L	-55	-63	12	4.83
Parietal Lobe	Inferior Parietal Lobule	L	-61	-26	31	7.01
		R	59	-33	29	6.22
		L	-55	-22	18	6.66
		R	63	-27	40	5.61
	Supramarginal Gyrus	L	-57	-49	36	4.76
Other areas	Extra-Nuclear	R	38	9	-7	5.88
	Insula	L	-40	6	0	3.72
	Cingulate Gyrus	R	6	15	31	3.94
		R	4	4	31	3.81
		L	-4	21	27	3.55
	Anterior Cingulate	L	-6	28	21	3.20

Significant at $p < 0.001$, uncorrected.

Table 9: Regions of significant activation for comprehension of written common nouns *vs*. geographical names.

Region		**Side**	**X**	**Y**	**Z**	**T**
Frontal Lobe	Inferior Frontal Gyrus	L	-26	20	-25	5.66
		R	48	32	-13	4.00
	Medial Frontal Gyrus	R	6	54	-16	5.39
		R	6	56	-10	4.56
		L	-8	50	-11	5.38
		L	-8	48	-14	5.08
	Middle Frontal Gyrus	R	40	32	-13	4.15
	Superior Frontal Gyrus	R	8	56	-1	3.73
Temporal Lobe	Superior Temporal Gyrus	L	-24	11	-22	4.65
	Middle Temporal Gyrus	L	-59	-51	-1	4.36
		R	59	-58	1	3.79
	Inferior Temporal Gyrus	L	-57	-60	-4	3.49
Occipital Lobe	Lingual Gyrus	L	-26	-68	-8	3.87
Parietal Lobe	Inferior Parietal Lobule	L	-55	-34	27	3.51
Other area	Anterior Cingulate	L	-8	45	7	3.94

Significant at $p < 0.001$, uncorrected.

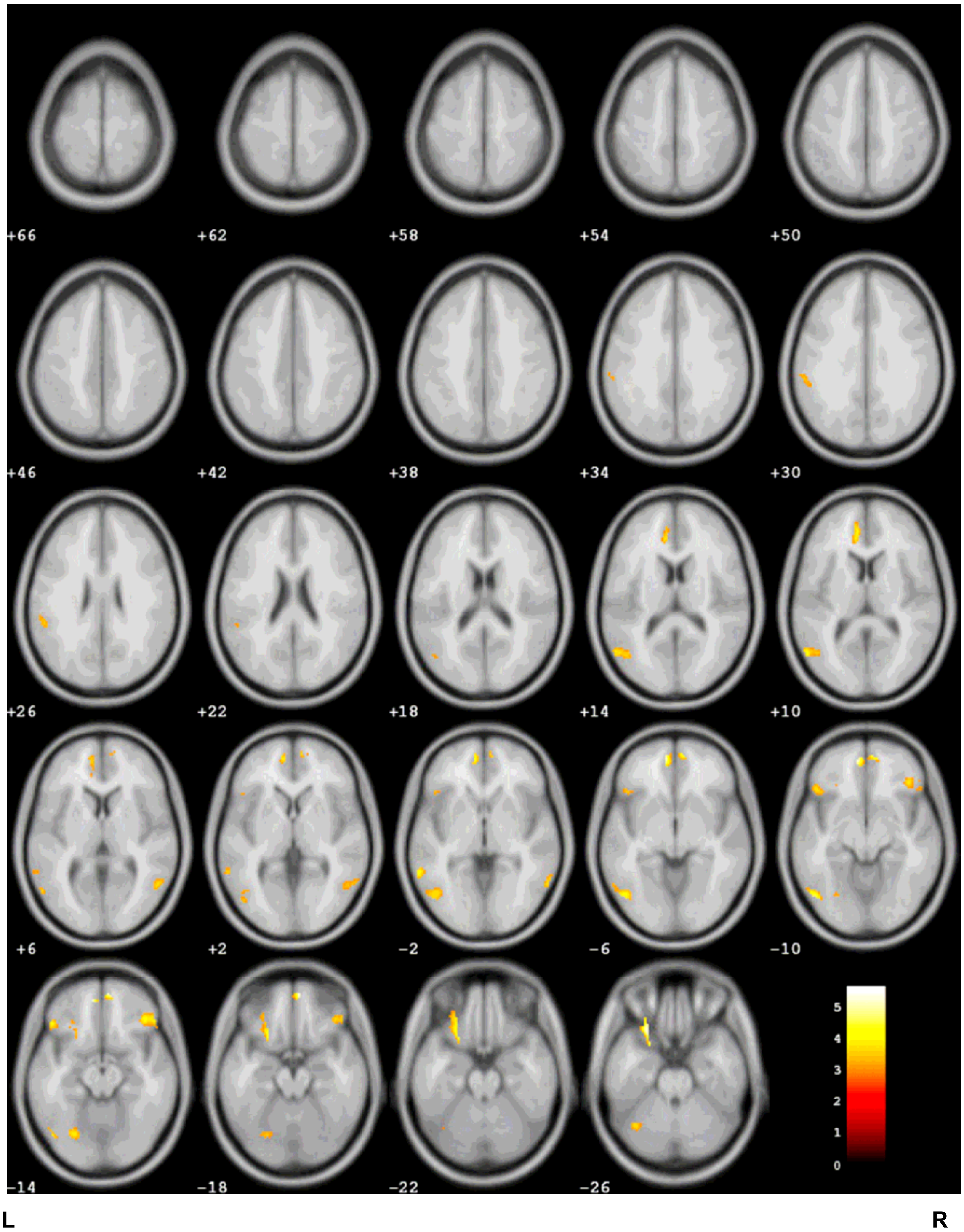


Figure 27: Activation map (4mm slices, *t*-value in color bar) for visual common nouns *vs*. geographical names. Significant activation is shown in the left posterior temporal cortex.

