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Why his Mother is Better Than a Mother

Psycholinguistic Investigation of Concept Types & Concept Type Shifts

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Abstract

The present dissertation investigates concept types and conceptual type shifts – as assumed by the Theory of Concept Types and Determination (short: *CTD*) by Sebastian Löbner (mainly 2011) – from a psycholinguistic perspective. First a solid theoretical basis is created by breaking down the core aspects and assumptions of the CTD and providing a broader semantic-syntactic theory backdrop for Löbner's model. Additionally, a psycholinguistic background is presented which considers theories and empirical research on word recognition.

The main part of the dissertation reports a series of behavioral experiments that examined the influence of contextual concept type information on noun recognition. The experiments used lexical decision and phoneme monitoring paradigms in order to address the nature and locus of a possible concept type congruence effect, as predicted by the CTD. Nouns of the four concept types were preceded by determiners of different types that provided congruent, incongruent or neutral conceptual type information. These combinations were presented to participants in German and English experiments. The results showed different reaction time patterns for the nouns in relation to the preceding determiner types. These results were complemented by a discussion of three different interpretations of *congruence* and respective statistical analyses of the experimental data in the attempt to empirically decide between the three possibilities. Additionally, with the aim to reject a pure frequency explanation of the CT-congruence effect, the reaction time data were correlated with co-occurrence frequency data that was extracted from corpora.

In summary, the results showed a facilitating effect of congruent determiner noun combinations in German and English experiments. The absence of the congruence effect in phoneme monitoring is interpreted as evidence for a post-lexical locus. Due to its facilitating nature, it can be assumed to reflect earlier post-lexical build-up of noun phrases, rather than later post-lexical checking mechanisms.

Abstract (Deutsch)

Die vorliegende Dissertation untersucht Begriffstypen und Begriffstypen-Verschiebungen (Konzepttypen-Shifts) gemäß der Theorie der Begriffstypen und Determination (Theory of Concept Types and Determination, kurz: *CTD*) von Löbner (hauptsächlich 2011) aus psycholinguistischer Perspektive. Um zunächst eine solide theoretische Basis zu erstellen, werden die Kernaussagen und Annahmen der CTD umrissen und in einen erweiterten semantisch-syntaktischen Forschungskontext eingebettet. Zudem wird der psycholinguistische Hintergrund der Forschung zum Wortverstehen referiert.

Den Hauptteil dieser Arbeit bilden die Beschreibung der Methoden und Ergebnisse sowie die Diskussion letzterer. Die Experimente verwendeten lexikalische Entscheidungsaufgaben sowie Phonem Monitoring um die Verarbeitung eines möglichen Begriffstypen-Kongruenz-Effektes in Sinne der CTD zu untersuchen. Determinier und Nomen wurden kombiniert und Versuchspersonen in deutschen und englischen lexikalischen Entscheidungs-Experimenten sowie in einem deutschen Phonem Monitoring Experiment präsentiert. Nomen, die zu einem der vier Begriffstypen gehören wurden mit Determinierern verschiedener Typen kombiniert und ergaben kongruente, inkongruente oder neutrale Kombinationen im Sinne der CTD. Ergänzt wurden die Ergebnisse durch eine Diskussion verschiedener Interpretationen des Begriffs *Kongruenz*, sowie durch eine Korrelationsanalyse empirischer Reaktionszeitdaten mit korpusanalytischen Daten, aus denen die Häufigkeiten gemeinsamen Vorkommens der verwendeten Determinierer-Nomen-Kombinationen extrahiert wurden.

Zusammenfassend lässt sich sagen, dass die Ergebnisse der Experimente eine Beschleunigung kongruenter Kombinationen von Determinierer und Nomen ergeben hat, die darauf schließen lässt, dass Begriffstypeninformation lexikalisch gespeichert ist und in einem post-lexikalischen NP-Aufbauprozess zum Tragen kommt.

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List of Abbreviations

Abbreviation	Description
CTD	Theory of Concept Types and Determination
CT	concept type
SC/ SN	sortal concept/ sortal noun
IC/ IN	individual concept/ individual noun
RC/ RN	relational concept/ relational noun
FC/ FN	functional concept/ functional noun
DT	determiner type
[U]	uniqueness
[+U]	unique
[–U]	non-unique
DET_{+U} / DET_{-U}	determiner that demands [+/–U] nouns
[R]	relationality
[+R]	relational
[–R]	non-relational
DET_{+R} / DET_{-R}	determiner that demands [+/–R] nouns
LDT	lexical decision task (experiment)
PM	phoneme monitoring (experiment)
M	mean
SD	standard deviation
SE	standard error

Prologue

The aim of this dissertation is to investigate the core assumptions of Löbner's (2011, also 1998 and 1985) Theory of Concept Types and Determination (short: *CTD*). The CTD is a theory about nouns and their underlying concepts. It classifies concepts into four types by means of two binary referential properties, uniqueness and relationality. A specific (unique) combination of values of these properties is inherent to each concept type. The four resulting concept types are *sortal* (non-unique and non-relational), *individual* (unique and non-relational), *relational*[1] (non-unique and relational) and *functional* (unique and relational). Nouns are combined with any type of determiner in natural language, and both carry conceptual type information. For every noun, conceptual type information (or the value specification of the referential properties) is lexically specified in the mental lexicon and determiners have certain concept type demands of nouns with which they are combined. If the concept type specification of a noun matches the requirements of the determiner, we have a case of congruence; if it mismatches the requirements of the determiner, we have a case of incongruence. According to Löbner (2011) this leads to concept type shifts of the noun, which are assumed to be additional processes in language processing. A more detailed outline of the CTD will be presented in section 1.1, followed by a sketch of the scientific context in which it was developed (in section 1.2).

The main focus of this dissertation is the psycholinguistic investigation of the CTD that aimed to find evidence for the central assumptions in language comprehension. A series of eight experiments was conducted (see section 2) using written and spoken word recognition paradigms, namely auditory and visual lexical decision and phoneme monitoring. The experi-

[1] It should be noted that the term *relational* is used ambiguously in Löbner's CTD: it either refers to the inherent referential property of relationality or more specifically to the value (non-)relational, or it refers to one of the four concept types, namely to relational concepts (or relational nouns). In the course of this dissertation, whenever necessary, I will add a footnote that specifies which of the two is meant by using the term *relational*.

ments were conducted in German and English in order to gain insight not only from two different modalities but also from two different languages.

Complementary results for more specific questions that arose from the CTD are presented in chapter 3. Section 3.1 investigates different possible interpretations of the notion of *congruence* by analyzing the experimental results according to three different congruence definitions. Section 3.2 complements the experimental results by adding correlation analyses of the reaction time data of selected experiments with co-occurrence data obtained by extraction from German and English corpus data. The final discussion in chapter 4 will conclude the dissertation and give an outline of further research paths for experimental CTD research.

1. Introduction and Theoretical Background

This chapter outlines the theoretical foundation of the present dissertation. In order to set the theoretical basis on which the experiments presented here (cf. chapter 2) were designed, the following sections will outline the CTD and related semantic research (section 1.1) and the relevant psycholinguistic background to the empirical data (section 1.2).

1.1 Concept Types and Determination

In the field of semantics there have been several approaches to noun classification, with the mass vs. count distinction (*water* vs. *woman*) and the distinction between sortal vs. relational nouns (*woman* vs. *wife*) being the most perseverant of them (cf. section 1.1.2 for an overview, discussion and references). Evolving from the traditional distinction between sortal and relational nouns a more fine grained theory of conceptual classification has been developed. From the groundwork in his 1985 paper to the finalized version in his 2011 paper, Löbner refined his *Theory of Concept Types and Determination* (short: *CTD*).

The core assumptions of this theory are the object of the present psycholinguistic investigation. Section 1.1.1 sketches Löbner's theory of concept types and determination. The central assumptions made within this theory initiated this line of psycholinguistic research and were the basis for the research questions investigated in the experiments that are reported here. Section 1.1.2 gives a short overview of the semantic tradition in which the CTD stands.

1.1.1 Löbner's Theory of Concept Types and Determination

The empirical work conducted and reported within this thesis is the *Theory of Concept Types and Determination* (short: *CTD*) by Löbner (1985, 1998, but mostly 2011) which, in its core is a theory about the structure of nominal concepts and their use in natural languages. According to the CTD, nouns and their respective concepts can be divided into four *concept types* (short: *CT*): *sortal*, *individual*, *relational* and *functional concepts* (*SC, IC, RC, FC*) (2011: 280f). These four concept types are assumed to be specified within the underlying meaning of each noun's concept. The distinction between the four concept types is based on the combination of two binary referential properties, namely *inherent uniqueness* represented by [±U] and *inherent relationality* represented by [±R]. Uniqueness separates individual and functional concepts that refer to unique entities in the world (e.g. *pope, mother*) from sortal and relational concepts that do not (e.g. *stone, leg*) (cf. ibid.: 283ff).

Relationality classifies nouns according to their number of arguments, thus it separates 1-place concepts (sortal and individual, e.g. *stone, pope*) from 2-place (or more) concepts (relational and functional concepts), which conceptually bear relationships to other concepts. These other concepts are additional arguments within the conceptual meaning (typically kinship terms like *mother,* part-of concepts like *leg* or more abstract concepts that refer to measurements like *distance*). In natural language these arguments are usually grammatically linked to the head noun by some sort of possessive construction (cf. ibid.: 285f).

The referential property values of a concept classify and identify it as one of the four types: SCs are [–U, –R], ICs are [+U, –R], RCs are [–U, +R] and FCs are [+U, +R] (cf. table 1). Each of these types has a certain default contextual profile i.e. is used with a typical – or "natural" (Löbner, 2011: 287) – grammatical construction according to its referential properties, thus concept types interact with determination types. These grammatical constructions are mostly different *types of determination* (short: *DT* for *determination/determiner type*[2]), with which the nouns usually occur (e.g. *a stone, the pope, my mother*). However, grammatical constructions might also include plural (e.g. *stones*) as well as a variety of possessive constructions, that are not necessarily by use of a determiner(-like) construction (e.g. *Peter's mother*). In turn, the different possible determination types by

[2] Löbner (2011) mostly uses the term *modes of determination* to refer to what I call *determination type* or *determiner type*.

default “require” the combined nouns to be of a certain type, i.e. to have specific values of the two referential properties. For example, definite determination requires a unique noun as in *the pope*; a possessive construc-construction requires a relational noun whose relation to another concept can be expressed by means of it (i.e. the possessive construction) as in *my/Peter’s mother*.

Although the CTs have preferred DTs and the DTs “demand” specific CTs (or rather uniqueness and relationality values), the CTD allows for a combinatory flexibility in that nouns of all CTs can be freely combined with all DTs. This may result in *congruent* determiner-noun combinations, as shown above, or in *incongruent* combinations like *our pope*, *the stone* or *a mother* (cf. Löbner, 2011: 306). Table 1 shows the four concept types and their respective typical (i.e. *congruent*) determiner types indicated by “✓” and atypical (i.e. *incongruent*) determiner types indicated by “↱”.

	[–U]	**Inherently unique [+U]**
[–R]	**SORTAL NOUNS** *stone book adjective water* ✓Indef., Plural, quantif., dem. ↱singular definite ✓ absolute ↱relational, possessive	**INDIVIDUAL NOUNS** *moon weather date Maria* ↱Indef., Plural, quantif., dem. ✓singular definite ✓ absolute ↱relational, possessive
[+R] inherently relational	**RELATIONAL NOUNS** *sister leg part attribute* ✓Indef., Plural, quantif., dem. ↱singular definite ↱absolute ✓relational, possessive	**FUNCTIONAL NOUNS** *father head age subject* ↱Indef., Plural, quantif., dem. ✓singular definite ↱absolute ✓relational, possessive

Table 1.1: Concept types & determination according to Löbner (2011: 307)

As mentioned before, concept types and determination types interact in a certain way[3]. Nouns can be used with concept type congruent determination, which is the default case; but nouns can also be used in the context of

[3] The CTD is only concerned with referential non-generic noun phrases and does not apply to non-referential or generic noun phrases.

concept type incongruent determination. The CTD assumes, that these cases lead to so called *concept type shifts*. Type shifts occur during the interpretation process of incongruent determiner-noun combinations. In order to understand an incongruent utterance, the noun must be coerced. Coercion leads to a change of the values of a noun's referential properties in order to match the properties "required" by the respective determination type. In doing this, the concept type of the noun implicitly changes as well – hence these coercion operations on concept types are called (*conceptual*) *type shifts* by Löbner (2011: 306f). According to the CTD, any concept type can be shifted to any other concept type by means of using a noun in a specific incongruent linguistic context, as there are no restrictions to these processes – although there are type shifts that are more frequent than others (cf. ibid.: 310ff).

Two brief examples from German shall illustrate concept type shift operations:

(1) a) *Der Papst wohnt in Italien*.
(*The Pope lives in Italy*.)
b) *Johannes Paul II. war ein freundlicher Papst.*
(*John Paul II. was a friendly pope.*)

According to the CTD the noun *Papst/ pope* is lexically stored as an individual concept: it is an inherently unique and non-relational concept and refers to the (one and only) head of the Catholic Church. Combined with the definite determiner *der/ the* in example (1a) it is used congruently (i.e. with an IC-congruent determination type), as the definite article requires an inherently unique noun and thus it is the default determination type for individual nouns like *Papst/ pope* (see table 1). On the other hand, the indefinite article *ein/ a* in example (1b) requires a non-unique concept, but because *Papst/ pope* is an inherently unique IC, the combination of *ein* and *Papst* in example (1b) leads to a mismatch between determiner and concept type. Due to this incongruence and in order for the values to match the ones required by the indefinite article *ein,* the interpretation of an utterance like b) coerces a modification of the referential properties of the IC

Papst, in this case a modification of the uniqueness value of *Papst* ([+U]→[–U]) which equals a concept type shift from individual to sortal. On a semantic level the indefinite use of Papst/ pope in b) is re-interpreted as referring to a whole "sort" of entities, namely (all) the heads of the Catholic Church, one of which is John Paul II..

Conversely, the following example sentences show a concept type shift of a sortal concept:

(2) a) *Ein Stein lag in der Mitte des Weges.*
(A stone was lying in the middle of the road.)
b) *Gib mir meinen Stein zurück!*
(Give me back my stone!)

German *Stein/stone* is a sortal concept, as it does not refer to a unique entity in the world (it is [–U]), nor does it by default carry any relationship to other entities built into its meaning (it is [–R]). In a) *Stein* is used congruently with the indefinite article *ein/a*, which requires a [–U] noun in order to form a type-congruent combination. In b) *Stein* is used with the possessive first person pronoun *mein*, which as a possessive construction requires as [+R] concept (cf. table 1.1). By using a sortal noun in a possessive construction as in b), the value of relationality is coerced: [–R] →[+R], thus the sortal concept *Stein* undergoes a concept type shift and becomes relational[4].

In summary, the CTD theory makes two basic assumptions. Firstly, conceptual type information of nouns is understood to be lexically stored, thus for most nouns there is one underlying – i.e. lexically stored – concept type[5]. The second assumption concerns the interaction between the underlying concept types and the different types of determination: If a noun that belongs to a particular concept type occurs in the context of incongru-

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[4] The term *relational* is intentionally left ambiguous at this point (referring to *relational* as in [+R], the referential property of RCs and FCs or to *relational* as in *relational concept type*).

[5] Some nouns can have more than one concept type due to polysemy, e.g. child can be understood as a sortal noun as in "non-adult human being" or as a relational noun as in "another persons' descendant".

ent determination, this CT incongruence leads to a concept type shift by coercing the noun to match the referential properties required by the DT. These two assumptions of the CTD fundamentally motivated the psycholinguistic investigation that will be reported within this thesis.

1.1.2 A Historical Backdrop to the CTD: Earlier and Related Approaches to Noun and Concept Classification

Partee and Borschev (2012) discussed Löbner's noun/concept type classification focusing on functional nouns and put forward a counter-claim:

> "[T]he basic types of nouns are sortal nouns, proper names and relational nouns, and for the most part functional nouns are simply an accidental subclass of the relational nouns. […] Our working hypothesis is that sortal and relational nouns are of different syntactic categories and different semantic types. Functional nouns are a subclass of relational nouns but not a separate category or type. If categories are clusters of features, functional and relational nouns share most of their features" (ibid.: 445f and 448).

However, although they claim, that functional nouns are no specific class of nouns, Partee and Borschev (ibid.) admitted, that there are linguistic contexts specific to functional nouns. This line of argumentation showed, that while Löbner (1985, 1998, 2011) has dealt with nouns by – firstly – developing a theory of noun concepts and separating different semantic concept types by describing their respective referential properties and has then – secondly – linked his conceptual categories to an analysis of linguistic uses of nouns, most of the research on this topic(s) has predominantly been conducted taking the inverse route. Most approaches to noun semantics started from indefinite, definite and possessive constructions in language use, and from there derive certain common properties that result in a distinction of noun (and in some cases also concept) classes.

This "inverse" pattern of analysis is especially visible in the (mostly formal semantic) literature about (in)definite(nes)s and what it implies for the logic and properties of nouns. Uniqueness is one of the two main features in terms of which definiteness has usually been defined (cf. Abbott, 1999, 2006a, b, and Barker, 2011). The uniqueness definition of definiteness – which corresponds to Löbner's view that also links uniqueness to definiteness (2011: 287) – understands definiteness as expressing uniqueness, i.e. definite descriptions refer to entities that are unique within a given discourse/context. This definition originates from Russell (1905: 481), and has been refined as "unique reference" by Strawson (1950: 332), extended to plurals and mass nouns by Hawkins (1991: 409). Furthermore uniqueness has received a more specific definition as an inherent property of nouns by Löbner (1985, 2011). The second definition links definiteness to the property of familiarity, i.e. definite descriptions refer to entities that are familiar in the discourse or familiar to the hearer. This definition originates from Christophersen (1939: 72) and was later established by Heim (1982, 1983: 223). In some cases, familiarity is linked to the notion of *salience* (cf. Barker, 2000: 217). Burkhardt (2008) provided empirical support from ERP data for the hypothesis that the definiteness property of nouns is not tied to the use with definite determination, but instead "[s]semantic definites possibly carry a feature of inherent definiteness in their lexical entry" (ibid.: 78). This hypothesis conformed to Löbner's (2011) notion of *inherent uniqueness*.

The notion of *relationality* has a rather old tradition, and the (formal) distinction between sortal and relational concepts goes back to Behaghel (1923: 22f) who distinguishes between "absolute" and "relative" concepts (also cf. Löbner 1985). De Bruin and Scha (1988) presented a formal semantic analysis of the difference between sortal and relational nouns. In some papers the distinction has been compared to verbs and their argument property of (in)transitivity. Partee and Borschev (2012: 446) stated that "[t]he distinction between sortal nouns and relational nouns is standardly taken as a distinction between one-place predicates and two- (or possibly more) place predicates". Barker (2011), however, showed that there are also one-place relational nouns, like for example *stranger*, which – according to Barker – is a relational noun but is "obligatorily intransitive" (ibid.: 1112), whereas the relational noun *enemy* is "optionally transitive" and the also relational noun *sake* is "obligatorily transitive" (quoted terms and examples cf. ibid.). Although a person is not a *stranger* just by lexical definition, but by a sort of "unknown"-relation to another person, the relation cannot be linguistically expressed by any possessive construction (**John's stranger* (example by ibid.), **my stranger*, **a stranger of John*), but the relation *to* the possessor can only be expressed by the construction *a stranger to me*.

Löbner (1985: 298ff) distinguished between semantic and pragmatic definites. Barker (2000) claimed a similar distinction for possessiveness. Lexical possessive interpretations result from the lexically specified possession relation of the head noun, while in extrinsic possessive interpretations the possession relation needs to be derived from the discourse context (ibid.: 216f) via *typeshifters* (cf. Barker, 2011: 1114). In Löbner's (2011) terms these distinction can be described as congruent uses of [+R] nouns in possessive constructions vs. incongruent uses of non-relational (i.e. [–R]) nouns in possessive constructions which are shifted to [+R]. Barker (2000) added a further point to this distinction:

> „It is important to realize that whether an instance of a possessive is lexical or extrinsic depends on context. Of course, a possessive can be lexical only if it contains a relational head noun. But even relational possessive can be lexical on one occasion of use and extrinsic on another. For instance, if John works in a day-care center, the phrase *John's child* can refer to the young person that John is tutoring at the moment, even if John does not have any of his own children" (ibid.: 217).

This instance of the noun *child*, which can be a lexical relational possessive (as in *John's (own) child*) or an extrinsic relational possessive (example see quote from Barker above), where the relation is not brought along by the head noun itself, has been called "polysemy" in Löbner (2011). In his view these two uses of the noun *child* result from two different readings or two different concepts with separate lexical entries: one is the relational concept *child* (*of someone*) and the other is the sortal concept *child* (as in *She is just a child.*), which in Barkers example above has been shifted to a relational noun (and is not equal to the inherently relational concept of *child* (*of someone*))[6].

Barker (2011) further mentioned that some languages make morpho-syntactic distinctions based on the inalienability of a concept (which in turn is based on relationality), thus different sorts of possessive constructions for alienable vs. inalienable nouns. He claimed that this is also true for English, where overt possessive linking of the possessee via a genitive construction is grammatical for inalienable (relational) nouns, but not for alienable nouns (this does not necessarily account for other possessive constructions):

> "In English, to the extent that only relational nouns can participate in the postnominal genitive possessive construction (*the brother of Mary*, **the cloud of Mary*), English makes a syntactic distinction between alienable (*cloud, squirrel*) and inalienable (*brother, speed*) nouns" (ibid.: 1112f).