7.3 Discussion

7.3.1 Interim discussion for the auditory experiment

In this experiment, auditory processing of proper names and common nouns was investigated. Comparisons between word categories and the control as well as comparisons between word categories revealed that there were partially different activation patterns for proper names and common nouns. This section will focus on the following topics. The first point concerns the implications of the occipital activation for the comprehension of personal names, geographical names and common nouns. Furthermore, an explanation for right hemispheric dominance (in the temporal cortex) of word categories in contrast to the control (pseudo-speech) will be provided since it relates to the question if pseudo-speech is a suitable baseline to subtract the word-category-specific effect. With regard to the dissociation between proper names and common nouns, the discussion will center upon the implications of the involved areas. Firstly, what are the functions of the bilateral anterior cortices for the comprehension of proper names? The second focus concerns the functional role of the premotor area for the processing of proper names. The third part of the section will focus on the functional role of the anterior precuneus for the processing of proper names. The last point of the discussion will consider the functional role of the posterior temporal cortex and the occipital cortex which characterize the processing of common nouns.

When comparing task conditions with auditory pseudo-speech, activation in the visual association cortices turned out to be significant for all word categories (see Figure 18). The engagement of visual association cortices differed in the sense of spatial extension between word categories. While common nouns yielded activation from bilateral middle occipital gyri along inferior occipital gyri to cuneus, lingual gyri and fusiform gyri, personal names' activation was restricted to a small area in the right middle occipital gyrus, fusiform area and bilateral cuneus gyri. Processing geographical names also predominately involved the right visual association cortex, which includes the middle occipital gyrus, lingual gyrus and cuneus.

One may have doubt as to how the occipital activation was revealed, since the experimental task comprised listening comprehension (the participants' eyes were closed). Was the activation in this area an artifact? The nature of the stimulus may provide an explanation. All word categories were concrete nouns and they contained features of imageability, for instance, one may have a concrete image of a table when listening to the word *table* and one may have a mental picture of *Harrison Ford* when listening to this name. Therefore, one may assume that they will involve the visual association cortex. This finding is also supported by the study of Proverbio et al. (2001) which revealed an occipital activation in the processing of common nouns. The different extents to which the occipital areas were involved may reflect the gradual difference of imageability of the word categories. That is, common nouns are the most concrete words with which the participants have a mental image. Personal names contain the less imageability and are not concrete objects such as geographical names. The rating results also support this hypothesis (see 7.2.1).

In this study, a right-sided preponderance in the temporal cortex was revealed when comparing different word categories with the pseudo-speech (see Figure 18). This finding is somehow in contradiction to the convention about the hemispheric dominance of language processing. Generally, regardless of input modality, word recognition has been found to activate bilateral or only left-sided BA 21 and 22 (for a review see Cabeza & Nyberg, 2002). In contrast, this study showed activation at area 21 only on the right side for common nouns and geographical names. For personal names, there was still bilateral activation at area 21. Furthermore, the involvement of Wernicke's area and Broca's area was not observed for all word categories. One should reconsider if pseudo-speech is suitable to subtract the lexical effect or the effect of word categories in Mandarin Chinese.

On the other hand, the right hemisphere may also play an essential role as well in the comprehension of spoken Chinese. A recent study of Valaki et al. (2004), comparing the laterality dominance of spoken word recognition of Chinese, Spanish and English with MEG (Magnetoencephalography), may provide some explanations for the preponderance of the right hemisphere in this study.

It is suggested that there is a difference in sense of laterality between speakers of Chinese and Indo-European languages when processing the spoken language (Valaki et al., 2004). While English and Spanish speakers showed a strong left sided lateralization, Chinese speakers showed a hemispheric symmetry in spoken word recognition tasks. The tendency of Chinese speakers was more prominent when the duration in temporoparietal cortices was tested, that is, the degree of hemispheric asymmetry in the duration of neurophysiological activity was reduced in this region. Furthermore, the study found that group differences in functional hemispheric asymmetry, occurring just after the initial sensory processing of the word stimuli, were primarily due to greater activation in the right temporoparietal region of the Chinese group. Actually, in Chinese, temporo-parietal cortex in both hemispheres was engaged for the same amount of time, but the net neurophysiological activity in the left hemisphere was stronger. Therefore, the authors suggested that there was a recruitment of a larger neuronal population in the vicinity of Wernicke's area and the prolonged participation of the right temporoparietal region is essential for perception of spoken Chinese. The authors concluded that there was a dissociation between duration and intensity of neurophysiological activity underlying spoken word recognition of Chinese, in other words, the same as what one can observe from Indo-European speakers, Chinese spoken word processing shows a left-hemisphere predominance in intensity and/or spatial spread of neurological activity and the prolonged engagement of the right temporoparietal region serves the processing of suprasegmental cues such as lexical tones (Valaki et al., 2004).

Taking this conclusion as a new basis, it is possible that the blocked sign of the current experiment was only able to show the predominance of the right hemisphere. The current blocked design may not be sensitive enough for dynamics of inter-hemispheric change. Furthermore, taking pseudo-speech as the baseline, as this study has done, may strengthen the significance of the right hemisphere since the right hemisphere became more active after the initial sensory processing of word stimuli (Valaki et al. 2004). In the condition task, analyzing lexical tone which is important for constituting the meaning of words in Chinese revealed activation in the right temporoparietal region, whereas pseudo-speech mainly employed initial sensory processing since further processing steps will not yield the meaning of words.

Before discussing the role of bilateral anterior temporal cortices for the processing of proper names, one must make two annotations. Firstly, at an anatomical level, it is difficult to segregate the recognition process and the naming process and their respective neuronal substrates since they occur automatically together in healthy participants (Gorno-Tempini et al., 2001). Besides, neurobiological models have claimed that speech perception is connected to speech production mechanisms (Braitenberg & Schüz, 1992; Fuster, 2003; Pulvermüller, 1999). Secondly, the comparative debate about the data of this study and the previous findings will be made, primarily, irrespective of modality because there was less functional imaging studies investigating comprehension of spoken proper names. Furthermore, evidence from neuroimaging studies supports the view that there is a semantic system shared by written and spoken language (Vandenberghe et al., 1996).