Taking Löbner's approach as a basis, a different analysis is possible. Assuming that any noun can occur in any determiner type or linguistic construction, the utterance *the cloud of Mary* is not syntactically ungrammatical, it is a well-formed but concept type incongruent utterance. Admittedly, it requires a very specific semantic context, thus semantic constraints might make this use of the noun *cloud* rather marked. However, according to Löbner's CTD, an example like *the cloud of Mary* is a perfectly grammatical construction and can be analyzed as an incongruent and therefore shifted use of the sortal concept *cloud* as a functional noun. The shift changes the referential properties relationality (by using the post-nominal genitive construction *X of Y*) and uniqueness (by using the definite article the) from [–R, –U] to [+R, +U]. *Note*: If the construction were *a cloud of Mary* the shift would be described as a change of the property of relationality from [–R] to [+R], thus from a sortal noun to a relational noun. The non-uniqueness would be preserved by the indefinite article *a* (for a more detailed discussion of relational nouns – also in com-

[6] For the analysis of a similar example in Koyukon that does not include polysemy cf. Löbner 2011: 325f).

bination with a familiarity approach of definiteness – cf. Barker, 1995, 2000, 2011).

With his notions of sortal, individual, relational and functional nouns, Löbner's CTD follows a long tradition in philosophy and linguistics. The origin of the notion of sortal nouns lies in philosophy and has been introduced by Locke (cf. Mackie, 1994: 312). Later Strawson (1959) used sortal nouns "because of their ontological role in classifying entities into sorts" (Partee and Borschev, 2012: 446, also cf. Barker 1995, 2000, 2011, who compares sortal nouns to relational nouns). The notion of functional nouns has been discussed in formal semantics and logic for a few decades (e.g. in Frege, 1891, cf. Löbner, 1985). In order to understand the meaning of a functional noun, a one-to-one function needs to be "performed" that assigns one entity to another entity (cf. for example Löbner, 1985, 2011). Individual nouns have been introduced by Carnap (1947) and Montague (1970, 1973), and mainly denominate proper names (cf. Löbner, 1985 and Abbott, 2011).

There have been other attempts to classify or categorize nouns in natural language, as for example the mass/count distinction. Gathercole (1986: 152-158) has provided an overview of the different approaches (e.g. philosophical, linguistic, ontological, etc.) to the mass/count distinction. A finer grained noun classification, which is to some extent similar to Löbner's CTD approach, has been developed by Fraurud (1996). She distinguished three main „classes"/categories of nouns:

> "[…] Individuals, Functionals and Instances, typically corresponding to proper nouns, definite NPs and indefinite NPs, respectively. […] The classes differ with regard to degree of individuation, relations to other entities, and ways (and degrees) of identification" (Fraurud, 1996: 71).

Individuals name and directly refer to unique objects in the world which do not have any relation[7] to other entities, thus they correspond to Löb-

[7] It may be noted that this notion of *relation* is ontological rather than semantic or conceptual.

ner's individual nouns. Functionals have an inherent or temporal relation to other entities through which they are identified (indirectly) and they are typically used in definite NPs (e.g. *his nose* or *the nose* (examples by Fraurud, ibid.)). These cases correspond to Löbner's functional (and relational cf. below) nouns. Instances are sortal types of objects or categories and refer to "kinds" of objects (rather than to individual objects), which also have no relation to other entities and are typically used in indefinite NPs, thus correspond to Löbner's sortal nouns.

Fraurud named a few instances of exceptional uses (according to her ontology) for which she tries to provide explanations, which – as I will show below – Löbner accounts for in a more plausible way. According to Fraurud (ibid.: 76) Functionals are typically used in definite NPs or (relational) definite descriptions which "suggest[…] a one-to-one relation". She reported some cases in which Functionals are used in indefinite constructions which suggest "a one-to-many relation", as in *a page of the book* vs. *the cover of the book* (examples ibid.: 76f), where *page* is a Functional (according to Fraurud), thus entails a relation to another entity (*book*), however, it is used with the indefinite determiner, indicating that it is not unique. Fraurud took this example as an argument to broaden the definition of Functionals, so that this class of nouns includes nouns with both 1:1 and 1:n relations. Functionals in Fraurud's sense incorporate unique and non-unique relational nouns, which are used in definite and indefinite NPs, respectively – a rather heterogeneous class of nouns. Löbner (2011) resolved this in a more systematic way by separating the two classes into functional vs. relational nouns, thus unique vs. non-unique relational nouns, used in definite vs. indefinite NPs, respectively.

Fraurud furthermore reported some examples that show that not all definite NPs are unique, thus also non-unique relational nouns can be used in definite NPs. For illustration I will use the German equivalent to Fraurud's Swedish example:

(3) *John steckte die Hand in die Tasche*.
(*John put his hand in his pocket* [lit.: *the hand in the pocket*])
(Translation taken from Fraurud's Swedish example (1996: 77).)

Fraurud suggested, that "definiteness of the NP can be seen as a signal of relationality rather than of uniqueness" (ibid.: 77). This is a possible explanation for the definite use of non-unique nouns; however, this interpretation of definiteness is problematic for the following case of definite descriptions, that Fraurud mentioned as "cases in question" (ibid.: 80):

> "[There] are definite descriptions as the *moon* and the *sun*, referring to entities that are 'unique' in the sense of being the only ones of their kind […]. Such definite descriptions function as proper names in that they directly identify the referents".

These two aspects (Fraurud's "problem" with definite use of non-unique Functionals, and definite use of Individuals) have been solved more elegantly by Löbner (2011): he distinguished between unique nouns without inherent relationality (individual nouns), unique nouns with inherent relationality (functional nouns) and non-unique nouns with inherent relationality (relational nouns, and of course non-unique non-relational nouns (sortal nouns), which, however, are not relevant for this point). Although Löbner's argumentation argued from concept to its use I will invert his line of thought for the sake of comparison with Fraurud: definite descriptions/NPs indicate uniqueness. But as not all relationality bearing nouns are unique (because there are relational vs. functional nouns) not all [+R]-nouns typically appear in definite NPs. Relational nouns typically (congruently) occur with indefinite determination, while functional nouns are congruent with definite determination.

Löbner's approach can well explain Fraurud's above mentioned indefinite uses of *Functionals*. The also mentioned definite uses of non-unique Functionals can be explained in Löbner's framework as (incongruent) definite uses of relational nouns of which the referential property of uniqueness is shifted via the use with the definite determiner. Löbner's theory allows for these constructions because of the approach that although nouns typically occur with certain determiner types, all noun types can potentially be used with any determiner type and are shifted in the case of incongruent determiner-noun combinations. Without assigning relationality to definite determiners – as Fraurud suggested (1996: 77, cf. above) – this approach also leaves room for Fraurud's just mentioned "problematic" cases of Individuals that are used in definite NPs (e.g *the moon*).

There are other references mentioning a "problem" concerning the definite use of non-unique constructions. Abbott (1999: 8f, 2006b: 131f) mentioned a „problem of non-unique definite descriptions", as in "*the bank of a river"* or "*John was hit on the arm*" (Abbott, 2006b, she used examples from Christophersen, 1939 and Ojeda, 1993). Barker (2011: 1120) called these cases *possessive weak definites*.

The idea of type mismatches and mechanisms for their resolution, i.e. type shifts and type coercion, have been discussed by de Swart (2011) and de Hoop (2012). What de Swart (2011: 575) described as *type mismatch* can be equated to Löbner's notion of *incongruence*, namely a construction in which the inserted noun does not match the features required by the determiner type or grammatical context. Type shifts have been introduced by Partee (1987), while Pustejovsky (1995) proposed type coercion as a mechanism to interpret "mismatching" uses of nouns (cf. de Swart, 2011: 576, who also showed that these notions have sometimes been used in a wider sense than in Löbner's framework, including aspectual coercion). Partee (1987) proposed and formally defined rules for type shifts that shift the meaning of NPs, but also noted that there are also non-formal or non-systematic type shifting principles in natural language which are applied due to "their substantive content [that] has some high cognitive naturalness (such as perhaps the rule which turns proper names into common nouns denoting a salient characteristic, as in *he's a real Einstein*)" (ibid.: 120, cf. also Partee and Borschev, 1998).

Pustejovsky's (1995) notion of type coercion has been utilized to explain the meaning transfer, or metonymic shifts when interpreting NPs with modifying adjective, such as *stone lion* and *chocolate teapot* (Kluck, 2007: 2), and sentences like *The ham sandwich from table three wants to pay* (example by de Swart, 2011: 580; the original example is from Nunberg, 1995: 115: *The ham sandwich is at table 7.*). Schuhmacher (2013: 1) argued that the interpretation of these phenomena is achieved by processes of complement coercion (type accommodation), reconceptualization and compositional enrichment.

1.2 A Psycholinguistic Approach to Nouns and Concept Types

To date, the CTD has not been investigated using psycholinguistic methods. The line of research presented in this dissertation[8] is the first attempt to find evidence for the assumed lexical specification of concept types, and for concept type shifts caused by type incongruence of contextual information with which nouns are combined. However, Burkhardt (2008) presented a series of experiments, which investigated Löbner's (1985) distinction between semantic and pragmatic definites in ERP studies. She reported an advantage of semantic definites (this term corresponds to the notion of congruent combinations of inherently unique nouns with definite determination in Löbner's later work) compared to pragmatic (i.e. context-dependent) definites (this term corresponds to the notion of incongruent combination of non-unique nouns with definite determination in Löbner's later work). This difference between semantic and pragmatic definites showed that the interpretation of pragmatic definites goes along with higher processing costs. She concludes that semantic definites seem to have an inherent definiteness property:

> "Semantic definites possibly carry a feature of inherent definiteness in their lexical entry [+DEF], which facilitates their discourse inte-

[8] This line of research was funded by the German research funding organization DFG (http://www.dfg.de/en) and was conducted in project C03 *Conceptual Shifts: Psycholinguistic Evidence* within the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en).

> gration. Pragmatic definites, in contrast, must enter into a discourse relation with previously mentioned referents, which is triggered by the definiteness feature on the definite determiner, demonstrative, or pronoun, and results in processing cost" (Burkhardt 2008: 78).

Adapting these results to the refined version of the CTD (Löbner, 2011), this study supports the assumption of the referential property of inherent uniqueness for a subclass of nouns, namely functional and individual, and provides a hint towards the assumed type shifting operations in the case of incongruent uses (pragmatic definites) – thus backs up the investigation of the CTD within the present dissertation.

The focus of Löbner's (2011) CTD lies on nouns and the influence of the immediate context which accompanies them in natural language, namely determiners. As introduced above, according to the CTD, nouns and determiners both carry inherent conceptual type information. Within a determiner-noun combination, conceptual type information can match, i.e. share the same referential property values. Löbner (2011) called these cases *congruent*. If conceptual type information mismatches between determiner and noun, the combination is incongruent, and results in concept type shifting operations on the noun's underlying concept induced by the context of an incongruent determiner, according to the CTD.

In order to initiate a first-time psycholinguistic investigation of the CTD, and to detect a possible cognitive effort that is theoretically attributed to type shifting operations, a word level behavioral approach, utilizing conceptually[9] matching vs. mismatching determiner-noun combinations, was chosen for the experiments presented in this dissertation. As written and spoken (or visual and auditory) word recognition is a field well investigated, the experiments presented in this dissertation followed this tradition and explored aspects of the CTD in language comprehension.

Section 1.2.1 outlines the relevant behavioral research in the field of word recognition, specifying on studies on gender priming for reasons given below. Section 1.2.2 summarizes the preliminaries and basic con-

[9] *Conceptually* in this context is meant in the sense of Löbner's notion of concept type.

cepts of the psycholinguistic CTD investigation in order to complete the theoretical basis for the experiments reported in chapter 2.

1.2.1 Written and Spoken Word Recognition

Written and spoken word recognition has a long tradition of investigation and a lot of behavioral evidence has been presented and discussed for various issues within this topic, including perception of the input signal, lexical access, context effects, and the locus of certain effects – to name just a few (cf. Frauenfelder and Tyler, 1987, Balota et al., 2006, Dahan and Magnuson, 2006, Mitterer and Cutler, 2006, among others for more detailed overviews and more in depth reviews of the relevant empirical work that has been conducted in these areas).

Concerning recognition processes, several sub-processes or functions are commonly distinguished, although different terms have been used to refer to them depending on the model which uses them (cf. for example Frauenfelder and Tyler, 1987, Dahan and Magnuson, 2006):

- *initial lexical contact* of speech input with mental representations of words/lexical candidates (in some approaches subsumed under the following function)
- *lexical activation* of lexical candidates (also referred to as *early stage* of word recognition)
- *lexical selection* of the best fitting candidate (also referred to as *later stage of word recognition*)
- *lexical access* of all information that is connected to the selected entry (this term is sometimes used as a general term that refers to lexical processing as a whole; also referred to as *lexical retrieval*)
- *post-lexical checking* or *(syntactic) integration* of context information; a process that takes place after the best fitting candidate has been accessed (in some approaches includes *post-lexical built-up* of a noun phrase)

The term post-lexical in more recent papers is mostly used as an antonym to the term *lexical*, referring to processing stages like build-up of noun phrases and checking mechanisms (=post-lexical), that occur after the word has been activated, selected and retrieved from the lexicon (=lexical). These are the notions of lexical and post-lexical that will be used throughout this dissertation.

There still seems to be no consensus about the organization of the lexicon or the structural and temporal properties of the processing stages. Neither is it clear which, how and when contextual information (e.g. syntactic, morphological, and semantic) affects lexical processing (cf. e.g. Frauenfelder and Tyler, 1987, McQueen and Cutler, 2001). Different models of lexical processing have been developed that try to model the lexicon's architecture, lexical processes and processing stages. Following the tradition of the overall view of a modular architecture of cognition (cf. Fodor, 1983), modular models have been proposed, like the ERP-based model by Friederici (1995), the *Autonomous Search* model (Forster, 1989) as well as *Race* (Cutler and Norris, 1979), and the successor *Merge* (Norris et al., 2000), which assume distinct (autonomous) units and sequential processing stages without interaction of top-down inhibition.

The *Cohort* model (Marslen-Wilson, 1978 for the *Cohort I* model, 1987 for the *Cohort II* model; Gaskell and Marslen-Wilson, 1997 for the *Distributed Cohort* model) assumes a non-modular distribution of lexical representations and the activation of all lexical candidates by initial contact with phoneme sequences in the input. Competitors are eliminated bottom-up at the uniqueness point of a word and context information is not necessary. According to interactive models like *TRACE* (McClelland and Elman, 1986) and *Shortlist* (Norris 1994) activation of candidates can happen via any phoneme sequence in the input. These models also allow for lateral inhibition between lexical candidates, the former allows for interaction by top-down facilitating feedback, the latter only allows for bottom-up inhibition. A vast number of empirical studies have been conducted that added empirical support for or against one or more of the different models (for an overview cf. Dahan and Magnuson, 2006, among others).

A relevant line of experimental research, which has influenced the methodological approach of the CTD investigation presented in this dissertation, has been conducted around the processing of nouns and the influence of grammatical gender provided by the context in various gender-marking languages (Friederici and Jacobsen, 1999, provide a concise overview). These studies compared determiner or adjective and noun combinations with matching, mismatching (or: congruent, incongruent) and/or neutral gender information within the NP. There have been reported a robust gender (congruence) effect in lexical decision, gating and phoneme monitoring, as well as in word and picture naming experiments for various languages (cf. Bates et al., 1995, 1996, Bentrovato et al., 1999, 2003 for Italian; Reyes, 1995 for Spanish; Colé and Segui, 1994, Grosjean et al., 1994, Dahan et al., 2000, for French; Schmidt, 1986, Hillert and Bates, 1996, Jacobson, 1999, Bölte and Connine, 2004, for German; Akhutina et al., 1999 for Russian; and Gurjanov et al., 1985 for Serbo-Croatian).

The results on the nature of the gender effect, however, have been rather heterogeneous with respect to the direction of the effect. Some studies yielded facilitation effects for nouns presented with congruent context cues (cf. Grosjean et al. 1994, Dahan et al. 2000, Bentrovato et al. 2003, Bölte and Connine 2004), others reported inhibition by incongruent cues (cf. Schmidt, 1986, Jacobsen, 1999, Bates et al., 1996), yet others showed a gender effect in both directions (cf. Bates et al., 1996, Hillert and Bates, 1996). Important to note is that not all studies used the same basic design of comparing all three values of congruence, namely congruent vs. incongruent vs. none/neutral baseline. Additionally Bates et al. (1996) criticized the aspect that the baseline might have been questionable in some studies.

Similarly divergent are the interpretations concerning the locus of the gender effect. In summary, facilitation effects are assumed to indicate lexical or post-lexical processing, while inhibition is assumed to serve as an indicator for post-lexical processes (this dichotomy is sometimes also referred to as *automatic* vs. *controlled* processes, cf. Posner and Snyder, 1975). Grosjean et al. (1994), Dahan et al. (2000), and Bentrovato et al. (2003) argued that gender information is utilized in the earlier stage(s) of lexical processing – either by pre-selection of lexical candidates for the activation process or by reducing the number of activated lexical candidates (Grosjean et al. 1994, however, do not exclude the possibility of an additional syntactic nature of the gender effect). Jacobsen (1999), Colé et al. (1994, 2003) as well as Bölte and Connine (2004) held the post-lexical view, according to which gender information comes to play in a later stage of word recognition, either acting on the build-up of the noun phrase or serving checking mechanisms (e.g. congruency checking of gender information carried by determiner and noun). Arguing for an interactive model, Bates et al. (1996) did not commit to a specific (lexical or post-lexical) locus of the gender effect and instead suggested that gender information may interact and influence word recognition in several steps or stages.

After having established the relevant theoretical basis for this dissertation, the following chapter will focus on the implementation of the core theoretical and methodological aspects into psycholinguistic investigation of the CTD.

1.2.2 Psycholinguistic Investigation of the CTD

In studies investigating grammatical gender, a number of paradigms have been developed which investigate, successfully demonstrate and – although not homogeneously – characterize the nature of the gender congruence effect. Two of these paradigms are implemented into the present psycholinguistic investigation of the nature and locus of the assumed concept type congruence effect and concept type shifts, namely lexical decision and phoneme monitoring.

This choice has been inspired and motivated by the methods used by Bölte and Connine (2004), who applied these methods to their investigation of the influence of gender information on noun recognition in German, a three gender language that inflectionally marks gender on determiners, adjectives and 3rd person pronouns. The lexical decision paradigm taps into all stages of word recognition, and thus involves a lexical as well as a post-lexical component, which makes it suitable for investigating a possible gender effect (cf. Goldinger 1996). By means of two lexical decision experiments with German determiner noun pairs, Bölte and Connine demonstrated a gender effect (or: *gender congruence effect*), i.e. facilitated lexical decision times for the processing of nouns that were preceded by gender matched (or: *congruent*) determiners as compared to gender mismatched (*incongruent*) determiners. In the first experiment, they used gender congruent determiners and compared them to a neutral baseline condition (noise); in the second experiment, congruent and incongruent determiners were used. For both experiments they reported a significant advantage of the congruent determiner, while the across-experiments analysis did not show a significant difference between the incongruent determiner and the baseline condition. The results showed a pure facilitation effect, but no inhibition.

Moreover, Bölte and Connine investigated the locus of the shown gender effect in order to add more empirical insight into the locus debate. For this purpose the phoneme monitoring paradigm was used. Phoneme monitoring is sensitive to lexical processes and has no post-lexical component (cf. Connine and Titone, 1996), and has been used to show a phonological mismatch effect, called *similarity effect* (cf. Bölte and Connine, 2004, Connine et al., 1997 and section 2.6). Bölte and Connine (2004) reasoned that, if gender information provided by a preceding determiner, acts at the lexical stage of word recognition, it should be visible in phoneme monitoring and possibly interfere with the similarity effect. They replicated the similarity effect; however, they found no gender effect and no interaction of gender with the similarity effect. They concluded that the gender effect, which had been found in lexical decision, must be post-lexical, in spite of its facilitatory nature.

Now, why would it make sense to adapt methods used in the investigation of grammatical gender to the investigation of lexico-semantic conceptual type information? Gender, on the one hand, is a morphological feature, that is lexically specified and inflectionally (thus overtly) marked on determiners, adjectives and pronouns in German (and in some languages like Italian also on nouns, cf. for example Bates, 1995, 1996, Bentrovato et al., 2003). As mentioned before, the aim of Bölte and Connine (and of most other researchers in this field) has been to gain insight into the nature and locus of the gender congruence effect, thus (if and) how gender information, that is provided by the grammatical context, influences noun processing.

Conceptual type information, on the other hand, is neither morphological nor is it overtly marked on nouns, determiners or other linguistic entities. However, conceptual type information is assumed to be lexical as well. Additionally, the aim of this line of research and the present dissertation is similar to the aim of Bölte and Connine's investigation of grammatical gender: in a nutshell, the aim of this dissertation is to gain first-time insight into the process, nature and locus of a possible concept type congruency effect, thus if and how conceptual type information provided (or rather *demanded* in this case) by the immediate context influences the processing of a subsequent noun. Therefore, beginning with behavioral methods and using lexical decision and phoneme monitoring with determiner-noun combinations as means of investigation of conceptual type information is a good choice – in spite of the semantic (not morpho-syntactic) and implicit (i.e. not morphologically marked) nature of the assumed conceptual type information.

In this dissertation, the results of eight experiments are reported. Experiments 1-6 and 8 used the lexical decision paradigm in the visual and auditory modality with German (experiments 1-4 and 8) and English (experiments 5 and 6). Furthermore, one phoneme monitoring experiment (experiment 7) was conducted. The two paradigms were used with determiner-noun combinations. A simplified version of Löbner's CTD-table (in table 1.2, also cf. table 1.1) shall illustrate the relevant aspects of the CTD that were selected for experimental investigation in this line of research:

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**[–R]**	**SORTAL NOUNS** *apple stone moment human* ✓indefinite ↱definite ↱possessive	**INDIVIDUAL NOUNS** *pope earth weather Police* ↱indefinite ✓definite ↱possessive
	Inherently relational [+R]	**RELATIONAL NOUNS** *colleague arm page idea* ✓indefinite ↱definite ✓possessive	**FUNCTIONAL NOUNS** *mother body age birth* ↱indefinite ✓definite ✓possessive

Table 1.2: Concept types & selected determiner types (modified version of Löbner 2011: 307)

As will be shown in more detail in section 2.1 and 2.2, selected nouns that belonged to one of the four concept types were combined with indefinite, definite and possessive determination, as these three types are the three (most) relevant determination types used with the concept types in German as well as in English.

2. Behavioral Experiments

In order to investigate whether conceptual type information affects word recognition and to shed light into the nature of a possible concept type congruence effect, which is predicted by the CTD, a series of behavioral experiments was conducted. Experiments 1-6 and 8 used the lexical decision paradigm with German and English stimuli and experiment 7 used the phoneme monitoring paradigm with German stimuli. Section 2.1 will discuss the hypotheses and the resulting predictions for the results of the experiments. Section 2.2-2.6 will comprise the reports of all experiments conducted in this line of research – including methodology, results as well as intermediate discussions (the latter will of course expand into the final discussion in section 4).

2.1 Hypotheses and Predictions

According to the CTD, nouns of specific concept types prefer to be used with specific determiner types which result in a congruent determiner-noun combination. This hypothesis (in the course of the following disquisition I will call this *hypothesis 1*) postulates that conceptual type information is lexically stored in that it assumes a (one) underlying concept type for every noun. For determiners, the CTD also postulates concept type specific features: determiners of a specific type demand or require nouns of a respective (congruent) concept type, i.e. nouns that have a specific combination of referential property values.

The CTD further predicts that nouns are flexible with respect to the determiner type with which they can be combined. Nouns of any concept type can be combined with every determiner type; the CTD allows for such flexibility by assuming type shifts. A lexico-semantic type shifting operation on a noun can be induced by a preceding determiner that mismatches the concept type specification of the noun and coerces the noun to change its referential properties, and with that its concept type is changed, i.e. type shifted (cf. section 1.1.1 for examples).

This theoretical model bears certain predictions for empirical investigation that will be discussed in the course of this section. However, let's first take a step back and examine the argument of *conceptual type information being lexically stored* from a more general point of view. Logically there are two possible assumptions concerning the (lexical) status of CT-information:

- *CT-information is lexically specified.*

versus

- *There is no lexical specification of CT-information.*

The assumption of lexical storage allows for three possibilities, of which hypothesis 1 is one (i.e. the CTD hypothesis, elucidated at the beginning of this section). Alternatively and going beyond the predictions of the CTD, hypothesis 2a also postulates that conceptual type information is lexically stored, however, allows for the possibility that more than one concept type(s) for each noun (thus any number of CTs between 1 and 4) are underlying and that the different entries are ranked by their activation level, for example due to different frequencies of co-occurrence (higher frequency of occurrence means faster and stronger activation in the mental lexicon) might be represented in the lexicon. A variant of this assumption is hypothesis 2b, which predicts that for every noun all four concept types are lexically stored and ranked by activation level, as well. The last possibility (hypothesis 3) is that there is no lexical specification of concept types at all. The relatively high proportion of incongruent uses (incongruent determiner-noun combinations found in German texts) reported by Brenner et al. (2014) may be seen as evidence for this hypothesis.

These accounts yield different definitions of (in)congruence and make different predictions with respect to potential processing costs which might arise for congruent versus incongruent determiner type and concept type combinations. If, on the one hand, the concept types were not lexically specified at all (hypothesis 3), there would be no distinction between congruent and incongruent determiner-noun combinations, thus no reaction time differences in word recognition tasks, and hence no extra processing costs should be measurable when presenting nouns preceded by conceptually incongruent determination.

On the other hand, if concept types are stored in the mental lexicon (hypothesis 1 and 2a and 2b), similar to grammatical features like gender information for example, the cognitive processes involved in processing congruent vs. incongruent determiner-noun combinations may lead to measurable reaction time differences in language comprehension. A concept type congruence effect should show up in word recognition paradigms. Congruent determiner-noun combinations would be processed faster than incongruent combinations. If such a concept type congruence effect occurred, the time difference could theoretically be caused by a facilitation effect for congruent determiner-noun combinations, in that congruent determination could facilitate lexical access or selection, or post-lexical processing of a subsequent noun.

Another possible explanation for the time difference would be an inhibitory effect of incongruent determiner-noun combinations, thus a delay in word recognition caused by additional processing costs of incongruent conceptual type information. Assuming that conceptual type information functions in a way similar to grammatical gender (cf. studies summarized in chapter 1, section 1.2.1), and assuming a measurable concept type congruence effect, facilitation, inhibition or both might cause this effect in the experiments reported here. However, in order to get a reliable measure for facilitation and/or inhibition, a neutral baseline (noun presented without any contextually provided type information) needs to be included. Depending on the direction of a possible CT-congruence effect, the experimental results may support one or more of the three (or 2½) hypotheses that assume a lexical representation of conceptual type information.

If hypothesis 1 were true, *congruent* determiner-noun combinations would be defined[10] as combinations of the (one) lexically stored concept type of a noun and the according congruent determiner type, which de-

[10] Although this step by step discussion of the implications and prediction of hypothesis 1 might seem like a mere repetition of what was explained in the beginning of this section, it needs to be executed for the sake of argumentation and comparison to the other hypotheses – hazarding the consequence of being repetitive to some extent.

mands the exact (matching) values of uniqueness and relationality that are specified in the noun's concept type. *Incongruent* determiner-noun combinations would be defined as combinations of a noun with its specific concept type and a determiner that requires uniqueness and relationality values that differ from the ones specified in the noun's concept type; these combinations cause a concept type shift in the noun. Bearing the assumption of concept type shifting operations as additional processes during word recognition, hypothesis 1 essentially predicts that incongruent determiners should cause an inhibition, thus slower responses compared to congruent determiners and also compared to a neutral baseline. Hypothesis 1 also predicts a facilitation of noun recognition caused by congruent determiners.

If hypotheses 2a and 2b were true, *congruent* determiner-noun combinations would be defined as the combination of a noun that has one or more possible underlying concept types with a determiner that matches the concept type with the highest ranking (=highest frequency of co-occurrence of determiner and noun). *Incongruent* determiners have different definitions depending on how many concept types are assumed to be underlying to a noun. If all four concept types are lexically stored for each noun, which would be hypothesis 2b (hypothesis 2a also allows for this possibility), an *incongruent* determiner would be defined as one that demands one of the noun's lower ranked concept types. Thus it might not help process the noun (i.e. it should cause slower responses than congruent determiners), however, in this case no inhibition would be expected as even the incongruent use of a noun would still trigger lexically stored conceptual information (which, in this case, would just have a lower ranking than the "top-CT").

If less than four concept types are lexically stored for each noun, which would be hypothesis 2a, an *incongruent determiner* has two possible definitions. It could be defined as in hypothesis 2b (i.e. as one of the underlying but lower ranked concept types), or as in hypothesis 1 (i.e. a determiner that demands one of the concept types that is not lexically stored for the respective noun). Presupposing a concept type shift for the latter definition, incongruent determiners might lead to an inhibition effect when compared to a baseline condition. However, this hypothesis does not necessarily need to entail the idea of concept type shifts. The first definition predicts no inhibitory effect. Table 2.1 summarizes the characteristics and predictions of all hypotheses.

<table>
<tr><th colspan="2">hypothesis</th><th>1</th><th>2a</th><th>2b</th><th>3</th></tr>
<tr><td colspan="2">lexical representation</td><td colspan="3">CT information lexically stored</td><td>no lexical specification</td></tr>
<tr><td colspan="2">representation</td><td>1 CT lexically stored</td><td>1 or more CTs lexically stored (1 up to 4)</td><td>4 CTs lexically stored</td><td>none</td></tr>
<tr><td rowspan="3">congruent determiners</td><td>definition</td><td>matches underlying CT</td><td colspan="2">highest co-occurrence frequency</td><td>none</td></tr>
<tr><td>expected RT compared to incongruent</td><td>faster</td><td colspan="2">faster than incongruent</td><td rowspan="2">no effect</td></tr>
<tr><td>expected RT compared to baseline</td><td>facilitation</td><td colspan="2">facilitation</td></tr>
<tr><td rowspan="3">incongruent determiners</td><td>definition</td><td>mismatches underlying CT, causes type shift</td><td>has lower co-occurrence frequency OR mismatches underlying CT, may cause type shift (if not lexically stored)</td><td>has lower co-occurrence frequency</td><td>none</td></tr>
<tr><td>expected RT compared to congruent</td><td>slower</td><td>slower</td><td>slower</td><td rowspan="2">no effect</td></tr>
<tr><td>expected RT compared to baseline</td><td>inhibition</td><td>possibly inhibition (only if CT is not lexically stored & type shifts are assumed)</td><td>no inhibition (equal to baseline)</td></tr>
</table>

Table 2.1: Summary of hypotheses, assumptions and predictions about the influence of conceptual information on word recognition

Presupposing that conceptual information is lexically specified in some way (hypotheses 1, 2a, and 2b), two further factors might influence the extent and the nature of a concept type congruence effect. One factor is the lexical stage at which conceptual type information is utilized during word recognition, thus the locus of the concept type congruence effect. If conceptual type information, which the context (in this case the preceding determiner) provides, in fact acts upon the process of lexical access or selection of nouns, we should observe a facilitating concept type congruence effect in word recognition tasks like lexical decision. If conceptual type information interacts at a later stage of word recognition, e.g. during post-lexical integration, built-up of a noun phrase or congruence checking mechanisms, then both, facilitation and/or inhibition, are possible outcomes (cf. section 1.2.1 for references concerning lexical/automated vs. post-lexical/controlled processing stages and the respective expected direction of context effects). In consequence, if the results show a concept type congruence effect and it is facilitating in nature, from lexical decision alone the locus cannot be pinned down. Therefore phoneme monitoring, a task that specifically taps in to the earlier stages of word recognition and has no post-lexical component, can be utilized to answer the question of the locus (cf. section 1.2.2 and 2.6.1).

The second factor is a possible interference with the above mentioned gender effect (cf. section 1.2). A lack of an inhibitory concept type incongruence effect might have two causes. On the one hand, it might simply just not be present (cf. hypothesis 2b or 3). On the other hand, it might interact with the facilitation caused by the inherent gender information that German determiners provide and which is present even in conceptually incongruent combinations (cf. Bölte and Connine, 2004, and section 1.2.1). A gender facilitation effect could interfere with a possible inhibition of conceptually incongruent determiners and in consequence might neutralize it. This aspect needs to be investigated in a separate step by using specific manipulations of grammatical gender (cf. experiment 4 in section 2.3.2 and experiments 5 and 6 in section 2.4).

In summary, the aforementioned hypotheses (including the assumptions of the CTD theory) predict that matching and mismatching combinations of CT and DT should differ with respect to reaction times in word recognition tasks – if conceptual type information is at all lexically stored. According to all hypotheses that assume some sort of lexical specification of conceptual information (hypotheses 1, 2a, and 2b), expected reaction time patterns for congruent and incongruent determiner-noun combinations are the following (for hypotheses 1 and 2a, listed inhibition effects are part of the prediction):

- faster reaction times for congruent determiner-noun combinations compared to incongruent
- facilitation for congruent determiner-noun combinations (compared to nouns used without any determiner)
- possibly also inhibition for incongruent determiner-noun combinations (compared to nouns used without any determiner)

In more detail regarding the referential properties this means:

- facilitation by indefinite determiner for non-unique nouns (and possibly also inhibition by indefinite determiner for unique nouns)
- facilitation by definite determiner for unique nouns (and possibly also inhibition by definite determiner for non-unique nouns)
- facilitation by possessive determiner for relational nouns (and possibly inhibition by possessive determiner for non-relational nouns)

And finally for the four concept types the expected patterns are

- facilitation by indefinite determiner for sortal nouns (and inhibition by definite and possessive determiner)
- facilitation by definite determiner for individual nouns (and inhibition by indefinite and possessive determiner)
- facilitation by indefinite and possessive determiner for relational nouns (and inhibition by definite determiner)
- facilitation by definite and possessive determiner for functional nouns (and inhibition by indefinite determiner)

Reversely the patterns of the results will give us evidence for the validity of the difference hypotheses. Furthermore, depending on the nature of the results, the experiments will provide evidence not only with respect to the CTD, but also for the cognitive status of conceptual type information and implicitly also for or against one or more of the various approaches to lexical access.

2.2 German Experiments I

The first two experiments reported in this section are a visual and an auditory version of a lexical decision experiment. Using German stimuli, the experiments were designed to explore whether conceptual type information influences written and spoken word recognition. The reasoning behind utilizing both modalities was to investigate if the predicted concept type congruence effect showed any modality specific differences.[11]

2.2.1 Experiment 1: German Visual Lexical Decision (Pilot)

A pilot experiment was designed with the aim to set a starting point for the investigation of the assumed concept type congruence effect. The experiment used a visual lexical decision paradigm with German noun phrases manipulating the combination of different determiner types with the four noun types, as assumed by the CTD.

2.2.1.1 Material and Methods

Participants

Experiment 1 tested 96 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (61 women, 35 men; mean age *M* = 25.83 years, *SD* = 6.62). They were paid a small fee for their participation.

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[11] A side note for the impatient reader: a compact overview of the results of these two experiments will be given in section 2.5, along with the results of experiments 3-6.

Materials

The experiment utilized a set of 80 German nouns, 20 of which had been selected from each of the four concept types (see table 2.2 below for examples, and appendix I. for a full list of the stimuli used). The concept type classification, which to establish was the first step in the selection process, is not a trivial one and required several phases until 20 “good” candidates per concept type could be selected. Furthermore, the selection of nouns had to meet three criteria of “simplicity”: no composites or other morphologically complex nouns nor polysemous nouns could be chosen, in order to ensure smooth lexical decision processes.

The initial selection of nouns was based on a corpus-linguistic analysis of German nouns according to their occurrences in certain contextual profiles. A corpus analysis was thought to provide a weighting of concept type specific contextual profiles for German nouns in the corpus, and by sorting according to the most frequent profile the nouns’ concept type should be easily extractable. As a desired result a good set of 20 nouns per concept type, thus 80 nouns in total should be selectable from the list of all nouns from the text corpus. For this purpose a German text corpus database was used, that consists of 30 million sentences from newspaper articles, and is part of the *Leipzig Corpus Collection*[12]. From this German text corpus all nouns with more than 500 occurrences in the corpus were extracted and their grammatical co-occurrences were listed[13], i.e. for example the noun *Sekunde* (*second*) occurring with definite, indefinite or demonstrative determination, with adjectives, numerals or quantifiers, in various possessive constructions, etc.

The resulting co-occurrence data were further automatically evaluated and grouped together according to criteria from the CTD (cf. Löbner, 2011). Occurrences as singular or plural form with indefinite determiner,

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[12] www.wortschatz.uni-leipzig.de

[13] The corpus extraction was conducted by Dr. Katina Bontcheva from Project INF *Service Project for Information Infrastructure* within the Collaborative Research Center 991 @Heinrich-Heine-University Düsseldorf (http://www.sfb991.uni-duesseldorf.de/en)

quantifiers, and demonstratives with or without adjectives and without any possessive construction (e.g. *eine Blume (a flower)*, *viele Hunde (lots of dogs)*) were considered [–U, –R]. Occurrence as singular with definite article (without adjective, numeral nor other complements or possessive constructions: e.g. *der Mond* (*the moon*)) was evaluated as [+U, –R]. Occurrences in singular form in either a left possessive construction (with a possessive pronoun: e.g. *sein Freund*) or with a definite determiner combined with a right possessive construction (genitive or preposition *von*: e.g. der *Freund von Anna* (*the friend of Anna*); *der Freund des Mannes* (*the man's friend*)) were evaluated as [+U, +R]. Occurrences as singular or plural forms in a combination of indefinite or demonstrative determination, quantifiers with right possessive constructions (e.g. *ein/dieser Bruder von Anna* (*a/this brother of Anna*)) were evaluated as [–U, +R]. The result was a list of German nouns with columns containing percentage numbers for their occurrence as [–U, –R] (sortal), [+U,–R] (individual), [–U, +R] (relational), and [+U, +R] (functional), respectively. As mentioned above, the initial idea was to simply sort the nouns by the four columns and thus receive the corpus' "best" sortal, individual, relational and functional nouns. However, in practice, this approach did not work quite as well.

The number of nouns with a proportion of more than 50% [–U, –R] uses was relatively high (about 380 nouns), thus finding sortal nouns based on the corpus analysis seemed easy at first glance. The number of nouns with a proportion of more than 50% [+U, –R] uses, thus individual nouns according to the corpus, was good enough (about 140 nouns). However, the nouns in both groups contained a fairly high proportion of composites (e.g. *Bundesland* (*German federal state*)) for individual (approximately 20%) as well as sortal (approximately 6%) nouns, and a good few abbreviations among the individual nouns (approximately 8%; e.g. *NATO*), and also some errors, i.e. words that were classified as nouns, but were not (complete) German nouns (e.g. *Asie*) – which probably were misanalysed due to parsing errors. These cases were eliminated and reduced the number of available nouns for these two concept types.

For [–U, +R] (relational) and [+U, +R] (functional) nouns, however, even the corpus analysis was complicated. To find any nouns at all, that fulfilled the criteria for [+U, +R] and even more so for [–U, +R], the threshold of 500+ occurrences in the corpus for the nouns had to be lowered to 10+ occurrences. This resulted in about 280 nouns that had more than 50% [+U, +R] uses, thus functional nouns, and only about 60 nouns with more than 50% [–U, +R] uses, thus relational nouns. Again, the lists contained relatively high proportions of composites (approximately 35% for functional nouns and 45% for relational nouns) and a few erroneous items, which were eliminated and reduced the number potential stimuli substantially. To add up to the nouns, the threshold of "more than 50% [+U, +R] or [–U, +R] uses" was modified. Due to this procedure, about 270 functional and about 70 relational nouns were included to the lists of potential candidates for the experiment. These nouns had between 30-50% [+U, +R] and [–U, +R] uses (only nouns with at least 50 occurrences in the corpus were included). From these added nouns again composites and erroneous items were removed.

The lists were scanned carefully by hand and for each noun the concept type was added based on my semantic evaluation that was grounded on the CTD. In this process, further nouns were excluded: in addition to composites, the corpus data contained a large number of deverbal nouns or nouns that were otherwise morphologically very complex like *Anhäufung*[14] (*accumulation*), which due to their morphological complexity did not meet the above mentioned "simplicity" criteria for experimental stimuli. The remaining list of nouns contained less than 20 nouns per concept type, that occurred in the specific context (e.g. [+U, +R] for functional) in more than 50%. Especially for relational nouns, thus nouns with a majority of [–U, +R] occurrences, the list was too short and, solely based on the corpus analysis, there were not enough nouns from which good candi-

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[14] This noun probably comes from the noun *Haufen* (*pile*/ *heap*), which was derived to a prefixed verb *an-häufen* and was then derived to a noun by means of a nominal suffix *An-häuf-ung*

dates could be chosen. Even with a lowering of the co-occurrence threshold to 30% the list was not sufficient.

As a retrieval of good candidates for each concept type could not be based on the corpus data and the result of the corpus data contradicted our semantic concept types evaluation, we asked a group of CTD-experts to annotate the nouns, that were extracted from the corpus data (minus excluded composites, morphologically complex nouns, etc., but regardless of their contextual profile that had been extracted from the corpus data, see above). Thus, in order to increase the number of possible candidates for each concept type, the nouns were discussed and evaluated among three annotators, Sebastian Löbner, Christian Horn, and Nicolas Kimm[15] (the latter two also conducted a corpus-based statistical investigation on the four concept types and their contextual profiles, cf. Horn & Kimm, 2014).. They semantically determined the concept types, by applying criteria like

- number of referents
- necessity of context for interpretation and identification of referent
- number of arguments
- inherent relationship to other entities

The criteria were a preliminary version of the annotation guidelines later published by Horn (2012; also cf. the short version in chapter 2.4 of this dissertation). Only if a noun was evaluated as being of a certain concept type by all three experts, it was taken into account. From the remaining list of nouns 20 nouns per concept type were selected including the matching process: the four concept types were matched with respect to lexical frequency in CELEX database (Baayen, Piepenbrock, and Gulikers, 1995), number of letters and phonemes, as well as number of syllables.

To balance the number of correct 'word' and 'pseudoword' lexical decision responses, the stimulus lists contained 80 additional pseudowords. These were non-existing words, created from the selected 80 word stimuli,

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[15] Project C02 *Conceptual shifts: Statistical Evidence* within the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en)

in order to assure that the number of syllables, phonemes and letters remained about the same. The pseudowords were created by hand. Starting from the 80 real word stimuli, two or more letters/phonemes were changed to form nonsense words following the phonotactic rules of German. Furthermore, 10 nouns (no specific selection criteria) and 10 pseudo nouns (created like mentioned above) were added as warm-up trials.

The following determiners were chosen to represent the three determination types (cf. Section 1.1 and Löbner 2011): the indefinite article *ein(e)* for indefinite determination, the definite article *der/die/das* for definite determination and the 3rd person possessive pronoun *sein(e)* for possessive determination. For the baseline/control condition, the "no" determiner cases, the string *xxxx* was used to fill in for the determiners preceding the nouns. Table 2.2 follows the concept type classification by Löbner (2011, cf. table 1.1, in chapter 1) and shows examples of the concept type and determiner type combinations that were used in this lexical decision experiment. Congruent combinations are marked by "✓", whereas incongruent combinations are marked by "↱".