This study (see Figure 19, 20, 23C), consistent with the clinical and experimental studies, has confirmed that the left temporal cortex plays a pivotal role in the comprehension of proper names. It has been reported that lesions in the left temporal lobe can cause selective disorder in proper name retrieval (e.g., Semenza & Zettin, 1988, 1989; Hittmair-Delazer et al., 1994; Fukatsu et al., 1999) and perception (Yasuda & Ono, 1998). With regard to previous functional imaging studies, the response of left anterior temporal cortex was found for semantic processing of objects and words

(Vandenberghe et al., 1996), person naming (Damasio et al., 1996), viewing famous faces and famous proper names (Gorno-Tempini et al., 1998), and face-name associative learning (Tsukiura, 2003, 2006).

There are two main hypotheses concerning the function of the left anterior temporal cortex in proper name recognition or retrieval. Whereas some scholars (e.g. Damasio et al. 1996; Grabowski et al., 2001, 2003; Tranel et al., 2006) suggest that this region plays an intermediary role in lexical retrieval, other researchers (Gorno-Tempini et al., 2000; Gorno-Tempini et al., 2001) argue that this area responds to the semantic processing of proper names. The hypothesis of intermediation implies that such intermediation regions are task- and category-related. They may vary, due to different tasks and categories, within participants but the intermediation areas for the same task must be the same across participants (Damasio et al., 2004). According to the former hypothesis, the left temporal pole operates the core process in proper name retrieval, with which conceptual processing and word retrieval can be activated. The latter hypothesis indicates that activation in the left anterior temporal cortex is predominantly involved in retrieving appropriate semantic information about the known items (Gorno-Tempini et al., 2000).

The left anterior temporal activation may reflect the mono-referential feature of the stimulus as well. Tranel (2006) has suggested that the left temporal polar area is associated with naming unique landmarks and persons which refer only to one single individual. The author further suggested that visually similar task items are necessary to activate the left temporal polar area. Therefore, it was suggested that geographical entities will not necessarily yield activation in this area (e. g. Semenza & Zettin, 1988, 1989). Contrary to Tranel, the activation of this area supports the view that Chinese geographical names, like personal names, seem to belong to the category with unique reference.

The activation of the left anterior temporal lobe indicates that this area plays a pivotal role not only in retrieval but also in the comprehension of spoken proper names (personal names and geographical names). One may conclude that the left anterior temporal cortex is associated with person-related semantics since the retrieval was not explicitly requested. However, the question whether this area reflects an intermediation function or a semantic function remains a matter of debate since the design of this study is not able to separate these two cortical representations.

In addition, this study revealed that the right anterior temporal lobe also plays a significant role in the comprehension of proper names (see Figure 18A, 19, 20, 23C). The right temporal pole (BA 38) was supposed to be responsible for the retrieval of personal names (Damasio et al., 1996; 2004). Further functional imaging studies indicated that the right anterior temporal cortex may contribute to the retrieval of newly learned personal names and the activity in this area reduced time-dependently with increased learning (Tsukiura et al., 2002, 2003). Neuropsychological studies reported that patients with lesions in the right anterior temporal lobe showed a loss of person-related semantics (Ellis et al., 1989; Evans et al., 1995; Hanley et al., 1989; Kitchner and Hodges, 1999) and poor performance in face recognition (Crane & Milner, 2002; Gainotti et al., 2003; Seidenberg et al., 2002). This area also involves recognition of unique entities (Damasio et al., 1996), recognition of famous people's faces (Leveroni et al., 2000) and the process of retrieval of faces with person-related semantics (Tsuikuira et al., 2006). The involvement of the right anterior temporal cortex implies that face recognition, as a part of person-related semantics, may be involved in the processing of personal names. For the processing of geographical names, this area may reflect the mono-referential feature of the stimulus.

In summary, bilateral anterior temporal lobes may be associated with person-related semantics, the feature of the mono-reference and face recognition. All these components are necessary for a successful comprehension of proper names. Tsuikuira et al. (2006) suggested that faces, names and person-related semantics may be mutually mediated by the bilateral anterior temporal lobe and the retrieval may be achieved without the mediation of person-related semantics by the left anterior temporal lobe. However, this study is not able to point out the dynamics between the bilateral anterior temporal cortices. Further research will be needed to help clarify this problem.

Bilateral activation in the premotor and motor area is a further characteristic of the comprehension of proper names (see Figure 19, 20, 24, 25). Activation in this area has been associated with speech production (Mori, et al., 1989; Wildburger et al., 1996), the repeating of presented words (Price et a., 1996), silent reading (Kuo et al., 2001), somatotopic representation of action words (Hauk et al., 2004) and articulatory features of speech sounds (Pulvermüller et al., 2006). Because the initial phonological distribution of personal names and common nouns was balanced, one may reason that activation in this area is more related to the potential to produce a speech. Thus, functional role of premotor and primary motor area for personal name comprehension still must be determined.

A neural activity was revealed in the anterior precuneus (BA 7) for the comprehension of personal names (see Figure 19). Neuroimaging studies have suggested that the precuneus plays a central role in visual imagery occurring in episodic memory retrieval (Buckner et al., 1995; Fletcher et al., 1996; Halsband et al., 1998). Further studies suggest that the more anterior portion of the precuneus reveals increased regional cerebral blood fluid in a polymodal imagery (for a review see Cavanna & Trimble, 2006). This result seems to be plausible since comprehending personal names may drive a higher order of cognitive functions such as episodic memory retrieval more often than common nouns.

More interestingly, in this study, the activation in the anterior precuneus may imply that the intentional self component is an important factor by comprehension of spoken personal names. This can be supported by the some recent neuroimaging studies have provided evidence that bilateral anterior precuneus is very important for self-relevant information processing (for a review see Cavanna & Trimble, 2006). Significant activation in this area has been found in judgments on one's own versus another person's face/personality traits, self-descriptive personality traits, reflective self-awareness, retrieval of judgments on the ego, first person versus third person short stories processing and mental simulation of others versus self-generated action (for a review see Cavanna & Trimble, 2006).