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**non-relational [–R]**	**SORTAL** ***Apfel / apple*** ✓ein Apfel/ an apple ↱der Apfel/the apple ↱sein Apfel/his apple xxxx Apfel/xxxx apple	**INDIVIUDAL** ***Papst/ pope*** ↱ein Papst/a pope ✓der Papst/ the pope ↱sein Papst/ his pope xxxx Papst/ xxxx pope
Relationality	**Inherently relational [+R]**	**RELATIONAL** ***Arm/ arm*** ✓ein Arm/ an arm ↱der Arm/ the arm ✓sein Arm/ his arm xxxx Arm/ xxxx arm	**FUNCTIONAL** **Mutter/mother** ↱eine Mutter/ a mother ✓die Mutter/ the mother ✓seine Mutter/ his mother xxxx Mutter/xxxx mother

Table 2.2: Example stimuli from experiment 1: congruent and incongruent combinations of nouns of the four concept types with the four determination types

The combination of four concept types and four determiner types result in a total of 16 experimental conditions. Determiner (or the neutral filler *xxxx*) and noun (or pseudoword) stimuli were combined as follows: Four basic lists of determiner-noun pairs were created in which each noun occurred only once per list, i.e. with only one of the four determiner types (indefinite, definite, possessive or neutral). For example, *ein Apfel* was presented in list 1, *der Apfel* in list 2, *sein Apfel* in list 3, and *xxxx Apfel* in list 4. The four determiner types were counterbalanced across lists, concept types and all nouns. In summary, each noun (or pseudoword) was combined with each determiner type across all four lists, but was presented in only one variant per participant.

The lists were pseudo-randomized so that no more than three 'word' or 'pseudoword' answers followed each other. It was also ensured that no more than three trials using the same concept type or determiner type followed each other. In total four randomized versions of each list were created. The experimental trials were preceded by 20 warm-up trials. These consisted of 10 words and 10 pseudowords that were combined with one of the four determiner types. These practice trials were randomized by hand to ensure the same conditions as the randomization of the experimental trials. The same set of warm-up trials preceded each list.

Procedure and Apparatus

The experiment was run using Presentation®[16] software on a PC (OS Microsoft Windows XP Professional). The stimuli were selected and combined for each trial by the Presentation® software[17] according to the selected list and were presented sequentially on a cathode ray monitor (centered; off-white font on dark-grey background to reduce eyestrain; refresh rate of 60 Hz). Each trial consisted of three parts: a fixation cross

[16] www.neurobs.com/

[17] Special thanks to Frauke Hellwig from Project A04 within the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en) for teaching, mentoring, and assistance with Presentation® scripts.

indicating the beginning of a trial, a visual determiner stimulus and a visual noun stimulus (word or pseudoword). The fixation cross and the determiner stimulus were presented with a duration of 500 ms. The noun stimulus was presented until the participants performed a button press or until a time-out of 3000 ms was reached. The three parts of a trial were separated by a 400 ms pause (blank screen). 1000 ms after button press (or after noun time-out) the following trial began.

Participants were seated in a sound attenuated booth where they faced the computer monitor. They participated in the experiment one at a time. Written instructions were used to instruct participants to perform a lexical decision ("word or non-word?") on the nouns as quickly and as accurately as possible by pressing assigned buttons on a response pad:

Aufgabe – Wort oder Kunstwort?

Auf dem Bildschirm erscheint immer zuerst ein Kreuzchen, das Dir anzeigt, wo du hinschauen sollst. Anschließend werden je zwei Wörter nach einander eingeblendet. Bei dem ersten handelt es sich entweder um einen der Artikel „ein(e), der, die, das oder sein(e)" oder „xxxx“. Das zweite Wort ist jeweils ein Nomen.
Deine Aufgabe ist es nun, zu entscheiden, ob es sich bei dem jeweils zweiten Wort, also dem Nomen, um ein echtes deutsches Wort handelt oder ob es ein so genanntes Kunstwort ist, also ein erfundenes Wort. Wenn es sich Deiner Meinung nach um ein echtes Wort handelt, drücke bitte die GELBE Taste (rechts). Bei einem Kunstwort drücke bitte die BLAUE Taste (links). In den folgenden Beispielen sind b) und c) echte Wörter des Deutschen, während a) und d) jeweils Kunstwörter sind.

Beispiele:

a) der	*Wulter*	*Kunstwort*	*BLAUE Taste*
b) xxxx	*Auto*	*Wort*	*GELBE Taste*
c) eine	*Maus*	*Wort*	*GELBE Taste*
d) sein	*Krenel*	*Kunstwort*	*BLAUE Taste*

Sobald du eine der Tasten gedrückt hast, wird das nächste Wort-Paar präsentiert. Falls du keine Taste drückst oder zu langsam bist, wird das nächste Wort-Paar präsentiert. Versuche Deine Entscheidung so schnell wie möglich, aber dennoch auch so richtig wie möglich, zu treffen. Du erhältst zuerst einige Übungswörter. An-

schließend gibt es eine kurze Pause, in der Du eventuelle Fragen loswerden kannst, bevor es dann richtig losgeht. [18]

Participants were given the opportunity to ask questions before and after the practice trials. The response pad was connected to Presentation®[19] in order to record the reaction times from noun onset up to participants' button press. The assignment of the left and right button to word or pseudo word answers was counterbalanced.

2.2.1.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (reaction times longer than 3000 ms) were excluded from all analyses (overall error and time-out rate: 1.82%). A subject and item analysis of errors was conducted in order to test, whether any participants or items showed an undue number of errors. The item analysis showed 44.79% false responses or time outs for the item *Uroma* (*great grandmother*), thus it was excluded from all analyses. It appears to have been misread as a pseudoword – probably due to (morpho)phonological missegmentation ("U-roma" instead of "Ur-oma"). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 1.18% of all correct answers (excluding *Uroma*)).

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[18] English translation: *Task – Word or pseudoword? A small cross will appear on the computer screen, which indicates, where you should focus. Subsequently, two words will appear sequentially. The first one will be either one of the articles "a", "the", or "his" or "xxxx". The following word will be a noun. Your task is to decide if the second word, the noun, is a real German word or if it is a made-up word. If you think it is a real word, please press the yellow (right) button. If you think it is a made-up word, please press the blue (left) button. In the following examples b) and c) are real words of German, whereas a) and d) are made-up words. [Examples] As soon as you press one of the buttons, the next word-pair will be presented. In case you do not press any button or if your reaction is too slow, the next word-pair will be presented. Try to make your decisions as quickly but also as accurately as possible. In the beginning you will receive a few practice trials after which you will have a short break to ask any questions before the main experiment begins.*

[19] www.neurobs.com

Concept Type and Determiner Type

Looking at the mean reaction times of the experimental data, combinations of determiner type and concept type in figure 2.1 suggested that most of the expected patterns (mentioned in chapter 1, section 1.2) can be found in the results, but, additionally, a few unexpected patterns arose.

For sortal nouns, the expected pattern was facilitation by combination with the indefinite article (and possible inhibition by definite and possessive determination). Figure 2.1 shows faster lexical decision times for sortal nouns (figure 2.1, yellow line) combined with all determiners compared to the no-determiner condition. Unexpectedly, the strongest facilitation – if one can say this considering that the differences between indefinite, definite and possessive determiner type are very subtle – was caused by combining sortal nouns with the incongruent possessive pronoun *sein/e* (*his*), while indefinite (=congruent) and definite determination does not influence sortal nouns differentially.

For individual nouns, the expected pattern is facilitation by combination with the definite article (and possible inhibition by combination with incongruent, thus indefinite and possessive determination). The facilitation pattern is reflected in the data: as in the case of sortal nouns, all determiners speed up IC lexical decision times compared to the cases, where no determiner (but the filler stimulus *xxxx*) was used (figure 2.1, green line). However, the strongest facilitation was caused by the congruent combination of individual nouns with the definite article.

For relational nouns, the expected pattern is facilitation by combination with indefinite and possessive determination (and possible inhibition by combination with definite determination). The facilitation pattern is reflected in the data, as well. For relational nouns, figure 2.1 shows facilitation by both congruent determination types, thus indefinite and possessive determination (red line), while latencies for the combination with the incongruent definite article are equal to the no-determiner condition.

For functional nouns, the expected pattern is facilitation by definite and possessive determination (and possible inhibition by combination with indefinite determination). Again, the data show facilitation by all determiners compared to the no-determiner condition, but, as expected, the biggest facilitation was caused by the congruent possessive determiner. The second congruent determination type for functional nouns, the definite article, however, had a smaller facilitating effect than the incongruent indefinite article, which is surprising, because the inverse pattern is expected. Additionally, there is a visible difference if we only examine the different concept types, without considering the determiner type variable. The concept types clearly differ with respect to lexical decision times. Relational nouns seem to be the slowest, followed by individual nouns, whereas functional nouns seem to be the fastest noun type, closely followed by sortal nouns.

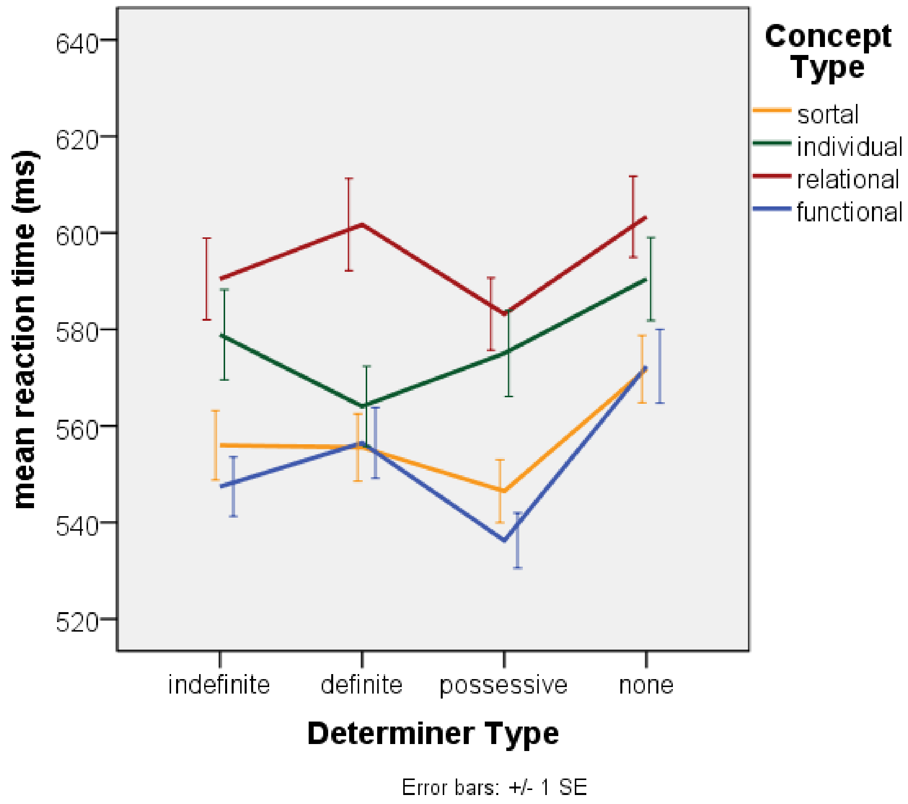

Figure 2.1: Lexical decision latencies for nouns of different concept types in combination with different determiner types in German visual LDT

In order to test, whether the described facilitation effects can be supported by statistical analyses, mean reaction times were submitted to *IBM SPSS Statistics*[20] in order to conduct a repeated measures analysis of variance (ANOVA). The four by four repeated measures ANOVA was conducted on subject means[21] with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Concept Type, $\chi^2(5) = 26.90$, $p = .000$, as well as for the interaction of Determiner Type and Concept Type, $\chi^2(44) = 101.41$, $p = .000$. For this reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .84$ for the main effect of Concept Type, and $\varepsilon = .82$ for the interaction). The results of the repeated measures ANOVA showed that both main effects were significant at $p < .001$ (see below), the interaction, however, was not significant, $F(7.34, 696.93) = 1.67$, $p = .109$.

There was a significant main effect of Determiner Type, $F(3, 285) = 13.81$, $p = .000$, $r = .36$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed a facilitation effect of any determiner compared to none: indefinite faster than none, $F(1, 95) = 16.45$, $p = .000$, $r = .39$, definite faster than none, $F(1, 95) = 10.21$, $p = .002$, $r = .31$; possessive faster than none, $F(1, 95) = 37.96$, $p = .000$, $r = .54$. Additionally, post hoc pairwise comparisons (with Bonferroni's α-correction) showed faster responses for the possessive determiner compared to any other DT (for all contrasts $p < .05$).

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[20] www.ibm.com/software/analytics/spss

[21] In addition to any ANOVA on subject means, an ANOVA on item means was conducted for every analysis of every experiment. In this chapter only subject means are reported. However, in Appendix V all item results are presented.

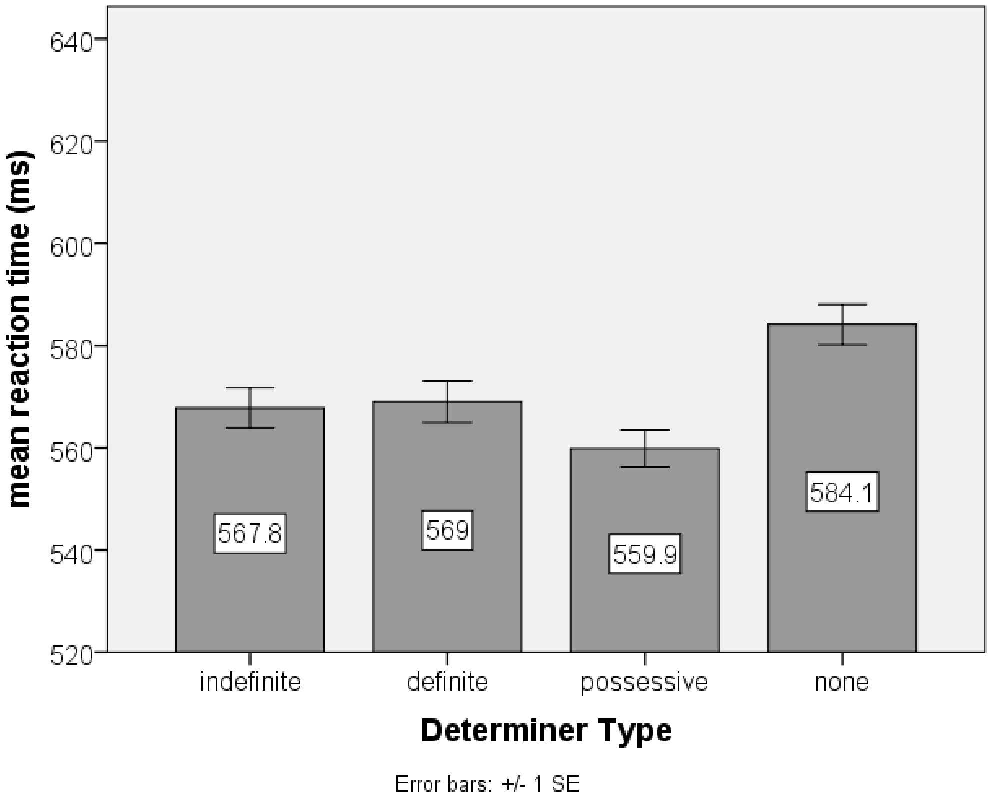

Figure 2.2: Lexical decision latencies for different determiner types in German visual LDT

There was also a significant strong main effect of Concept Type, $F(2.52, 239.62) = 32.82$, $p = .000$, $r = .51$. Planned contrasts (simple (first)) compared each concept type to sortal concepts, and revealed significantly faster responses for sortal nouns compared to individual nouns, $F(1, 95) = 20.32$, $p = .000$, $r = .42$, and relational nouns, $F(1, 95) = 58.64$, $p = .000$, $r = .62$. There was no significant difference contrasting functional and sortal nouns, $F(1, 95) = .69$, $p = .410$. Post hoc pairwise comparisons (with Bonferroni's α-correction) confirmed that sortal and functional nouns were processed faster than individual and relational nouns (for all comparisons $p < .001$), and responses for individual nouns are again faster than for relational nouns ($p = .043$).

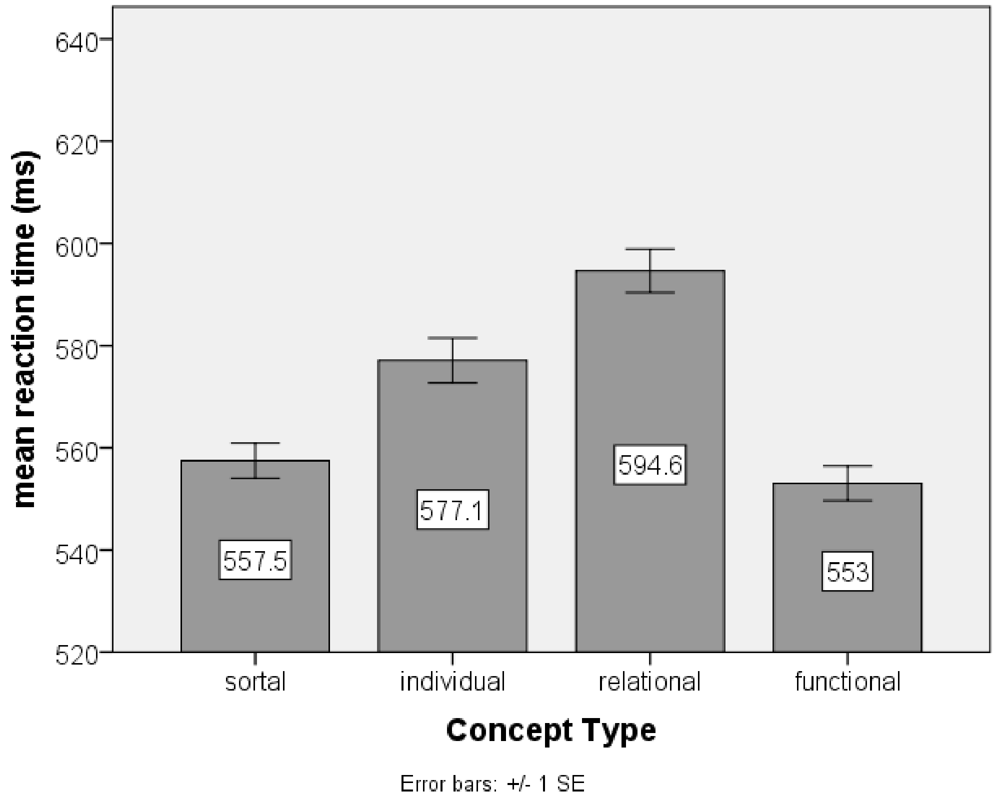

Figure 2.3: Lexical decision latencies for different concept types in German visual LDT

These results indicate that any determiner serves as a cue during noun processing, if only due to the gender information, that is provided alongside the feature requirements.

Looking at the data for the concept type and determiner type combinations we receive a detailed but implicit view of the influence of congruent vs. in congruent determination on German noun recognition. However, a clearer view on a possible congruence effect can be achieved by looking at congruent vs. incongruent cases overall. Therefore a second step of analysis was conducted, where the conditions were grouped together according to overall congruence.

Overall Congruence

This separate overall congruence analysis takes one step back and looks at congruence from a more general perspective. The combinations of concept type and determiner type are grouped together according to congruent vs.

incongruent (and no) determiner-noun combinations. For this analysis *congruent determination* was defined based on the CTD-Table (Löbner 2011: 307; cf. table 1.1), in which congruent ("✓") vs. incongruent ("↱") determination is marked for each concept type.

Table 2.3 below is a modified version of the CTD-table and gives a brief overview for example stimuli used in experiment 1. Congruent combinations (green) are indefinite determiner and sortal/relational concepts, definite determiner and individual/functional concepts, and possessive determiner and relational/functional concepts. All other combinations were analyzed as incongruent (red). At this point it should, however, be noted that the definition of congruence is worthy of discussion and will be examined more closely in chapter 3.1. The expected pattern for this analysis (following the definition of congruence shown in table 2.3, derived from table 1.1) is facilitation for congruent combinations and a possible inhibition for incongruent combinations, or at least an equal mean lexical decision time as for the no-determiner condition.

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**non-relational [–R]**	**SORTAL** ***Apfel / apple*** ✓ein Apfel/ an apple ↱der Apfel/the apple ↱sein Apfel/his apple xxxx Apfel/xxxx apple	**INDIVIUDAL** ***Papst/ pope*** ↱ein Papst/a pope ✓der Papst/ the pope ↱sein Papst/ his pope xxxx Papst/ xxxx pope
	inherently relational [+R]	**RELATIONAL** ***Arm/ arm*** ✓ein Arm/ an arm ↱der Arm/ the arm ✓sein Arm/ his arm xxxx Arm/ xxxx arm	**FUNCTIONAL** **Mutter/mother** ↱eine Mutter/ a mother ✓die Mutter/ the mother ✓seine Mutter/ his mother xxxx Mutter/xxxx mother

Table 2.3: Example stimuli from experiment 1: overall congruent (green) and incongruent (red) DT-CT combinations

The first step of the analysis, the Concept Type × Determiner Type analysis, showed a strong main effect of Concept Type, i.e. significantly different reaction times for the four concept types – albeit the stimuli were matched for length and occurrence frequency. This bears important consequences for this analysis step: As for the overall congruence analysis the nouns of the four concept types (or rather the experimental conditions, that the nouns appeared in) are grouped together according to congruent vs. incongruent determiner-noun combinations and, more importantly, the concept types are not equally distributed over congruence groupings (cf. table 2.2), a linear normalization was applied to the reaction times. This procedure aimed to minimize mean reaction time differences that were merely caused by the concept types themselves. The linear normalization multiplied the reaction time values with a factor of the reaction time for the overall no-determiner condition(s) (as these cases were not influenced by any preceding determiner) divided by the mean reaction time of the no-determiner condition(s) for each concept type (in a more technical but simpler formula: $RT_{norm} = RT * RT_{none}\ mean\ /\ RT_{none}\ mean\ per\ concept\ type$).

The expected pattern for this overall congruence analysis is faster lexical decision times for congruent cases compared to incongruent cases. Concurrently, a facilitation for congruent cases compared to no-determiner cases should be visible, and possibly an inhibition in the case of the incongruent category compared to no-determiner cases. Looking at the data in this overall manner, figure 2.4 suggests the expected pattern of facilitation for congruent cases (in comparison to no-determiner cases) and an advantage for nouns presented with congruent in comparison to incongruent determiners. However, there was no inhibitory effect visible for incongruent cases.

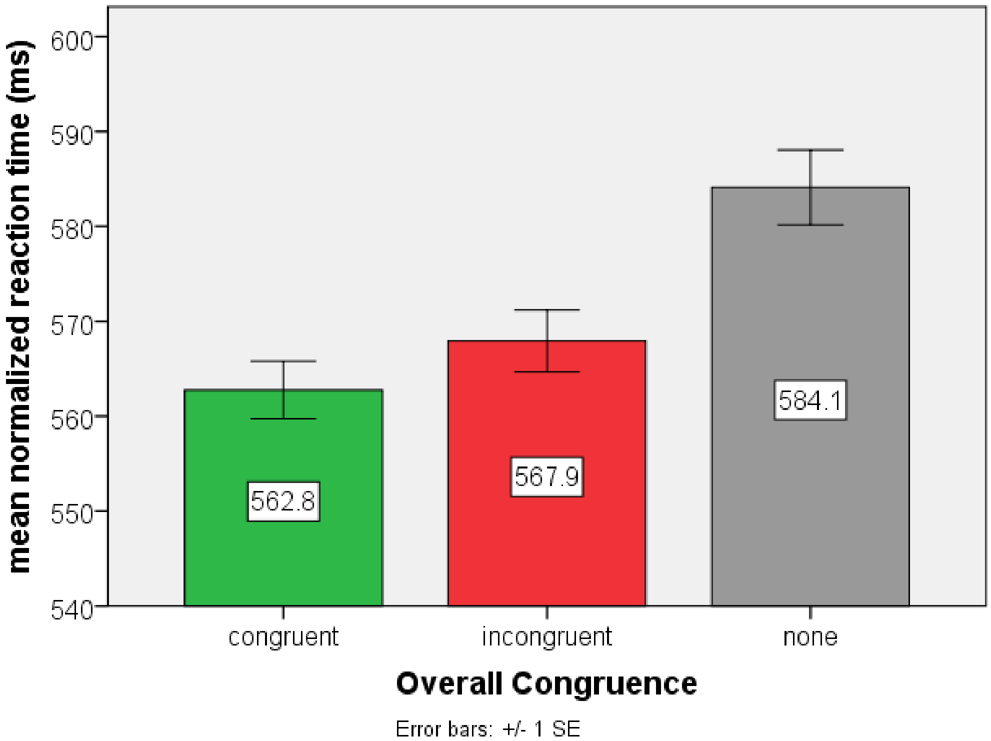

Figure 2.4: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT

In order to test, whether the described facilitation effects can be supported by statistical analyses, mean reaction times were submitted to *IBM SPSS Statistics*[22] in order to conduct a repeated measures analysis of variance (ANOVA). The one-way repeated measures ANOVA was conducted with the factor Overall Congruence {incongruent, congruent, none}. The results of the ANOVA showed a significant effect of Congruence, $F(2, 190) = 16.46$, $p = .000$ $r = .39$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases but no influence or inhibition by incongruent cases (vs. none), and revealed significantly faster responses only for incongruent determiner-noun combinations compared to the no-determiner cases, $F(1, 95) = 15.97$, $p = .000$, $r = .38$. However, there was no significant difference between congruent and incongruent cases $F(1, 95) = 2.63$, $p = .108$. Additionally, a

[22] www.ibm.com/software/analytics/spss

selective post hoc comparison of congruent vs. no determiner showed significantly faster responses for congruent determiner-noun combinations (p = .000).

Referential Properties and Determiner Types

A further possible approach to analyze the experimental data is grouping the experimental conditions according to the referential properties that define the four concept types, uniqueness and relationality. In this structure, we receive separate analyses for uniqueness as well as for relationality with the respective relevant determiner types (see table 2.4 below). On the one hand, unique and non-unique nouns in combination with definite and indefinite determination were compared. On the other hand relational and non-relational nouns in combination with possessive determination were compared. The no-determiner cases were added to both feature analyses as a control.

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**non-relational [–R]**	**SORTAL** ***Apfel / apple*** ✓ein Apfel/ an apple ↱der Apfel/the apple ↱sein Apfel/his apple xxxx Apfel/xxxx apple	**INDIVIUDAL** ***Papst/ pope*** ↱ein Papst/a pope ✓der Papst/ the pope ↱sein Papst/ his pope xxxx Papst/ xxxx pope
	inherently relational [+R]	**RELATIONAL** ***Arm/ arm*** ✓ein Arm/ an arm ↱der Arm/ the arm ✓sein Arm/ his arm xxxx Arm/ xxxx arm	**FUNCTIONAL** **Mutter/mother** ↱eine Mutter/ a mother ✓die Mutter/ the mother ✓seine Mutter/ his mother xxxx Mutter/xxxx mother

Table 2.4: Example stimuli from experiment 1: congruent and incongruent combinations with respect to the referential properties and the four determination types

For the same reasons mentioned in the results section *Overall Congruence* (see above) the same linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none}\_mean / RT_{none}\_mean\_by\_concept\_type$).

Uniqueness and Determiner Type

Figure 2.5 shows the results of experiment 1 for unique and non-unique nouns in combination with the indefinite and definite article, and the no-determiner conditions. The expected effects are

- facilitation for unique nouns used with definite determination (and possible inhibition by indefinite determination)
- facilitation for non-unique nouns used with indefinite determination (and possible inhibition by definite determination)

The bar chart in figure 2.5 shows a general facilitation by any determiner compared to the no-determiner conditions. Furthermore, it suggests a difference in latencies for nouns used with the definite determiner: the definite determiner seems to facilitate the processing of unique nouns (congruent) in comparison to non-unique nouns (incongruent) and uses without any determiner.

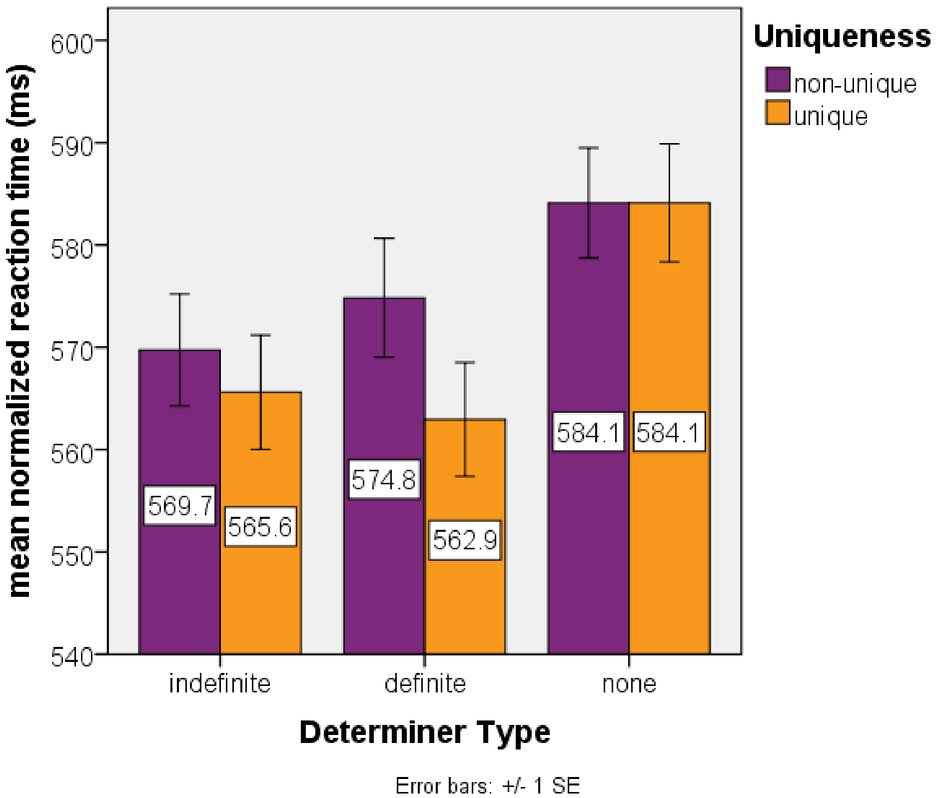

Figure 2.5: Lexical decision latencies for unique and non-unique nouns used with indefinite, definite and no determiner in German visual LDT

The difference between unique and non-unique nouns used with the indefinite article is minimal. Only the use of definite determination seems to show the expected pattern. Unique nouns in combination with the congruent, definite article show faster reaction times than non-unique nouns (incongruent).

In order to test, whether the described facilitation effects can be supported by statistical analyses, a repeated measures ANOVA was conducted with the factors Determiner Type {indefinite, definite, none} × Uniqueness {non-unique, unique}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(2) = 7.16$, $p = .028$, as well as for the interaction of Determiner Type and Uniqueness, $\chi^2(2) = 6.78$, $p = .034$. For this reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .93$ for the main effect of Determiner Type, and $\varepsilon = .94$ for the interaction).

The results of the repeated measures ANOVA showed that there was no significant main effect of Uniqueness, $F(1, 95) = 1.75$, $p = .190$, neither was the interaction of Determiner Type and Uniqueness significant, $F(1.87, 177.63) = .87$, $p = .414$. However, there was a significant main effect of Determiner Type, $F(1.86, 177.02) = 9.40$, $p = .000$, $r = .30$. Planned contrasts (simple (last)) compared the indefinite and definite article to the no-determiner condition as a baseline and revealed a facilitation effect of any determiner compared to none: indefinite faster than none, $F(1, 95) = 17.02$, $p = .000$, $r = .39$, definite faster than none, $F(1, 95) = 10.65$, $p = .002$, $r = .32$.

Relationality and Determiner Type

Figure 2.6 shows the results of experiment 1 for relational and non-relational nouns in combination with the possessive determiner and the no-determiner condition. The expected effect is facilitation for relational nouns used with the possessive determiner. The bar chart suggests a general facilitation by the possessive determiner compared to the no-determiner condition. The expected difference between relational vs. non-relational nouns used with possessive determination is visible, however, the possessive determiner caused only slightly faster reaction times for relational nouns (congruent) compared to non-relational nouns (incongruent).

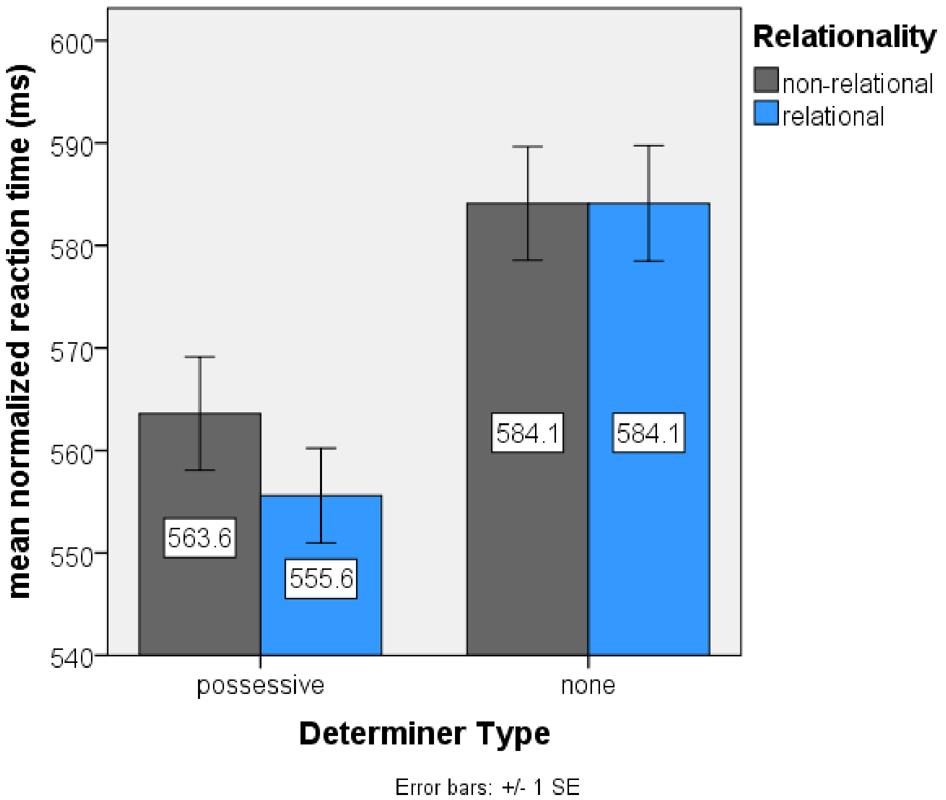

Figure 2.6: Lexical decision latencies for relational and non-relational nouns used with possessive and no determiner in German visual LDT

In order to test if the described facilitation effects can be supported by statistical analyses, a repeated measures ANOVA was conducted with the factors Determiner Type {possessive, none} × Relationality {non-relational, relational}. The results of the repeated measures ANOVA showed that there was no significant main effect of Relationality, $F(1, 95) = .63$, $p = .429$, neither was the interaction of Determiner Type and Relationality significant, $F(1, 95) = 2.03$, $p = .158$. However, there was a significant large main effect of Determiner Type, $F(1, 95) = 38.31$, $p = .000$, $r = .54$, in that the possessive determiner compared to the no-determiner condition facilitated the processing of nouns, $F(1, 95) = 38.31$, $p = .000$, $r = .54$.

2.2.1.3 Summary and Intermediate Discussion

This pilot experiment used the visual lexical decision paradigm in order to investigate whether conceptual type information influences noun recognition in German. Determiner-noun combinations were used and compared, which were congruent or incongruent with respect to conceptual type information or a combination of nouns with the neutral determiner stimulus *xxxx* as a baseline.

The results showed a determiner type effect, i.e. indicating that, compared to the neutral baseline, any determiner serves as a facilitating contextual cue during noun processing. This effect implicitly replicates the findings of aforementioned studies (cf. section 1.2.1) that found a facilitating effect of context information, especially determiners, in the visual modality. This effect might especially be attributed to the inflectionally marked gender information that the used determiners carry alongside the conceptual feature requirements, and thus support the facilitating nature of congruent gender information compared to the neutral baseline (cf. for example Grosjean et al., 1994, Dahan et al., 2000, and Bölte and Connine, 2004).

The results also showed a significant concept type effect: sortal and functional nouns elicited significantly shorter latencies than individual and relational nouns. One could infer that sortal and functional as well as individual and relational nouns form two noun classes. This is a questionable distinction as the members of both classes inherently differ with respect to relationality and uniqueness, even if we do not argue from a CTD point of view, relational and individual nouns especially are not one of a kind – or *class*, that is. There is no theoretical assumption that supports this classification. Thus the results could be interpreted by means of the assumption of four concept types, of which SCs and FCs as well as ICs and RCs happen to be distributed in the same lexical decision time range.

From an empirical point of view, the data suggest that individual and relational concepts seem to be more costly to process and to interpret than sortal and functional concepts. In general, relational concepts seem to be the most difficult of the CTs to process. As frequency was counterbalanced between concept types, a frequency based advantage for sortal and functional nouns can be ruled out. A speculative but possible issue is a difference in lexical complexity of the concept types, an issue that will be resumed in the discussion of the English lexical decision data. Only if the concept types are distributed in the same order across reaction time values, can further hypotheses like lexical complexity, which shall then be explained in more detail, be argued for.

The processing of the different concept types was not (or at least not significantly) influenced by the preceding determiner type. Yet, although there was no statistically significant interaction between determiner type and concept type, a visual inspection of the data (cf. figure 2.1) yielded some of the expected (congruent) patterns for the different determiner-noun combinations. There was a non-significant but measurable facilitation for relational nouns caused by indefinite and possessive determination, facilitation for individual nouns preceded by the definite determiner, and facilitation for functional nouns caused by the possessive determiner. Rather unexpected was that the incongruent indefinite determiner seemed to have a more facilitating effect on functional nouns than the congruent definite determiner. Furthermore, the lack of facilitation of sortal nouns caused by the congruent indefinite determiner (as compared to the other determiners) is not in line with the expected facilitating effect of definite determination. Even more surprisingly, the strongest facilitating effect on sortal nouns was caused by the incongruent possessive determiner.

Concerning the overall congruence analysis, there was a statistically significant overall congruence effect. However, the comparisons only revealed a significant facilitation of nouns used with any “real” determiner compared to the neutral baseline, but no significant difference between congruent vs. incongruent combinations, yet, a visual examination of the data showed a slight advantage for congruent cases.

A similar picture is visible for the analysis of the experimental data according to the referential features uniqueness and relationality. Statistically there was neither a significant uniqueness nor a relationality effect, and both features were not significantly influenced by determiner type, but again the data show a measurable difference for unique vs. non-unique nouns presented with definite determiner. The definite article caused a faster recognition of unique nouns compared to non-unique nouns.

Although the ANOVAs were not significant for the relevant interactions and thus did not statistically validate the expected patterns, most of the expected patterns are measurable and visible in the data. Additionally the lexical decision task seems to be sensitive for conceptual type information as there is a clear effect of concept type. This fact motivated the further pursuit of investigating the concept type congruence effect. An additional impulse to continue this line of research in the auditory domain comes from Goldinger (1996), who noted that visual and auditory lexical decision data might yield different results, as for example the neighborhood effect is reported to show contradictory results in visual and auditory lexical decision experiments. Therefore it is an important step to examine the results of the auditory version of this experiment, reported in the following section.

2.2.2 Experiment 2: German Auditory Lexical Decision[23]

The aim of experiment 2 was to examine if the measurable (although not significant) concept type facilitation by congruent determiners, which the results of experiment 1 suggested, can also be found in spoken word recognition. Therefore experiment 2 used an auditory lexical decision paradigm with the same determiner-noun combinations as in experiment 1.

[23] Parts of this experiment have been previously reported in Brenner et al. (2014).

2.2.2.1 Material and Methods

Participants

Experiment 2 tested 96 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (54 women, 42 men; mean age *M* = 24.01 years, *SD* = 6.78). They were paid a small fee for their participation.

Materials

For experiment 2 the same set of materials (nouns, determiners and lists) was used as in experiment 1. But as experiment 2 was designed as an auditory lexical decision experiment the stimuli were spoken, recorded and processed as sound files which were then presented via headphones.

All experimental items (word and pseudoword stimuli, determiners and warm-up stimuli) were spoken by a male German native speaker[24] and were recorded in a sound attenuated booth. For recording the stimuli, a microphone head was used, which was linked to a powering module, which again was linked directly to a PC. The stimuli were recorded digitally with a sampling rate of 44.1 kHz and a 16-bit (mono) sample size using Audacity 1.3[25]. The recorded files were stored on a computer hard drive for further processing. The sound files were edited into separate files for each stimulus and cut at zero crossings of onset and offset of each item under visual and auditory control using Audacity 1.3 and Adobe® Audition 3.0[26]. Furthermore, as the fourth type of determination, the no-determiner (or baseline) condition, a noise stimulus was used as an equivalent for the previously used visual filler stimulus *xxxx*. This stimulus was constructed by using Brown noise[27] with the same length as the mean length of the determiner stimuli. All items were converted to WAV-files for experi-

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[24] Special thanks to Mark Wellers, who gave this experiment his voice.

[25] http://audacity.sourceforge.net/

[26] http://www.adobe.com/de/products/audition.html

[27] Brown (or Brownian) noise is named after Robert Brown, a botanist, who discovered Brownian motion. Brownian motion is a process of random molecular or particle motion. Similarly, the sound signal of Brown noise changes randomly.

mental presentation. As an equivalent to the visual fixation cross in experiment 1, a warning beep sound (standard Windows XP beep sound) was used.

Procedure and Apparatus

Experiment 2 used nearly the same set-up as experiment 1: Participants were tested in a sound attenuated booth one at a time. The experiment was run using Presentation®[28] software on a PC (see Section *Procedure and Apparatus* of experiment 1). Determiner (or noise) and noun (or pseudoword) stimuli were selected and combined for each trial by Presentation® software according to the selected list. The warning (beep) sound (duration of 260 ms) indicated the beginning of each trial, after 400 ms it was followed by one of the determiners. The auditory target stimulus followed 400 ms after the offset of the determiner. After the participants' button press (or after a time-out of 5000 ms if no response was made) and a 1000 ms pause the next trial began. As in experiment 1, the main experimental trials were preceded by the 20 practice trials.

The stimuli were presented via headphones (mono signal) from the PC hard drive. Although the main experiment was performed auditorily, written instructions were used to instruct participants to perform a lexical decision ("word or non-word?") on the nouns as quickly and as accurately as possible by pressing assigned buttons on a response pad:

> ***Aufgabe – Wort oder Kunstwort?***
> *Das Experiment ist auditiv, setze bitte deshalb vor Beginn des Experiments die Kopfhörer auf. Du hörst zuerst ein „beep", das dir anzeigt, dass die (nächste) Runde losgeht. Anschließend hörst du ein Wortpaar aus einem der Artikel "ein(e), der, die, das oder sein(e)" oder ein Rauschen und anschließend ein Nomen, wie z.B. „Maus", „Perspektive" oder „Wulter".*
> *Deine Aufgabe ist es nun, zu entscheiden, ob es sich bei dem jeweils zweiten Wort, also dem Nomen, um ein echtes deutsches Wort, wie z.B. „Maus" oder „Perspektive", handelt oder ob es ein so genanntes*

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[28] www.neurobs.com/

*Kunstwort ist, also ein erfundenes Wort, wie z.B. „Wulter". Wenn es sich Deiner Meinung nach um ein echtes Wort handelt, drücke bitte die **GELBE** Taste (rechts). Bei einem Kunstwort drücke bitte die **BLAUE** Taste (links).*

In den folgenden Beispielen sind b) und c) echte Wörter des Deutschen, während a) und d) jeweils Kunstwörter sind.
Beispiele:

a) der	*Wulter*	***Kunstwort***	***BLAUE** Taste*
*b) *rauschen**	*Perspektive*	***Wort***	***GELBE** Taste*
c) eine	*Maus*	***Wort***	***GELBE** Taste*
d) sein	*Krenel*	***Kunstwort***	***BLAUE** Taste*

Sobald du eine der Tasten gedrückt hast, wird das nächste Beep + Wortpaar präsentiert. Falls du keine Taste drückst oder zu langsam bist, wird direkt das nächste Beep + Wortpaar präsentiert. Versuche Deine Entscheidung so schnell wie möglich, aber dennoch auch so richtig wie möglich, zu treffen. Du erhältst zuerst einige Übungswörter. Anschließend gibt es eine kurze Pause, in der Du eventuelle Fragen an den Versuchsleiter loswerden kannst, bevor es dann richtig losgeht.[29]

Participants were given the opportunity to ask questions before and after the practice trials. The response pad was connected to Presentation® in order to record the reaction times from noun onset up to participants' button press. The assignment of the left and right button to word or pseudo word answers was counterbalanced.