The bilateral occipital and the left posterior temporal as well as parieto-temporal activation characterizes the processing of common nouns (see Figure 21, 22, 26, 27). Significant activation in bilateral visual association cortices may indicate that a greater amount of visual-sensory associations or representation of the visual features of the stimuli (Damasio et al., 2004) linked to common nouns rather than personal names. As already discussed in the previous sections, this finding may be stimulus-driven. One may not associate each name to a face or person-related semantics if he or she does not know someone whose name was the presented stimulus. In contrast, while listening to common nouns, one may easily associate common nouns with relevant concrete features.

A significant activation for the processing of common nouns was located in the posterior part of left middle temporal gyrus (see Figure 21, 22, 26, 27). This finding provides evidence that semantic processing was more intensively engaged than proper names. Left posterior temporal cortex and the left temporal-parietal junction have been shown to be associated with semantic tasks in visual or auditory studies for Indo-European languages (Binder et al., 2003; Booth et al., 2002; Chee et al., 1999; Friederici et al., 2000b; Gorno-Tempini et al., 1998; Luke et al., 2002; Mummery et al., 1998; Price et al., 1999). Also, a recent study on Chinese languages supports the view that the involvement of this area indicates the semantic processing of reading words (Booth et al., 2006). Moreover, this area has been shown to represent nouns (Damasion & Tranel, 1993; Daniele et al., 1994; Li et al., 2004).

Concluding, personal names, geographical names and commons may automatically involve an occipital activation. The different extensities of activation probably imply that these three word categories contain gradual differences with regard to the grade of visual association. Right temporal activation by comparing word categories and the pseudo-speech may be a language-specific neural correlate for Mandarin Chinese. Activation in this area may imply the processing of suprasegmental cues, for instance, lexical tones. The dissociation between proper names and common nouns can be characterized with different neural correlates. Proper names engage bilateral anterior temporal cortices, premotor or motor areas and the anterior precuneus. The involvement of the anterior temporal cortex may be related to person-specific semantic processing, including face recognition, or the mono-referential feature of proper names. Premotor areas may be indices for a potential to produce the speech. The activity in the anterior precuneus may reflect the self-processing which provides an evolutionary advantage for the recognition of personal names (see chapter 8 for more discussion). Common nouns, in contrast, significantly engage the occipital cortex, occipito-temporal junction and the left posterior temporal cortex. These findings may imply that common nouns contain strong imageability, they are more conducive in evoking a mental visualization. Besides, probably based on the richness of associative features, they stimulate a more intensive semantic processing than proper names which is reflected in the involvement of the left posterior temporal area.

7.3.2 Interim discussion for the visual experiment

In this experiment, visual processing of proper names and common nouns was investigated. Comparisons between word categories and the control as well as comparisons between word categories revealed different activation patterns for proper names and common nouns. When compared with Arabic words, personal names mainly evoked activation in the left frontal area. Common nouns involved the ventral frontal cortex and the central sulcus. Geographical names engaged predominantly the left middle temporal cortex. When one compares proper names and common nouns with each other, proper names, including personal names and geographical names, evoked significant activation in the frontal lobe including the frontal eye fields and premotor areas, whereas common nouns yielded significant activation in the left posterior temporal cortex and temporo-parietal areas. Since the role of the occipital activation, the parieto-temporal activation, the bilateral anterior temporal activation and the premotor areas have been discussed in 7.3.1, this discussion will only deal with a few germane topics. The first one concerns the functional role of the parietal lobe for the processing of geographical names. The second one considers the meaning of the frontal eye fields for the processing of personal names. The third topic will contribute to the implication of the left dorsolateral frontal activity for the processing of personal names. At last, the implication of the activation in occipito-temporal junction for the processing of proper names will be discussed.

The parietal lobe is important for the processing of geographical names (Figure 20, 23C, 25). Bilateral extrastriate cortices (BA 19), right inferior parietal lobule (BA 40) and angular gyrus (BA 39) yielded significant activation in the auditory modality, whereas the bilateral inferior parietal lobules (BA 40) characterize the processing of the written geographical names. This area may contribute to the visual-spatial capability which is probably an important element for the processing of geographical names. A recent fMRI study investigating the visual-spatial judgment of Chinese speakers has provided evidence that the involvement of extrastriate areas is crucial for the spatial perception (Lee et al., 2005) and that both hemispheres (predominantly right) participate in the process (Cook et al, 1994, as cited in Lee et al., 2005, p. 1872). Previous studies have also provided evidence for the function of visuo-spatial capabilities, for example, Wapner and Gardner's investigation (1979) in global aphasia patients has suggested that comprehension of geographical names is supported by the visuo-spatial capabilities. Furthermore, the left parietal lobe may contribute to the semantic memory of geographical names. (Goodglass & Wingfield, 1993; McKenna & Warrington, 1978; Warrington & Clegg, 1993).

Personal names evoked significant activation in bilateral frontal areas which also included frontal eye fields (see Figure 24). Frontal eye fields are suggested to be associated with eye movements, gaze shifts, orientating and attentional reactions (Joseph, 1996). Furthermore, it is involved in focusing attention on certain regions within the visual field (Segraves & Goldberg, 1987, as cited in Joseph, 1996, p. 406), guiding eye movement while reading (Ritaccio, 1992, as cited in Joseph, 1996, p. 407). In addition, neurons in the frontal eye fields demonstrate anticipatory firing before a response is made and will continue firing until the behavior is initiated (Gottlieb et al., 1994; Pragay et al., 1987). If the involvement of frontal eye fields implies the anticipation of response, this will be consistent with the finding of the behavioral study in which the reaction time of the recognition for personal names was significant faster than for common nouns. One may suggest that subjects were more attentive while reading common nouns and they were more prepared to make a response.

The left dorsolateral frontal area is also important for the processing of personal names (see Figure 24). Activation in the left dorsolateral frontal area is suggested to be involved in working memory loading (Pochen et al., 2002), especially in verbal working memory (for a review see Wagner & Smith, 2003). The activation in this area implies that reading personal names probably engages working memory more than common nouns.

The right occipito-temporal junction was also proposed to be essential for the processing of personal names (see Figure 24). This may reflect the familiarity of the stimulus. The activation pattern encompassing bilateral occipito-temporal junctions, precuneus, and posterior cingulated cortex has been suggested to be associated with processing written familiar personal names (Sugiura et al., 2006). According to Sugiura et al. (2006), these regions likely support the differential representation of personally familiar people and personally familiar places. Previous experimental studies also support that the right hemisphere can process familiar names successfully (Ohnesoege and Van Lancker, 1999; 2001). Therefore, the right occipito-temporal junction may be associated with the grade of the familiarity where the stimulus was considered as familiar by the participants.

Concluding, the visual experiment revealed partially different activation patterns between the processing of proper names and common nouns in Mandarin Chinese. The parietal lobe plays an important role the processing of geographical names. The involvement of this area may be related to the visuo-spatial capability. The processing of written personal names can be characterized with the activation in the frontal eye fields and the left dorsolateral frontal area. These activations may be due to the attentive status of the participants, readiness to make a response and a strong memory loading while reading personal names. The occipito-temporal junctions may imply the familiarity of the stimulus. The involvement of this area may indicate that the participants are familiar with the presented personal names.

8. General discussion

In the present behavioral study, consistent with the studies of German and English (Müller & Kutas, 1997; Schuth et al., 2002; Werner & Müller, 2001), Chinese participants' reaction time of category decision task was faster for proper names than common nouns. Contrary to the studies of German and English (Müller & Kutas, 1997; Schuth et al., 2002; Werner & Müller, 2001), the participants in this study were not able to recognize proper names with 160 ms gates. Furthermore, the present fMRI study showed that the comprehension of proper names and common nouns engaged partially different neural structures. This chapter will focus on the advantage of reaction time in proper name recognition as well as implications of behavioral and neuroimaging findings for the theories of proper names and language universals.

8.1 Why can one recognize proper names faster?

8.1.1 Debate about some psycholinguistic factors

Despite modality, the choice reaction time for personal names and geographic names was significant shorter than the choice reaction time for common nouns. Mandarin Chinese speakers seemed to recognize proper names faster than common nouns. This holds for personal names and geographic names, but not for brand names. In terms of choice reaction time, personal names and geographic names are similar to each other whereas brand names are more similar to common nouns. What accounts for the temporal advantage in recognizing proper names? There are many factors that may predict the speed and the accuracy of spoken word recognition, such as word frequency, familiarity, neighbourhood effect, word length, imageability, concreteness, age of acquisition, etc.

The word frequency usually bases on an absolute value from counting occurrences of words in a specified pool of written language samples. In this sense, high frequency words are supposed to be recognized faster than low frequency words (Baumgaertner & Tompkins, 1998; Grosjean, 1980; for review see Monsell, 1991; Tyler, 1984). In the present study, proper names as well as common nouns were high frequency words. However, one can not control the absolute frequency in which proper names are much less frequent than common nouns (Ruoff, 1981). In the Sinica corpus of modern Mandarin Chinese, among five million words, there are 950.702 common nouns and 87.536 proper names (Chinese Knowledge Information Processing Group, Academia Sinica, Taipei, personal communication, May 9, 2005). The present finding indicates that frequency effect is not the main account for the discrepancy between these two word categories since the reaction time for proper names was faster even though they were less frequent. Furthermore, word frequency effect is suggested to affect the speed of visual, but not auditory lexical decision tasks (Turner et al., 1998). This implication is interesting for the interpretation of the present results, since the temporal advantage in recognizing proper names is independent of modality (Shoblag, 2005; Yen & Müller, 2003). This may allow one to assume that the dissociation exists in the access to semantics or at a level which is common to both modalities.

Taking word length into consideration, the number of syllables was the same for all word categories. However, the acoustic length in connected speech varied slightly between the four word groups. The latency of personal names was much longer than common nouns. Nevertheless, the reaction time for the proper names was shorter.

Neighbourhood effect of items was not balanced in the present behavioral study explicitly. However, by controlling the distribution of the initial phonemes of proper names and common nouns, the neighborhood effect could be reduced. At a phonological level, the number of potential phonemes following the initial phonemes is balanced for both categories because they have the same initial phonemes. The matching of the distribution of initial phonemes may even reduce the influence of neighborhood effect in visual modality because the phonological computation is rapid and early even by reading (for a review see Feng, 2001; Tsai, 2004). Therefore, by controlling the initial phoneme, the neighborhood effect should be reduced in both the auditory and the visual modality.

Age of acquisition is often considered as an important indicator for the speed of word processing. It is defined as the average age at which words are learned or the order in which they are learned and it is usually measured using subject rating. Researchers reported that words learned at an early age can be responded to faster than words learned later (Tuner et al.1998) and the age of acquisition effect is larger for low frequency words than high frequency words (Gerhand & Barry, 1999). By nature, the frequency and age of acquisition are highly correlated. High frequency words are learned at a younger age than low frequency words. Moreover, early studies show that there is at least a partial frequency effect which may be accountable for the age of acquisition effect (Carroll & White, 1973a, b). It is a rather difficult task to decide whether proper names or common nouns are acquired earlier. Both common nouns and proper names are acquired at a very early age (Hall, 1999). Again, if the correlation between frequency effect and the age of acquisition effect can be applied to predict the recognition speed of these two categories. Common nouns are supposed to be recognized faster than proper names, which is exactly the opposite of the present findings. This can strengthen the hypothesis that internal organization of mental lexicon plays an essential role for this dissociation whereas proper names have a special status which enables a fast access.