[29] English translation: *The experiment is presented aurally, thus please put on the headphones before the experiment begins. You will hear a beep sound, which indicates the beginning of the next trial. Subsequently, you will hear a word pair. The first on will be one of the articles "a", "the", or "his" or "xxxx". The following word will be a noun [Examples]. Your task is to decide if the second word, the noun, is a real German word [Examples] or if it is a made-up word [Examples]. If you think it is a real word, please press the yellow (right) button. If you think it is a made-up word, please press the blue (left) button. In the following examples b) and c) are real words of German, whereas a) and d) are made-up words. [Examples] As soon as you press one of the buttons, the next beep + word-pair will be presented. In case you do not press any button or if your reaction is too slow, the next beep + word-pair will be presented. Try to make your decisions as quickly but also as accurately as possible. In the beginning you will hear a few practice trials after which you will have a short break where you can ask any questions before the main experiment begins.*

2.2.2.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (reaction times longer than 5000 ms) were excluded from all analyses (overall error and time-out rate: 0.92%). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 0.91% of all correct answers). As for experiment 1, the analysis of the data was conducted from several perspectives.

Concept Type and Determiner Type

Already at first sight, it is visible that the reaction time data of experiment 2 (see figure 2.7 below) are more clear-cut than the results of experiment 1 (cf. section 2.2.1.2), and quite strongly suggest the expected patterns. In order to examine the data a short summary of the expected effects shall be recapitulated. We expect facilitation for congruent determiner-noun combinations (and a possible inhibition for incongruent determiner-noun combinations). For the four concept types this means:

- facilitation by indefinite determiner for sortal nouns (and inhibition by definite and possessive determiner)
- facilitation by definite determiner for individual nouns (and inhibition by indefinite and possessive determiner)
- facilitation by indefinite and possessive determiner for relational nouns (and inhibition by definite determiner)
- facilitation by definite and possessive determiner for functional nouns (and inhibition by indefinite determiner)

Looking at the lexical decision times for experiment 2, for sortal nouns (yellow line) the graph suggests that the strongest facilitation of the processing of sortal nouns was caused by the indefinite – congruent – determiner. The definite determiner also caused a slight facilitation. Although the definite determiner is incongruent for sortal nouns, the facilitation might be explained due to frequency of occurrence of sortal nouns, and the definite article, which is used after a sortal noun is introduced in a discourse. The possessive (and thus incongruent) determiner, however, caused an inhibition on lexical decision latencies for sortal nouns, which corresponds to the hypothesis.

For individual nouns (green line), we see facilitation when combined with the definite determiner, which is the congruent determiner type for individual concepts, whereas the incongruent combinations with indefinite and possessive determination are almost equal to the no-determiner condition. For relational nouns (red line), the data show a facilitating effect of all determiners; however, it was slightly stronger for the combination with the indefinite and possessive determiner.

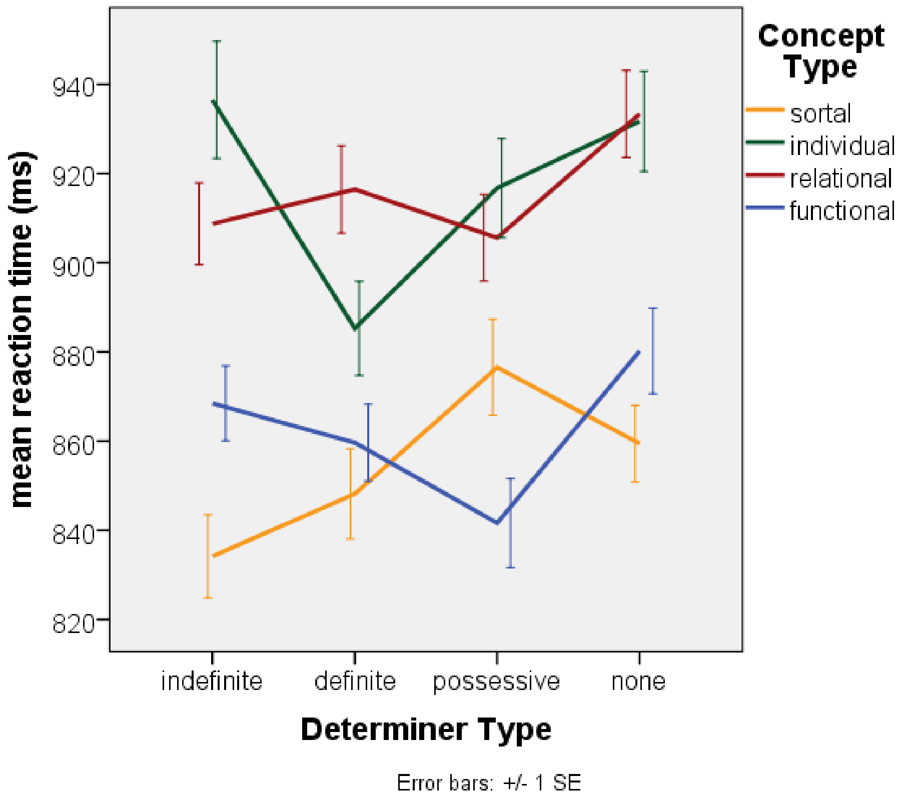

Figure 2.7: Lexical decision latencies for nouns of different concept types in combination with different determiner types in German auditory LDT

For functional nouns the strongest facilitation was caused by presentation with the possessive determiner, followed by the definite determiner, which are both congruent determiner types for functional nouns. The indefinite determiner caused a slight facilitation compared to the no-determiner condition (only a little less than the definite determiner). In addition to the expected interaction effects of concept type and determiner type, a rather clear cut concept type effect is visible: sortal and functional nouns seem to be processed about 70 ms faster than individual and relational nouns.

In order to test, whether the described effects of congruent (and incongruent) determination on the different concept types can be supported by statistical significance, mean reaction times were submitted to *IBM SPSS Statistics*[30] in order to conduct a repeated measures analysis of variance (ANOVA). The four by four repeated measures ANOVA was conducted with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the interaction, $\chi^2(44) = 92.94$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .82$) was used to correct the degrees of freedom. The results of the repeated measures ANOVA showed that all effects were significant at $p < .01$.

There was a significant main effect of Determiner Type (see figure 2.8), $F(3, 285) = 4.09$, $p = .007$, $r = .20$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed a significant facilitation of definite, $F(1, 95) = 10.40$, $p = .002$, $r = .32$, and possessive determiner, $F(1, 95) = 4.91$, $p = .029$, $r = .22$, compared to none. The indefinite determiner compared to none did not pass the significance threshold, however, it was very close to significant, $F(1, 95) = 3.85$, $p = .053$, $r = .20$.

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[30] www.ibm.com/software/analytics/spss

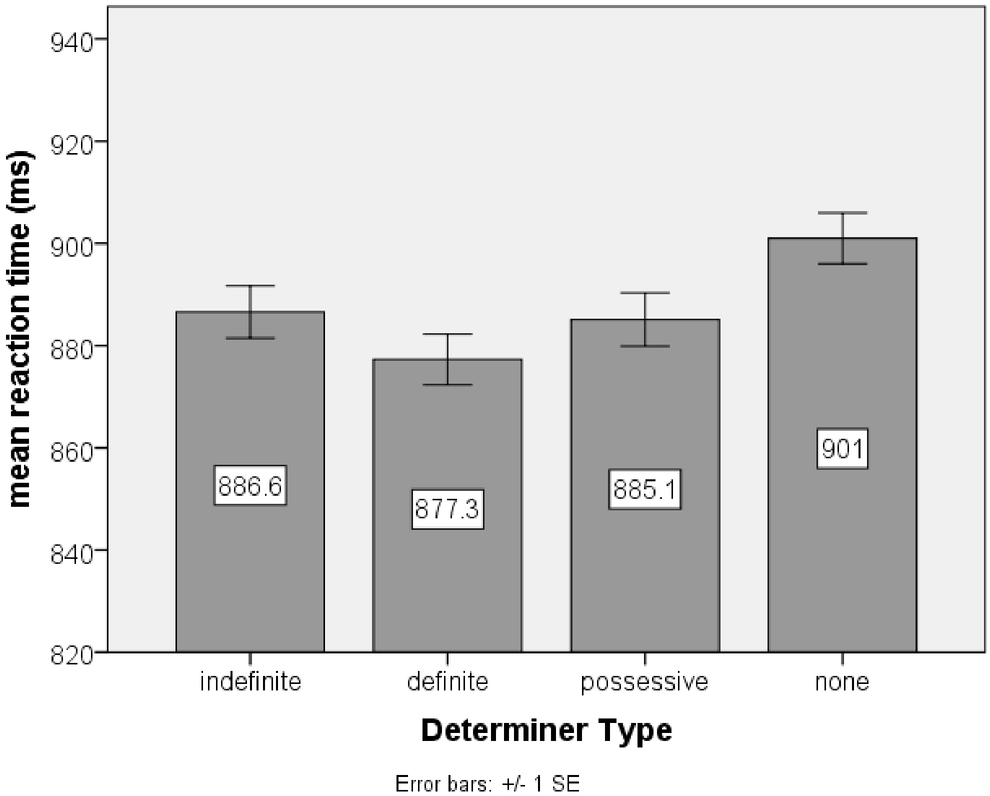

Figure 2.8: Lexical decision latencies for different determiner types in German auditory LDT

There was also a significant main effect of Concept Type (see figure 2.9), $F(3, 285) = 50.98$, $p = .000$, $r = .59$. Planned contrasts (simple (first)) compared each concept type to sortal concepts, and revealed significantly faster responses for sortal nouns compared to individual, $F(1, 95) = 83.70$, $p = .000$, $r = .68$, and relational nouns, $F(1, 95) = 104.26$, $p = .000$, $r = .73$. There was no significant difference comparing functional and sortal nouns, $F(1, 95) = 1.61$, $p = .208$. Post hoc comparisons (with Bonferroni's α-correction) confirm that sortal and functional nouns were processed faster than individual and relational nouns (for all comparisons $p = .000$), whereas there was neither a difference between each of the two "slow" nor between the two "fast" CTs, respectively (for all comparisons p=1.0). This effect supports and reinforces the findings of experiment 1, as the differences are even more pronounced.

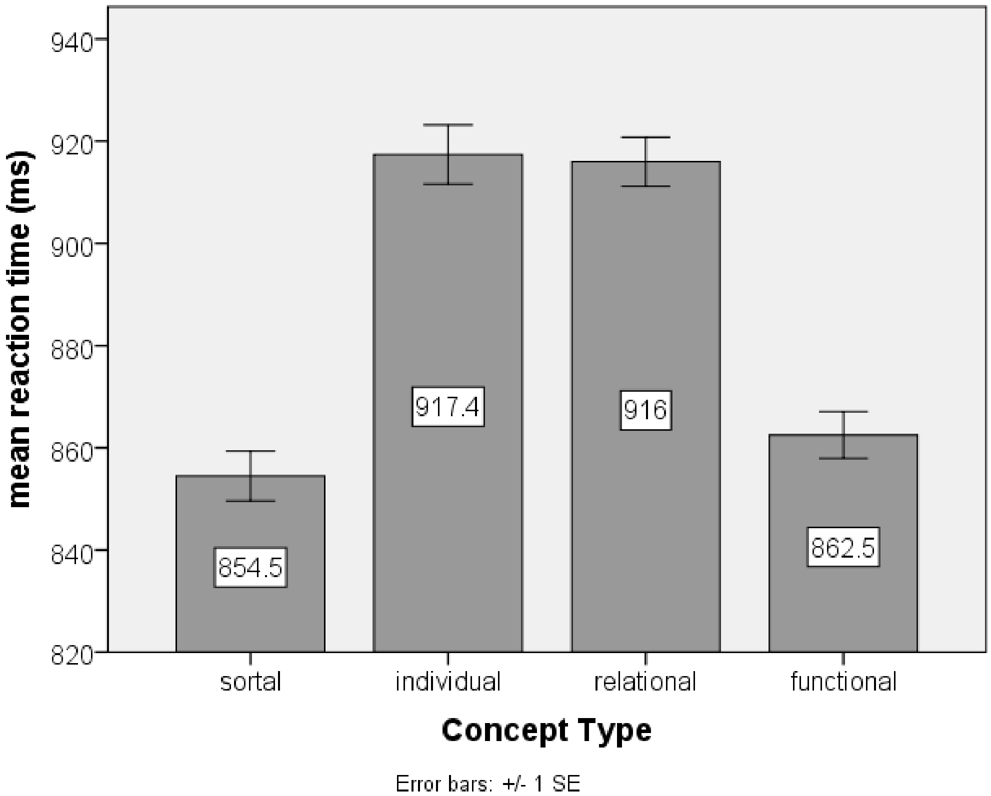

Figure 2.9: Lexical decision latencies for different concept types in German auditory LDT

The ANOVA also yielded a significant interaction between the factors Determiner Type and Concept Type, $F(7.36, 699.55) = 4.91$, $p = .000$, $r = .22$. In order to analyze which of the factor levels caused the interaction effect, separate one-way ANOVAs were conducted for the factor levels of Concept Type analyzing the factor of Determiner Type {indefinite, definite, possessive, none}.

For sortal nouns, the results of the one-way repeated measures ANOVA with the factor Determiner Type {indefinite, definite, possessive, none} showed a significant effect of Determiner Type, $F(3, 285) = 5,38$, $p = .001$, $r = .23$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed significantly faster responses only for indefinite determiner compared to no determiner, $F(1, 95) = 6.65$, $p = .011$, $r = .26$. Definite and possessive determiners did not differ significantly from no-determiner cases, $F(1, 95) = .80$, $p = 374$, and $F(1, 95) = 2.91$, $p = .091$. Additionally, post hoc comparisons (with Bonferroni's α-correction) showed significantly faster responses for the indefinite vs. the possessive determiner, p = .003.

For individual nouns, the results of the one-way repeated measures ANOVA showed a significant effect of Determiner Type, $F(3, 285) = 5.53$, $p = .001$, $r = .24$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed significantly faster responses only for definite determiner compared to no determiner, $F(1, 95) = 10.64$, $p = .002$, $r = .32$. Indefinite and possessive determiners did not differ significantly from no-determiner cases, $F(1, 95) = .39$, $p = .536$ and $F(1, 95) = .81$, $p = .372$. Additionally, post hoc comparisons (with Bonferroni's α-correction) showed significantly faster responses for the definite vs. the indefinite determiner, p = .000.

For relational nouns, the results of the one-way repeated measures ANOVA with the factor Determiner Type showed only a marginal effect of Determiner Type, $F(3, 285) = 2.38$, $p = .070$, $r = .16$.

For functional nouns the results of the one-way repeated measures ANOVA showed a significant effect of Determiner Type, $F(3, 285) = 4.57$, $p = .004$, $r = .22$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed significantly faster responses only for possessive determiner compared to no determiner, $F(1, 95) = 13.53$, $p = .000$, $r = .35$. Indefinite and definite determiners did only marginally differ from no-determiner cases, $F(1, 95) = 1.65$, $p = .202$ and $F(1, 95) = 3.27$, $p = .074$.

The results of the ANOVAs support the visual examination of the lexical decision data for Concept Type and Determiner Type. As for experiment 1, a more general analysis of overall congruence (comparing all congruent combinations with all incongruent combinations and using the no-determiner condition as a control) might more explicitly show the nature of the congruence effect.

Overall Congruence

For the overall congruence analysis of experiment 2 the same categories were grouped together as was described in the respective section of experiment 1. The expected pattern for this analysis is facilitation for congruent combinations and a possible inhibition for incongruent combinations, or at least an equal mean lexical decision time as for the no-determiner condition. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2), a linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none}\_mean / RT_{none}\_mean\_by\_concept\_type$). Figure 2.10 suggests the expected facilitation for congruent conditions compared to both, incongruent and no-determiner conditions, whereas there is almost no difference between incongruent and no-determiner conditions.

In order to test, whether the described effect can be validated by statistical results a one-way repeated measures ANOVA was conducted with the factor Overall Congruence {incongruent, congruent, none}. The results of the ANOVA showed a significant effect of Congruence, $F(2, 190) = 12.70$, $p = .000$, $r = .34$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases, but no influence or inhibition by incongruent cases (vs. none), and revealed that nouns, which were presented with a preceding congruent determiner, yielded faster responses than incongruent determiner-noun combinations, $F(1, 95) = 18.48$, $p = .000$, $r = .40$. No significant difference was found between incongruent and no-determiner cases, $F(1, 95) = .83$, $p = .364$.

Additionally, a selective post hoc comparison of congruent vs. no determiner showed significantly faster responses for congruent noun-determiner combinations ($p = .000$). These results validate the hypothesis, that congruent determination – in contrast to incongruent determination – helps processing nouns during language comprehension.

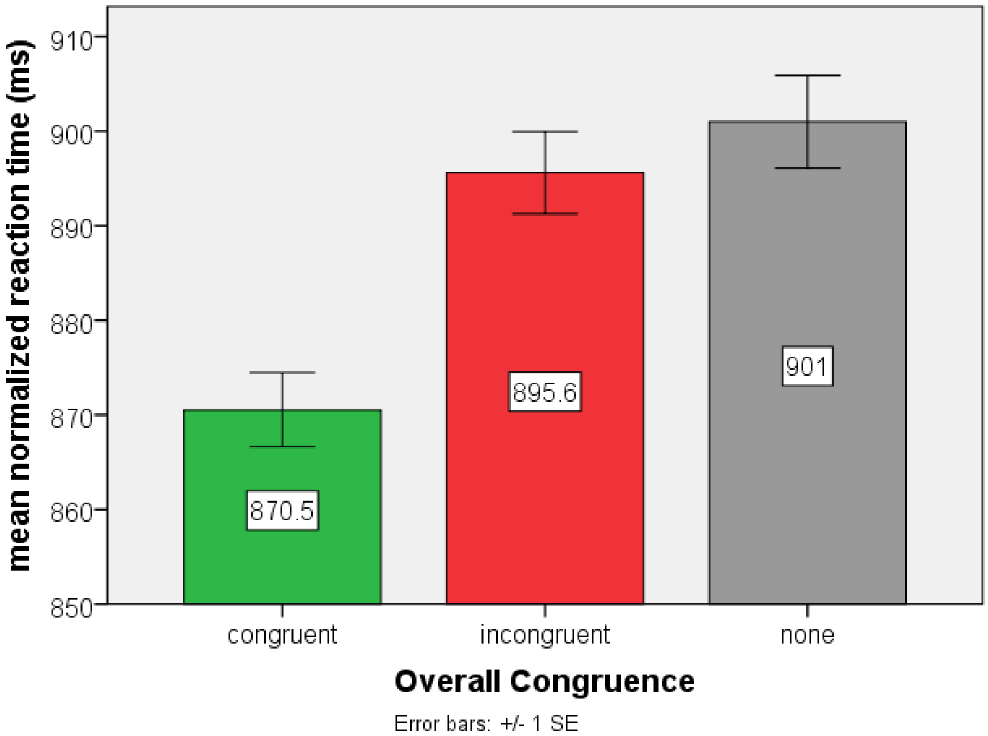

Figure 2.10: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German auditory LDT

Referential Properties and Determiner Types

For the analysis of the referential properties the same categories were grouped together as described in the respective section of experiment 1. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2), a linear normalization was applied to the reaction times ($RT_{norm}= RT * RT_{none}\_mean/ RT_{none}\_mean\_by\_concept\_type$).

Uniqueness and Determiner Type

Figure 2.11 shows the results of experiment 2 for unique and non-unique nouns in combination with the indefinite and definite article, and the no-determiner conditions. The expected effects are

- facilitation for unique nouns used with definite determination (and possible inhibition by indefinite determination)
- facilitation for non-unique nouns used with indefinite determination (and possible inhibition by definite determination)

The bar chart suggests the expected facilitation effects for non-unique nouns used with the indefinite determiner (congruent) as well as for unique nouns used with the definite determiner (congruent).

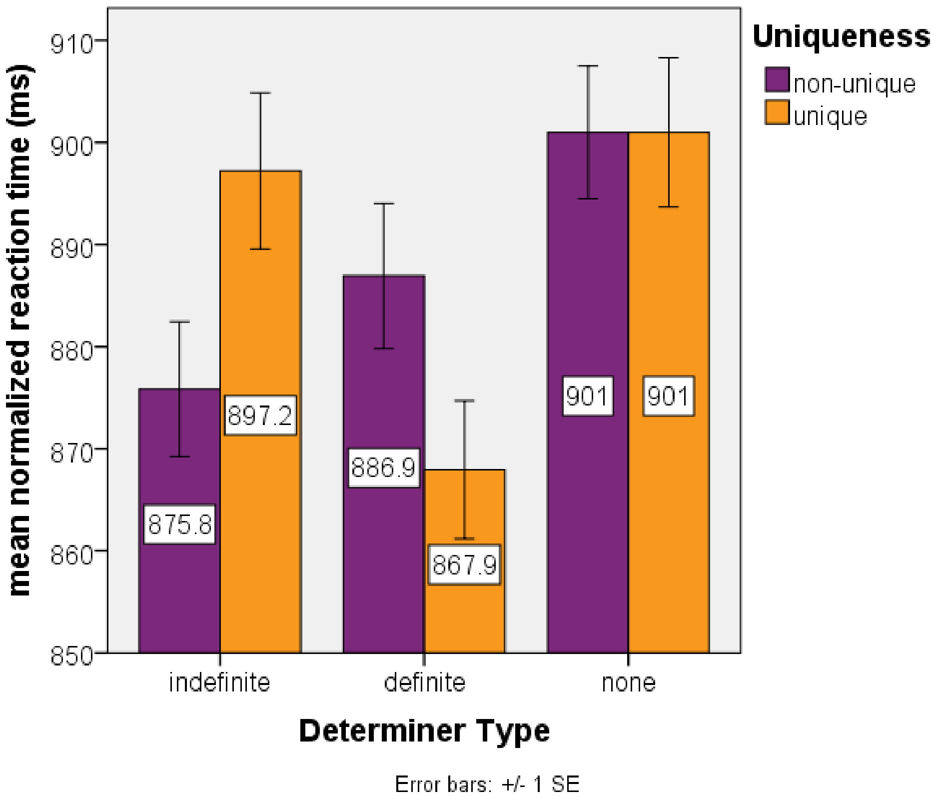

Figure 2.11: Lexical decision latencies for unique and non-unique nouns used with indefinite, definite and no determiner in German auditory LDT

In order to test, whether the described facilitation effects can be supported by statistical analyses, a repeated measures ANOVA was conducted with the factors Determiner Type {indefinite, definite, none} × Uniqueness {non-unique, unique}. The results of the repeated measures ANOVA showed that there was no significant main effect of Uniqueness, $F(1, 95) = .09$, $p = .77$. However, there was a significant main effect of Determiner Type, $F(2, 190) = 5.90$, $p = .003$, $r = .24$, and, more importantly, the interaction of Determiner Type and Uniqueness was significant as well, $F(2, 190) = 6.91$, $p = .001$, r= .26, although the effect was rather small. Planned contrasts for the factor Determiner type (simple (last)) compared the indefinite and definite article to the no-determiner condition as a baseline and revealed a facilitation effect of any determiner compared to none: indefinite faster than none, $F(1, 95) = 4.01$, $p = .046$, $r = .20$, definite faster than none, $F(1, 95) = 10.34$, $p = .002$, $r = .31$.

In order to analyze which of the factor levels can be held responsible for the interaction effect, separate one-way ANOVAs were conducted for unique vs. non-unique nouns, each with the factor Determiner Type {indefinite, definite, none}. The ANOVA for non-unique nouns showed a significant effect of Determiner Type, $F(2, 190) = 4.94$, $p = .008$, $r = .22$. Planned contrasts (simple, last) compared the determiners to the no-determiner condition as a baseline and revealed a significant difference between the indefinite article and no determiner, $F(1, 95) = 9.55$, $p = .003$, $r = .30$, indicating the expected facilitation effect of the indefinite and therefore congruent determiner for non-unique nouns. There was only a marginal difference between the definite determiner and the neutral baseline, $F(1, 95) = 3.29$, $p = .073$, $r = .18$.

The ANOVA for unique nouns also showed a significant effect of Determiner Type, $F(2, 190) = 7.18$, $p = .001$, $r = .27$. Planned contrasts (see above) yielded a significant facilitation caused by the definite – congruent – determiner, $F(1, 95) = 9.98$, $p = .002$, $r = .31$, but the results show no difference between the indefinite determiner and baseline conditions, $F(1, 95)$, $p = .696$. Additionally, the post hoc comparison of definite vs. indefinite uses of unique nouns showed significantly shorter latencies for definite ($p = .001$).

Relationality and Determiner Type

Figure 2.12 shows the results of experiment 2 for unique and non-unique nouns in combination with the indefinite and definite article, and the no-determiner conditions. The expected effect is facilitation for relational nouns used with the possessive determiner. The bar chart in figure 2.12 suggests the expected facilitation effects of possessive determination only for relational nouns (congruent) but not for non-relational nouns (incongruent).

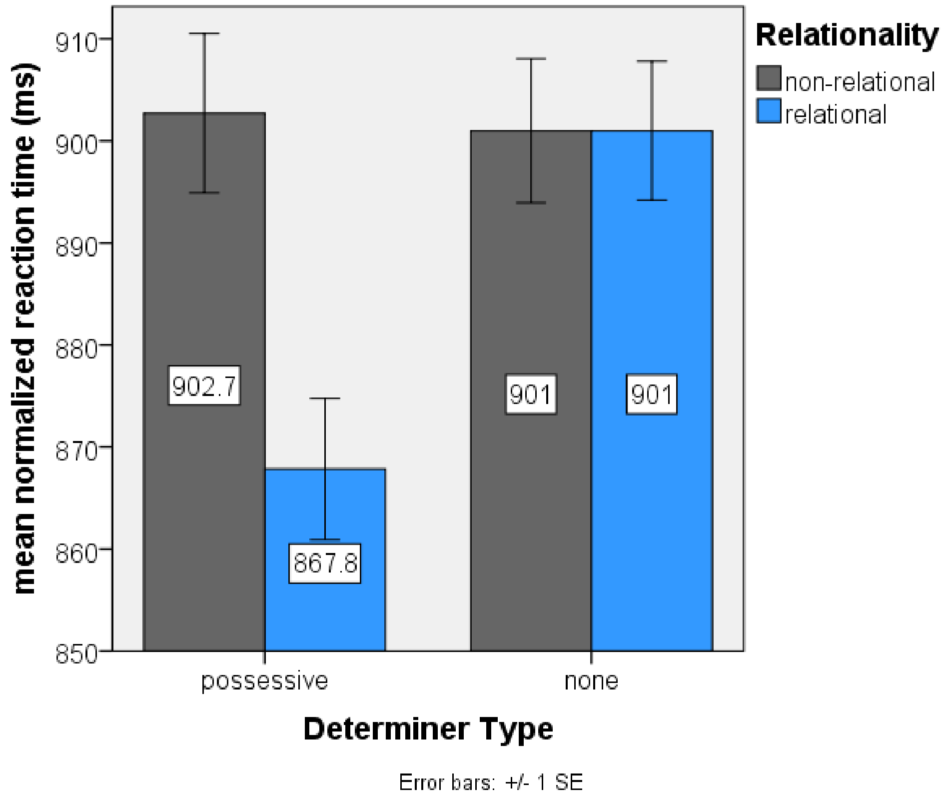

Figure 2.12: Lexical decision latencies for relational and non-relational nouns used with possessive and no determiner in German auditory LDT

In order to test if the described facilitation effects can be supported by statistical analyses, a repeated measures ANOVA was conducted with the factors Determiner Type {possessive, none} × Relationality {non-relational, relational}. The results of the repeated measures ANOVA revealed that all effects were significant. There was a significant main effect of Determiner Type, $F(1, 95) = 5.03$, $p = .027$, $r = .22$, in that nouns presented with the possessive determiner were processed faster than presented in the noise condition. There was also a significant main effect of Relationality, $F(1, 95) = 6.73$, $p = .011$, $r = .26$, in that relational nouns were processed faster than non-relational nouns. This effect was caused by the strong facilitation of relational nouns used with the possessive determiner, shown in the interaction effect between Determiner Type and Relationality which was significant as well, $F(1, 95) = 8.13$, $p = .005$, $r = .28$.

2.2.2.3 Summary and Intermediate Discussion

Like the visual version in experiment 1, this auditory lexical decision experiment (2) examined theoretical predictions of the CTD theory by investigating the influence of cued congruent vs. incongruent conceptual type information on noun processing in language comprehension. The results showed that definite and possessive determination – in contrast to the indefinite or no determiner – facilitates noun recognition in general. These results slightly deviate from the findings of experiment 1, where all determiners sped up lexical decision times compared to the neutral baseline. The concept type effect that was found in experiment 1 was replicated in experiment 2: sortal and functional nouns were processed faster than individual and relational nouns. For a discussion of this effect cf. intermediate discussion in section 2.2.1.3.

From a CTD point of view, the more exciting finding was that experiment 2 confirmed the predicted influence of CT-congruent/incongruent determiners on nouns of the four concept types which was statistically supported by the interaction effect. The results show that specific, congruent determiners have a facilitating effect on specific concept types. Sortal nouns were facilitated by the congruent indefinite article, individual nouns were facilitated by the definite article, and functional nouns were facilitated by the congruent possessive determiner. For relational nouns, statistics only found a marginal determiner type effect, however, a visual inspection of the data in figure 2.7 shows slightly faster lexical decision times for relational nouns that were preceded by the indefinite and possessive determiner, which is in line with the CTD predictions.

The expected patterns were also reflected in the separate analysis of the properties uniqueness and relationality. Recognition of relational nouns was facilitated when combined with congruent possessive determination compared to the neutral noise stimulus, and yielded faster responses than non-relational nouns with possessive determiner. Unique nouns in contrast to non-unique nouns were facilitated by the congruent definite determiner, while non-unique nouns were facilitated by the congruent indefinite determiner.

Furthermore, an overall analysis of congruence revealed that congruent determiners lead to significantly faster recognition of nouns than do incongruent determiners. This effect of congruent conceptual type information is facilitatory in nature, as the results also showed faster responses for congruent cases compared to the neutral baseline, while there was no difference between incongruent and no determiner (i.e. the neutral baseline). The presence of the concept type congruence effects found in experiment 2 rule out the possibility, that nouns might be lexically unspecified for concept type (at least for German), as in this case they should equally well combine with all determiner types to create noun phrases. Instead, the results favor a lexical specification of a noun's concept type as assumed by CTD.

Moreover, contextual conceptual type information seems to act on language comprehension in a similar way as grammatical gender information (cf. section 1.2 and also Bölte and Connine, 2004). Both facilitate noun recognition if congruent and have no (inhibitory) effect if incongruent. It should, however, be noted that the reaction times likely include a gender effect, as both congruent and incongruent determiners, but not the neutral baseline condition (no determiner) provided correct grammatical gender information. On the one hand, this might explain why basically any determiner facilitated overall noun processing in experiment 1 and 2 (here with the exception of the indefinite article).

On the other hand, a mere gender effect as explanation for the concept type congruence effect in experiment 2 can be ruled out, because if this were the case CT-incongruent determination, which was still gender-congruent, should have also shown facilitation but in fact did not differ from the neutral condition (cf. figure 2.10 above). Furthermore, the indefinite article as well as the possessive article do not distinguish between masculine and neuter, thus across all determiner conditions the gender effect might be smaller than in Bölte and Connine's study (2004) where only the definite determiner was used, which distinguishes between all three German grammatical genders, feminine, masculine and neuter.

However, a constant contribution of a gender effect cannot be ruled out, which in case of the CT-incongruent condition might have compensated the possible inhibition (i.e. type shift costs). Thus, depending on the size of the gender effect, the observed facilitation might be in part or fully explained by a gender effect, such that the concept type congruence effect would to a corresponding degree be an inhibition by incongruent determination rather than facilitation by congruent determination. This aspect will be addressed in experiment 4 (cf. below).

What became obvious in the analysis of experiment 2 and the comparison to the results found in experiment 1, is that there were considerable differences between the modalities. In the data of experiment 1, the visual version of the lexical decision experiment, some of the expected congruence facilitation patterns were visible and measurable. Experiment 2, the auditory lexical decision experiment, did show an Overall Congruence effect as well as expected interactions between specific DTs and CTs (as well as uniqueness and relationality), in the form of facilitation for congruent combinations and no difference between incongruent and no-determiner conditions – just as predicted by the hypotheses of the CTD. However, the expected congruence effects are supported by statistical results only in the data from experiment 2 but not in the data from experiment 1. As referenced above, Goldinger (1996) also mentioned modality specific differences in lexical decision data.

A clear numerical difference occurred when comparing the range in which the mean reaction times occurred: The overall mean reaction time (in ms) of the visual experiment 1 was M = 570.17 (SD = 1.96), while the overall mean reaction time (in ms) of the auditory experiment 2 was M = 887.48 (SD = 2.54), thus there is an approximately 300 ms difference between the two modalities. An important difference in presenting the stimuli lies in the nature of the modality specific procedures. In visual lexical decision experiments determiner and noun stimuli were shown on the screen and thus the input was available from word onset. As reaction times were measured from stimulus onset, there was a slight reaction time delay due to the later recognition point in the auditory modality. In auditory lexical decision stimulus onset is not equal to full availability of the input as it takes up to the uniqueness-point of a word, until the correct word can be identified (or – to phrase it according to the *Cohort* model (cf. section 1.2.1) – until the competing candidates in the cohort are eliminated). The mean length of the sound stimuli (in ms) was M = 513.57 (SD = 129.43), thus a mean uniqueness-point of around 300 ms is a plausible cause for the reaction time differences.

Additionally, apart from modality, the most obvious difference between experiment 1 and 2 was the duration of stimulus presentation, and thus also interstimulus interval (ISI) between determiner and subsequent noun stimulus. In the visual version the determiner stimulus had a fixed duration of 500 ms, ISI was set to 400 ms. In the auditory version the duration of the determiner stimulus varied between 296 and 544 ms (M = 413.13, SD = 75.15) and the ISI was also set to 400 ms. What was mentioned for the nouns also holds for the determiner stimulus. It is not fully available at the onset, thus it might take a few milliseconds time to process it. Thus, in a follow-up visual lexical decision experiment (cf. experiment 3) the ISI was increased by 300 ms to accommodate for this difference.

2.3 German Experiments II

The experiments reported in this section are two visual lexical decision experiments that use the same stimulus material as experiment 1. Experiment 3 is a follow-up to the pilot experiment (1) and in experiment 4 a gender congruence manipulation was added as a condition (again cf. section 2.5 for a compact overview of the results).

2.3.1 Experiment 3: German Visual Lexical Decision

The aim of experiment 3 was to match the processing time of the visual and auditory experiments and to check whether the expected congruence effects seen in experiment 2 could be replicated in the visual modality if participants were given more time between determiner and noun.

2.3.1.1 Material and Methods

Participants

Experiment 3 tested 96 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (70 women, 26 men; mean age *M* = 23.53 years, *SD* = 4.01). They were paid a small fee for their participation.

Material, Procedure and Apparatus

In experiment 3 the exact same materials as in experiment 1 (nouns, pseudowords, determiners, warm-up stimuli and lists) were used. The experimental set-up (location, hardware, software, instructions) of experiment 3 was equivalent to the set-up of experiment 1. The trials differed from the ones in experiment 1 solely in the inter stimulus interval between the determiner stimulus and the following noun stimulus: in this experiment the pause (blank screen) was presented for 700 ms before the noun stimulus was presented. Reaction times were again measured from target onset.

2.3.1.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (RT longer than 3000 ms) were excluded from all analyses (overall error and time-out rate: 2.21%). A subject and item analysis of errors was conducted in order to test, whether any participants or items showed an undue number of errors. Again, one item was excluded from all analyses, as it had an error rate of 65.63%. This supports the hypothesis that participants misread *Uroma* due to (morpho)phonological mis-segmentation (cf. section 2.2.1.2). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 1.28% of all correct answers (excluding *Uroma*)).

Concept Type and Determiner Type

In contrast to the previous results the data of experiment 3 (see figure 2.13 below) show quite flat and almost parallel lines which indicate a lack of processing differences for the four concept types in combination with the determiner types. However, the graph suggests clear cut concept type differences if we only examine the different concept types, without considering the determiner type variable. The concept types clearly differ with respect to lexical decision times. Relational nouns seem to be the slowest, followed by individual nouns, whereas functional nouns seem to be the fastest noun type, followed by sortal nouns. The expected patterns for the combination of concept type and determiner type have been mentioned before (see results sections for experiments 1 and 2).

Looking at the lexical decision times for sortal nouns in experiment 3, figure 2.13 shows a rather flat yellow line, indicating that sortal nouns had not been influenced differentially by the four determiner types. There is a very slight facilitation visible that could be caused by the determiners compared to the no-determiner condition, and the lowest peak ("strongest" facilitation) for sortal nouns is the combination with the definite determiner. For individual nouns (green line), there is a noticeable facilitation for the use with the definite determiner. Indefinite and possessive determination only slightly sped up lexical decision times of individual nouns. In the case of relational nouns (red line) the distribution of mean lexical decision times is similar to that of sortal nouns except for the overall slower processing of relational nouns. The graph shows a very slight facilitation for all determiners compared to the no-determiner condition. Functional nouns (blue line) show the same pattern, a slight facilitation by any determiner compared to none, and almost non-existent differences between the determiners.

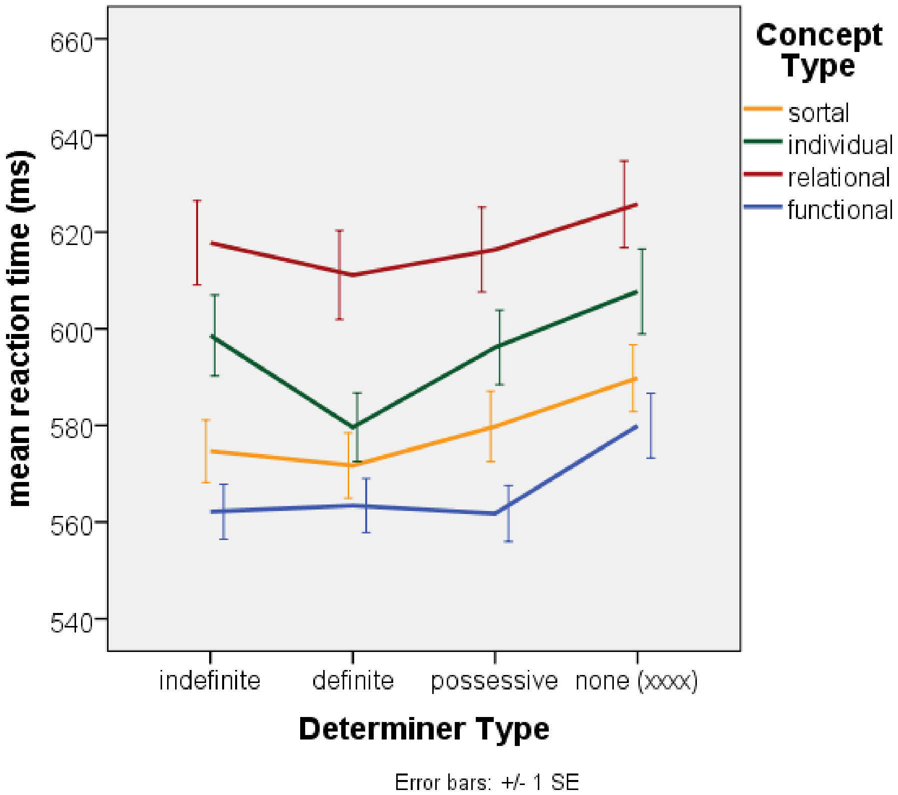

Figure 2.13: Lexical decision latencies for nouns of different concept types in combination with different determiner types in German visual LDT

In order to test, whether the described facilitation effects can be supported by statistical analyses, mean reaction times were submitted to *IBM SPSS Statistics* in order to conduct a repeated measures analysis of variance (ANOVA). The four by four repeated measures ANOVA was conducted with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(5) = 11.39$, $p = .044$, and Concept Type, $\chi^2(5) = 44.05$, $p = .000$, as well as for the interaction, $\chi^2(44) = 146.91$, $p = .000$. For that reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .93$ for the main effect of Determiner Type, $\varepsilon = .79$ for the main effect of Concept Type, and $\varepsilon = .74$ for the interaction effect). The results of the repeated measures ANOVA showed that both main effects were significant at $p < .001$ (see below), the interaction of Determiner and Concept Type, however, was not significant, $F(6.68, 634.56) = .51$, $p = .110$.

There was a significant main effect of Determiner Type (see figure 2.14), $F(2.79, 264.72) = 7.39$, $p = .000$, $r = .27$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline and revealed significantly faster responses for any determiner compared to no determiner: $F(1, 95) = 7.69$, $p = .007$, for the comparison indefinite vs. none, $r = .27$; $F(1, 95) = 16.44$, $p = .000$, $r = .39$, for the comparison definite vs none; $F(1, 95) = 9.62$, $p = .003$, $r = .30$, for the comparison possessive vs. none.

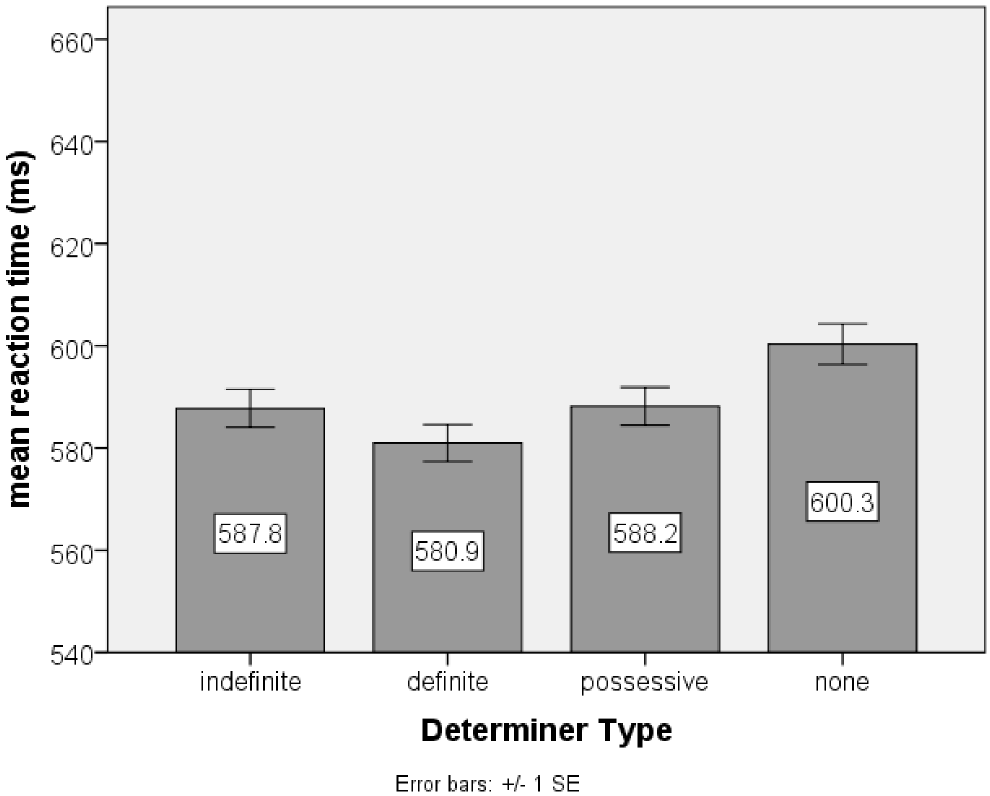

Figure 2.14: Lexical decision latencies for different determiner types in German visual LDT

There was also a significant main effect of Concept Type (see figure 2.15), $F(2.38, 225.86) = 36.99$, $p = .000$, $r = .53$. Planned contrasts (simple (first)) compared each concept type to sortal concepts, and revealed significantly faster responses for sortal nouns compared to individual $F(1, 95) = 10.94$, $p = .001$, $r = .32$, and relational nouns $F(1, 95) = 58.16$, $p = .000$, $r = .62$, but functional nouns had significantly faster responses compared to sortal nouns, $F(1, 95) = 12.21$, $p = .001$, $r = .34$. Post hoc pairwise comparisons (with Bonferroni's α-correction) additionally show that all concept types differ significantly from one another: individual and functional nouns yielded faster responses than relational nouns, and functional nouns yielded faster responses than individual nouns (for all comparisons $p < .01$).