Proper names and common nouns are both categorized in the word class of concrete nouns. Stimuli rating of imageability have shown that common nouns evoke more mental imaging than personal names and geographical names. According to Wippich and Bredenkamp (1979), there is high correlation between concreteness and imageability of words. High imageability-words show superior responses than low-imageability words and the imageability effect can not be attributed to other factors such as word length (Tyler et al., 2000). If the contribution of imageability effect can predict the decision time for proper names and common nouns, one may expect that concrete common nouns will reveal faster responses. The present finding implies that there is a form-based effect which is stronger than the aforementioned factors and may explain the dissociation between proper names and common nouns by means of reaction time.

8.1.2 Advantage of personal name recognition: An evolutionary approach

The present neuroimaging findings showed that the comprehension of auditory personal names involved the anterior precuneus whereas comprehension of visual personal names was associated with the frontal eye fields. These areas successfully predict that personal names can be recognized faster than common nouns. Moreover, personal names (auditory modality) revealed activation in the premotor areas which may also predict the advantage in the reaction time. The activation in the precuneus has been suggested to be correlated with a faster reaction time (Oishi et al., 2005) and the activation in the frontal eye fields implies anticipatory firming before a response is made (Gottlieb et al., 1994; Pragay et al., 1987).

With the present data, one may state a new hypothesis that the advantage of proper name in recognition time, especially personal names, must have its origin in the evolution of language. Since human being lives in groups, understanding the behavior and intentions of other group members is very important. The precondition of this understanding forms representations of other individuals as belonging to the same species and as being an individual with individual characteristics and individual motivation (Emery & Clayton, 2005). Such ***social intelligence*** has been suggested to be one of the "primary causes of the dramatic expansion of the brain during primate evolution" (Emery & Clayton, 2005, p.182). The ***Social intelligence hypothesis*** postulates that all long-lived, large-brained social animals should possess the cognitive abilities to perform social functions (Humphrey, 1976 as cited in Emery & Clayton, 2005). The evolution of such abilities in primates was constrained by a significant increase in the size of neocortex that provided the impetus for larger social groups (Dunbar, 1992). In the non-human primate brain, two areas are identified which are similar to the Wernicke's and Broca's areas in man (Galaburda & Pandya, 1982). The analogical Wernicke area is associated with judgment of distance of an acoustic call and if the acoustic signal is its own call or other intra-specific calls (Deacon, 1989). Differentiation between individuals of the same species constitutes one of important function of language evolution. From a biological point of view, names serve the function to identify individuals for human beings just like acoustic signals for colonial breeding birds. Such colonies usually consist of several thousand breeding birds in which the recognition of individuals is an important strategy for chick survival. After returning from a foraging trip, parents send a form of searching sound so that the chicks can answer with a special signal to announce their location (Müller & Kutas, 1997).

Therefore, one may assume that applying personal names was not coincidence but reflect an evolutionary function in human social behavior. As stated in 2.4, human beings did not need personal names during the primitive life style where the social group was small. As the communication between people got more intensive and the size of social groups increased, representation of one individual with his voice and gestalt might not be efficient enough (Xiao, 1987). Using personal names provides an efficient way because they directly refer to the individual and can simplify the exchange of information or communication. Using personal names including information about individuals is an analog behavior to categorizing that can efficiently reduce neural processing time (Müller, 2004). Furthermore, personal names, on the one hand, signalizing conspecifics and on the other hand, referring to other members of the same species, provide conditions to recognize individuals for a further dimension of a social relationship. This relationship includes who can benefit offspring survival, who can offer a cooperation, who can be one's partner, who causes conflicts, who owns more resources, etc.. The content of human communication concerns mostly human behavior (Dunbar, 1996). A rapid speed of processing such information, which is categorized in personal names, may provide an evolutionary advantage.

The present fMRI study also supports this approach. When talking about the evolution of language, it is more meaningful to take spoken language into consideration since the written language is an invention. The written language represents a very tiny part of the use of language whereas spoken language has evolved with Homo sapiens (Müller, 1990). For the recognition of spoken personal names, the precuneus plays an important role. This area is pivotal for self-relevant information processing (for a review see Cavanna & Trimble, 2006) and the recognition of one's own name (Perrin et al., 2005). Compared to other non-human primates and other animals, the precuneus is highly developed in human being, it comprises a larger portion of the brain volume. Moreover, the precuneus of human beings has the most complex columnar organization and the last regions to myelinate (Goldman-Rakic, 1987). The involvement of the precuneus, together with the activation in premotor areas, supports the view that rapid personal name recognition has its origin in the evolution of the species.

8.2 Implications for theory of proper names

The present behavioral study and fMRI study have provided evidence that the double dissociation between proper names and common nouns is not just a theoretical concept but also has a cognitive basis. Chapter 8.2.1 is intended to discuss the themes concerning the reference and the degree of meaning. A further issue will focus on the reorganization of the inner structure of proper names that are based on the present finding. The implication of cognitive models of the processing of proper names will be provided in 8.2.2.

8.2.1 Double dissociation with a cognitive reality

As the philosophy of language shows, proper names and common nouns dissociate at several levels. Ancient Chinese philosophers considered them as referring units of different levels of classification hierarchy (e.g. Wu, 1997; see 1.1 for more details). Common nouns are general terms denoting a class of concepts whereas proper names refer to an independent concept. Western philosophers broach this discussion in a further aspect, that is, degree of meaning (cf. Algeo, 1973; see 1.2 for more details). The present studies show that this dissociation is not only a theoretical retrospection by arising merely through the analysis of language. Furthermore, the dissociation exists with a mental basis which is reflected in divergent processing time and partially different neural substrates.

The present neuroimaging results also highlight the aspect of degree of meaning and unique reference. Compared with proper names (personal names and geographical names), the comprehension of spoken and written common nouns involved posterior temporal areas and the parietal-temporal junction (see Figure 21, 22, 26, 27). The same areas have been proposed to be associated with the semantic processing (e.g. Friederici et al., 2000b). The postulation of Mill (1843/1973) that proper names contain no meaning (saying 'less' meaning more suitable in my point of view) is supported with evidence from functional anatomy (Yen et al., 2006).

On the other hand, one can not refute the account that proper names can carry meaning (Frege, 1892) since the comprehension of spoken personal names evoked activation in the bilateral anterior temporal cortex in the present study (Figure 19). The same area has been suggested to be the response to person-specific semantics (Tsukiura et al., 2002; Tsukiura et al., 2003; Tsukiura et al., 2006). The comprehension of spoken and written geographical names (Figure 20, 25) induces neural activity in the bilateral parietal lobe which may contribute to the semantic memory of geographical names (Goodglass and Winfield, 1993; McKenna & Warrington, 1978; Warrington & Clegg, 1993).

With regard to the reference, the activation in the left anterior temporal cortex in the present study (Figure 19, 20) can be seen as support for the mono-referential feature of proper names since this area has been supposed to involve the retrieval of names with unique reference (Damasio et al., 1996, Tranel, 2006). With these findings, the theory of proper names in philosophical linguistics can be supported with the neurolinguistic data.

As presented in chapter two, one important issue of descriptive linguistics is to classify the structure of nouns, that is, which word categories can be considered as prototypical proper names? What are the distinctive features? It is suggested that German proper names and common nouns differ, for example, in the second formant (Baumotte, 2005). With respect to the reaction time for category decision task, the advantage in recognizing geographical names may be rather language-specific. Similar experimental paradigms revealed the advantage of reaction time in recognizing geographical names in Mandarin Chinese (Yen & Müller, 2003) and Arabic (Shoblag, 2005) but not in German (Werner & Müller, 2001). With regard to the same gating paradigm used in the present study, Mandarin Chinese native speakers were not able to recognize word category information while English native speakers and German native speakers were able to (Müller & Kutas, 1997).

By looking up the word *proper name (Eigenname)* in a dictionary, for example, in the *Duden Grammatik der detuschen Gegenwartssprache* (Drosdowski, 1995), one will usually find out that proto-typical proper names include subclasses such as personal names and geographical names. This categorization is usually based on the reference semantics in which proper names refer to one individual. In Mandarin Chinese, proper names and place words, the part of speech which contains geographical names, are often differentiated because of diverse syntactic constraints (Chao, 1968). In the present study, there was no significant difference in the reaction time between personal names and geographical names. In Mandarin Chinese, the response to both word categories was faster than for common nouns. In German grammar, both place names and personal names are theoretically considered as proper names, whereas the reaction time of place names is more similar to common nouns (Schuth et al., 2002;

Werner & Müller, 2001). These findings provide an alternative way to reconstruct the grammar on the basis of cognitive processing in which personal names are classified as proto-typical proper names. As to the role of geographical names, there must be a language- and culture-specific influence. The present neuroimaging results of comprehension of spoken Chinese geographical names also supports to the categorization of personal names and geographical names in the same class. The activation patterns of these two word categories are similar since they both involve the premotor areas and the anterior temporal cortex. Geographical names, like personal names, have a special processing status for Mandarin speakers. Geographical names probably comprise a part of self-identification within Mandarin Chinese speakers and reflect a stronger connection between human beings and places where they come from. This culture-specific argument is only one possible explanation.

Regarding the role of brand names, one may suggest not to classify them into the class of proper names but common nouns for several reasons. First, in the view of reference semantics, a brand name X usually refers to all extent objects of the world whose name is X. Moreover, in daily use of language, for example, sentence such as, *Do you have a coke?*, usually means, *Do you have a cola?.* Actually, *Coke* is a brand name but in a pragmatical context an alternative word for drink. It functions as a common noun. Moreover, the present behavioral study showed that brand names did not function as proper names in the sense of the choice reaction time. The reaction time for brand names was more similar to common nouns. The account that brand names are rather common nouns than proper names can be supported with the present reaction time data.

8.2.2 Support for the cognitive model of proper name processing

The dissociation between proper names and common nouns has been shown in several neuropsychological studies, for instance, the difficulty in retrieving of proper names occurs more frequently than any other kind of word (Bolla et al., 1991; Young et al., 1985) as well as selective impairment in linguistic input or output (Cipolotti et al., 1993; Ellis et al., 1989; Schweinberger, 1995; Semenza & Sgaramella, 1993; Van Lancker & Klein, 1990; Yasuda & Uno, 1998). As have stated in chapter three, cognitive models have been developed based on those findings. These accounts are mainly intended to explain difficulty in the retrieval of proper names. On the other hand, they reveal some aspects of perception of proper names such as the activation of lexical candidates and access to lexical information. Thus, discussing the temporary data respective of these accounts may contribute to refine the theory of proper name processing.

Semantic account (Cohen & Faulkner, 1986) supposes that the rich association and imageability of common nouns make them easier to recall than proper names. Proper names encompass poor semantic association because of their mono-referential features. The present fMRI study has provided support that the involvement of visual association cortex (Figure 21, 22) is the essential characteristic of common nouns.

In the framework of Valentine et al. (1996), semantic system is divided in identity-specific and general semantic system. Recognition of faces and names must access information about individual people and pre-lexical nodes of person-identity. This model implies that face recognition and name recognition may utilize common processes and that the differentiation of semantic lexicon causes the different difficulties in retrieval and access difficulty of proper names and common nouns. Processing of common nouns is more robust because of multiple links from semantic systems converge on lemmas for common nouns. In contrast, links from identity-specific semantic converge on person identity nodes that are connected by a one-to-one mapping to lemmas for proper names.

The present neuroimaging data also supports this model with the respect to the differentiation of the semantic lexicon. Comprehension of spoken personal names is associated with activation in bilateral anterior temporal cortices (Figure 19). These areas are suggested to be related to semantic processing of proper names (Gorno-Tempini et al., 2000; Gorno-Tempini et al., 2001) and person-specific semantics including face recognition (Tsukiura et al., 2002; Tsukiura et al., 2003; Tsukiura et al., 2006).

With regard to the connection between semantic system and the lemma for personal names, the model of Valentine et al. (1996) postulates a stronger connection for common noun processing than proper name processing. The present study has revealed that common nouns engaged the left posterior temporal cortex as well as the parieto-temporal junction (Figure 21, 22, 26, 27) which is associated with semantic processing. This finding can be considered as an indirect evidence for this approach.

8.3 Implication for language-universals

There is folklore among anthropologists regarding the question of the universality of personal names. It concerns a “small isolated community” (Bright, 2003, p. 672-673) where individuals have no personal names which other people use to refer specifically to them. However, it is suggested that such society does not exist. “Any anthropologists who might have reported such a community were misled by the operation of taboos on uttering personal names”. Furthermore, it is suggested that “the use of personal names, having varying levels of descriptiveness, is a sociolinguistic universal of the human species" (Bright, 2003, p. 672).

Along the tradition of the name using, one could assume that the processing of personal names must have been internalized as a cognitive universal of human beings. The present studies provide evidence in Mandarin Chinese that proper name is a special category that is different from other language categories. Despite major differences between Chinese and Indo-European languages, for instance, tone *vs*. intonation language, alphabetic *vs*. logographic writing system, limited *vs*. free naming tradition, the dissociation between proper names and common nouns can be supported. The faster recognition of personal names compared with common nouns has been identified in German (Schuth et al., 2002; Werner & Müller, 2001), Chinese (Yen & Müller, 2003) and Arabic (Shoblag, 2005). Therefore, personal names, as a category of intra-specific identification, may be language-universal.

As mentioned in the previous chapters, neurolinguistic and neuropsychological evidence for the dissociation between proper names and common nouns has been also found in English, Italian, Japanese and Chinese (e.g. Gorno Tempi et al., 1998; Semenza & Zettin, 1989; Tsukiura et al., 2003; Yamadori, 2002, Yen et al., 2005a, b, Yen et al., 2006). The present fMRI study provides the evidence that comprehension of spoken and written proper names and common nouns in Mandarin Chinese may involve partially different brain structures. The involvement of bilateral anterior temporal cortices has been found in naming English personal names (Damasio et al., 1996) as well as the comprehension of spoken Chinese personal names (Yen et al., 2005a, b) and written Japanese names (Sugiura et al., 2006). Furthermore, the activation in the left anterior temporal cortex was shown in comprehension of written English personal names (Gorno-Tempini et al., 1998), spoken Chinese proper names (Yen et al., 2005a, b) and the recognition of written Japanese personal name (Yamadori, 2002, Tsukiura et al., 2003). The present data supports the view that the activation of anterior temporal cortex for proper name processing, irrespective of its functional role (see 7.3.1), may be language-universal. Nevertheless, one must treat this issue with caution since this area does not yield significant activation in the visual modality.

Significant activation in the precuneus was observed in the present fMRI study. This area can be considered as language-universal, since this area has been suggested to be associated with familiar name processing in Japanese (Sugiura et al., 2006), recognition of one's own name in French (Perrin et al., 2005), memory retrieval of name-cued recall of familiar people in English (Maddock et al., 2001), recognition of famous names in English (Gorno-Tempini et al., 1998) and learning face-name association in German (Herholz et al., 2001). Consistent with previous research, the present data also supports the view that the precuneus plays a pivotal role of for proper name processing. One may assume that precuneus, supplying retrieval of episodic memory and self-information processing, underlines the functional anatomy of the comprehension of proper names.

8.4 Conclusion

Proper names are considered to be a special category within the class of concrete nouns. In a theoretical point of view, proper names do not have a hierarchical and analytical organisation but are more holistic since they refer to individuals directly. Moreover, language philosophers extend the referential point of view into the degree of meaning. Some argue that proper names do not carry meaning (e.g. Kripke, 1980) whereas others suggest that the meaning of proper names is the description of the individual (e.g. Wittgenstein, 1960). Dissociation between proper names and common nouns is also supported by a large number of descriptive linguistic studies regarding the phonology, morphology, grammaticality and sociolinguistic properties of it (see chapter two). Furthermore, neuropsychological and neurolinguistic studies provide support that this dissociation comprises a cognitive reality (e.g. Müller & Kutas, 1997; Weiss & Müller, 2003). This differentiation does not only exist at a pure language level but also evokes diverse reactions and neural processes in the users of a language.

The present work investigated the dissociation between proper names and common nouns of Mandarin Chinese speakers in behavior of category decision time and functional anatomy. As the results showed, Chinese speakers can recognize proper names more rapidly than common nouns in a category decision task. Furthermore, the comprehension of proper names and common nouns also involve partially different brain structures. The comprehension of proper names is associated with activation in bilateral anterior temporal cortices, anterior precuneus, premotor and primary motor areas. The comprehension of spoken common nouns is associated with the activation of the left posterior temporal cortex as well as the visual areas. The comprehension of written proper names engages more frontal areas while comprehension of written common nouns yields significant activation in left posterior cortex and the parieto-temporal junction. These findings imply the view that proper names and common nouns differ in the intensity of semantic processing. Corresponding to the hypothesis which has been discussed in the philosophy of language for over two thousand years, the special status of proper names is supported by this work.

Issues for the future research

The present work provides category-specific evidence for proper names and common nouns respective of decision time and neural substrates. However, it remains unclear if this category-specific dissociation, reflected in the diverse involvement of brain structures, is attributed to lexical semantics. The current fMRI study indicates that proper names and common nouns dissociate in the activation in temporal lobe which is suggested to be associated with semantic processing. Recently, it was suggested that grammatical categories may be encoded at the level of lexical form and it is also represented in the brain (Shapiro & Caramazza, 2002; 2003). With the current design, one was not able to observe if the grammatical information of proper names and common nouns was represented. Obviously, the semantic account is not the whole story. If the semantic account alone can explain the neural representation, one should observe the same activation pattern in auditory and visual modality. In contrast, the temporary data shows discrepancy between different modalities. This issue needs to be explored using tasks designed to activate grammatical processes. Furthermore, by applying methodological extension, such as event-related design or the combination with other neuro-physiological techniques, e.g. EEG, MEG, one may gain some understanding how lexical categories are represented in the brain and as to how different brain structures work together to achieve comprehension and lexical retrieval.

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