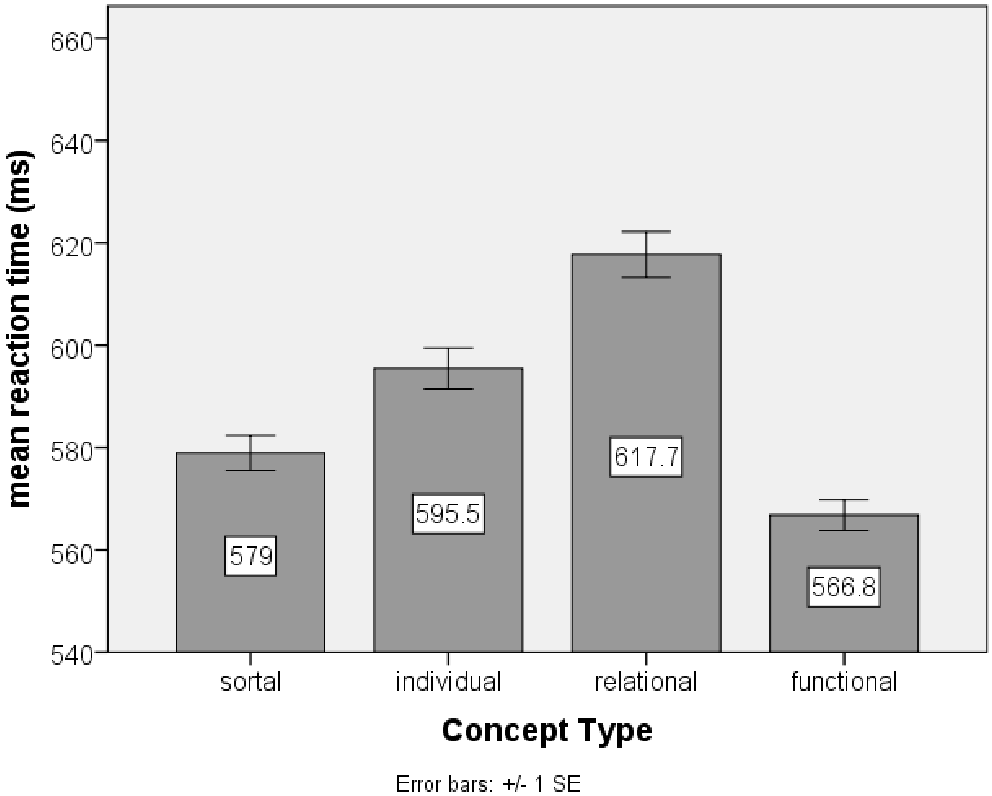

Figure 2.15: Lexical decision latencies for different concept types in German visual LDT

Overall Congruence

For the overall congruence analysis of experiment 3 the same categories were grouped together as described in the respective section of experiment 1. The expected pattern for this analysis is facilitation for congruent combinations and a possible inhibition for incongruent combinations, or at least an equal mean lexical decision time as for the no-determiner condition. For the same reasons mentioned in the results section of experiment

1 (see Section 2.2.1.2) a linear normalization was applied to the reaction times (RT_{norm}= RT * RT_{none}_mean / RT_{none}_mean_by_concept_type).

Looking at the data in this overall manner figure 2.16 suggests facilitation for congruent cases (in comparison to no-determiner cases), but the data show just a very subtle advantage for the congruent conditions in comparison to incongruent ones. However, there was no inhibitory effect visible for incongruent cases, processing of incongruent combinations was also facilitated compared to the no-determiner condition.

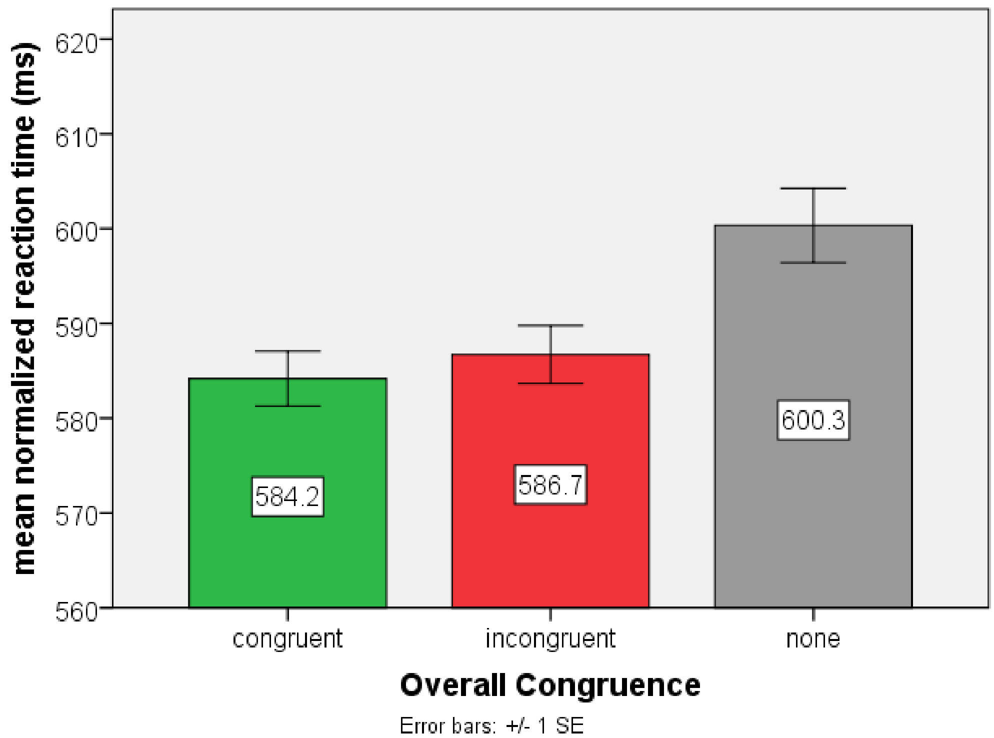

Figure 2.16: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT

In order to statistically test a possible overall congruence effect, a one-way repeated measures ANOVA was conducted with the factor Overall Congruence {incongruent, congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence, $\chi^2(2)$ = 6.80, p = .033, thus the Greenhouse-Geisser estimate of sphericity (ε = .94) was used to correct the degrees of freedom. The results of the ANOVA showed a significant effect of Congruence, $F(1.87, 177.61) = 10.65$, $p = .000$, $r = .32$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases but no influence or an inhibition by incongruent cases (vs. none), and revealed significantly faster responses only for incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 95) = 12.62$, $p = .001$, $r = .34$. However, there was no significant difference between congruent and incongruent cases, $F(1, 95) = .56$, $p = .455$. Additionally, a selective post hoc comparison of congruent vs. no-determiner conditions showed significantly faster responses for congruent noun-determiner combinations ($p = .000$).

2.3.1.3 Summary and Intermediate Discussion

Experiment 3 was a follow-up experiment to the visual pilot experiment and used the same set-up with the exception of ISI between determiner and noun. The results of experiment 3 showed the same pattern as experiment 1: There was a significant but small main effect of Determiner Type in the shape of a facilitating effect of determiners on noun recognition in general, i.e. faster responses for nouns combined with any determiner compared to nouns presented without any determination (i.e. the neutral baseline). The results also revealed a significant strong main effect of Concept Type, which included the same CT differences as shown in experiment 1: Sortal and functional nouns elicited faster responses than individual and relational nouns, and individual nouns were again faster than relational. Additionally, functional nouns elicited significantly shorter latencies than sortal nouns. However, despite the increased ISI between determiner and noun, the responses to nouns with different concept types were not modulated by the different determiner types.

In general, the reaction time data did not show too much variation (cf. figure 2.13 as compared to figure 2.1), except for the visible advantage of individual nouns preceded by the definite article. The same is also visible for the overall congruence analysis. As in experiment 1 there was an overall congruence effect, however, it only showed a facilitation of nouns used with any determiner compared to the no determiner uses, but no difference between congruent vs. incongruent combinations (not even visible in figure 2.16). Thus only an overall influence (i.e. helping) of any determiner on noun processing can be inferred. In summary, giving participants more time between stimuli (between prime and target) minimizes the measurable but not significant effects even more and does not make up for the modality dependent magnitude (and significance) of concept type congruence effects.

2.3.2 Experiment 4: German Visual Lexical Decision

The aim of this experiment was to examine if a gender effect could be found in addition to the expected concept type congruence effect, and if so, whether it influenced the concept type congruence effect. For this purpose experiment 1 was taken as a basis and was altered in one aspect. The same stimuli were used as in the previous experiments, with the exception that a gender congruence manipulation was added. The gender effect had been shown by Bölte and Connine (2004) – among others (cf. section 1.2.1) – in the form of facilitation for nouns presented with gender matching determination as compared to mismatching determination.

Others had additionally found an inhibitory effect of mismatching gender information. Experiment 4 adds to this line of research by supporting the facilitating, inhibitory, or double-sided nature of the gender effect – depending on the results. Furthermore, an important aspect of interest was to show whether a concept type congruence effect could be found in addition to the gender effect and whether both effects interacted with each other. This is especially informative in comparison to the data shown in previous experiments, where a clear facilitation effect of (correct) determiners compared to the baseline could be shown, which suggests that gender information influences the present experiments to a certain degree.

2.3.2.1 Material and Methods

Participants

Our study tested 140 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (104 women, 36 men; mean age *M* = 22.44 years, *SD* = 3.76). They were paid a small fee for their participation.

Materials, Procedure and Apparatus

In experiment 4 the same materials as in experiment 1 and 3 (nouns, pseudowords, determiners and lists) were used. Additionally, a further independent variable was introduced. Gender-congruence of the determiner was manipulated in addition to the previous manipulation of concept type and determiner type congruence. The experimental set-up (location, hardware, software) of experiment 4 was equivalent to the set-up of experiment 1. A revised version of the written instructions was given to participants of experiment 4:

> ***Echtes oder erfundenes Wort?***
> *Deine Aufgabe ist es, auf einem Bildschirm präsentierte Nomen danach zu beurteilen, ob sie echte oder erfundene Wörter sind.*
> *Du siehst auf dem Bildschirm bei jedem Durchgang drei aufeinander folgende Dinge:*
>
> *(1) Ein Kreuzchen: Es zeigt dir an, wo die Wörter erscheinen werden,*
>
> *(2) 1. Wort: entweder einer der Artikel „ein/e", „der/die/das", „sein/e" oder „xxxx"*
>
> *(3) 2. Wort: ein Nomen oder ein Kunstwort, das wie ein Nomen aussieht.*
>
> *Das jeweils 1. Wort kann ein korrekter oder falscher Artikel oder das „Füllmaterial" xxxx sein; ob er passt oder nicht, kannst du einfach ignorieren. Das erste Wort mögest du also bitte nur lesen, nicht beurteilen. Wenn das 2. Wort erscheint, ist es deine Aufgabe, per Tastendruck zu entscheiden, ob es sich bei diesem um ein echtes deutsches Wort oder ein Kunstwort handelt: Drücke dazu bitte die*

*GELBE Taste (rechts), wenn es sich deiner Meinung nach um ein echtes Wort handelt und die **BLAUE** Taste (links), wenn du glaubst ein Kunstwort gelesen zu haben.*

Beispiele:

Durchgang	***1***	***2***	***3***	***4***
Kreuzchen	+	+	+	+
1. Wort	***eine***	***der***	***seine***	***xxxx***
2. Wort	***Maus***	***Wulter***	***Stift***	***Auto***
richtige Taste	***Wort***	***Kunst-wort***	***Wort***	***Wort***

Sobald du einen Knopf gedrückt hast, wird der nächste Durchgang präsentiert. Falls du mal keinen Knopf drückst oder zu langsam bist (das passiert schon mal ☺), wird der nächste Durchgang automatisch präsentiert. Versuche Deine Entscheidung bitte so schnell wie möglich, aber dennoch so richtig wie möglich zu treffen. Du erhältst am Anfang einige Übungsdurchgänge gefolgt von einer kurzen Pause, in der du noch eventuelle Fragen loswerden kannst, bevor es dann richtig losgeht. Folge einfach den weiteren Anweisungen auf dem Bildschirm.[31]

As in the previous experiments, participants were given the opportunity to ask questions after they read the written instructions and after they finished the practice trials. The assignment of the left and right button to

[31] English translation: *Task – real or made-up word? Your task is to evaluate whether words, which appear on the computer monitor, are real or made-up German words. In every trial you will see a set of three things, which will be presented sequentially: (1) A cross: It shows you, where the words will appear. (2) 1. Word: either one of the articles "a", "the", "his" or "xxxx". (3) 2. Word: a noun or a made-up word that might look like a noun. The first word might be a correct or false article or the filler "xxxx"; you can ignore the correctness, thus the first word is simply for you to read, not to judge. When the second word appears, your task is to decide by button press if it is a real German word or if it is a made-up word: Please press the yellow (right) button if you think it is a real word and press the blue (left) button if you think it is a made-up word. [Examples table] As soon as you press one of the buttons, the next trial will be presented. In case you do not press any button or if your reaction is too slow (which sometimes happens ☺), the next trial will be presented automatically. Try to make your decisions as quickly but also as accurately as possible. In the beginning you will see a few practice trials after which you will have a short break to ask any questions before the main experiment begins. You may simply follow the instructions on the computer screen.*

word or pseudoword answers was counterbalanced and reaction times were measured from target onset.

2.3.2.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (overall error and time-out rate: 2.15%) were removed. Furthermore, a subject and item analysis of errors was conducted in order to test, whether any participants or items showed an undue number of errors. One item, *Uroma* (*great-grandmother*), was again excluded as it had an error rate of 65% (for possible explanation see section 2.2.1.2 above). Additionally, outlier trials with reaction times beyond three standard deviations from mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 1.57% of all correct answers (excluding *Uroma*)).

Concept Type, Determiner Type, and Gender Congruence

Looking at the mean reaction time data of experiment 4 in figure 2.17 the graph suggests the same concept type differences that the data of experiment 1-3 showed: fastest lexical decision times for functional nouns, followed by sortal, individual nouns, whereas relational nouns are the slowest nouns. Examining the data with regard to combinations of determiner type and concept type, the data seem to show some visible effects, however, a closer look reveals rather surprising patterns. In summary and as a reminder, the expected patterns were:

- facilitation by indefinite determiner for sortal nouns
- facilitation by definite determiner for individual nouns
- facilitation by indefinite and possessive determiner for relational nouns
- facilitation by definite and possessive determiner for functional nouns

Figure 2.17 shows lexical decision times for the complete data set (after the cleaning described above). Thus correct and incorrect gender trials are summarized in figure 2.17 and the following description of the interaction patterns. (However, we will see in figure 2.18, that the patterns do not differ, if we only look at the data for correct gender.)

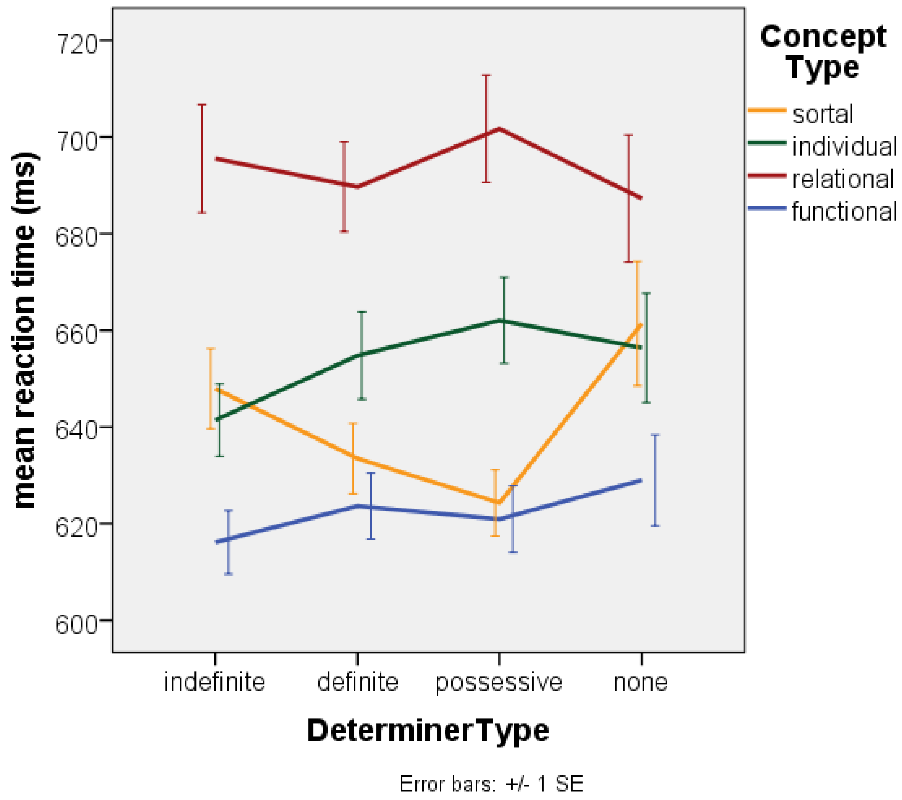

Figure 2.17: Lexical decision latencies for nouns of different concept types in combination with different determiner types in German visual LDT (overall)

For sortal nouns (yellow line), the graph suggests a clear facilitation effect when combined with the possessive – incongruent – determiner followed by the definite determiner (both in comparison to the no-determiner condition). The congruent indefinite determiner only caused a minor facilitation compared to the no-determiner condition. For individual nouns, the green line again is rather flat, but – compared to the no-determiner condition – shows a slight facilitation only for combination with the indefinite – incongruent – determiner. Definite (congruent) determination does not have any influence (compared to the no-determiner condition) and possessive determination shows a very slight inhibitory effect (also compared to the no-determiner condition), which fits our hypotheses (though it is a very small effect).

The red line showing relational nouns suggests the exact opposite of the expected pattern: figure 2.17 shows a slight inhibition effect for the congruent combinations with possessive and indefinite determination and no effect for the definite determiner (again all determiners are compared to the no-determiner condition). Functional nouns show almost the same mean lexical decision time for all four determiner types. If we look at the milliseconds level we could identify a slight facilitation effect caused by the incongruent indefinite determiner and a tiny facilitation effect caused by the – congruent – possessive determiner, however, these differences to the no-determiner condition are so very small, that they will probably not withstand the statistical test.

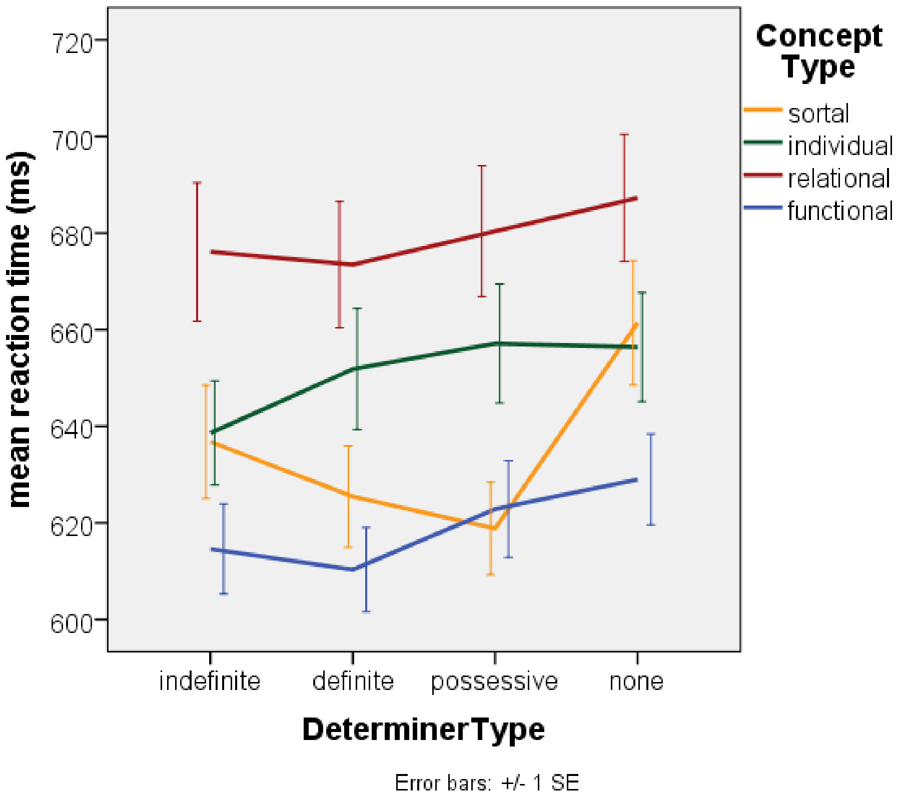

Figure 2.18: Lexical decision latencies for nouns of different concept types in combination with different determiner types in German visual LDT (only correct gender cases)

If we look at the correct gender trials only (in figure 2.18), the patterns are almost the same as the overall representation. Only the inhibitory effect of possessive determination on relational nouns and the tiny facilitation effect of possessive determination on functional nouns have vanished, and a slight facilitation effect of definite determination on functional nouns has been added to the data. Apart from that, the data including and excluding the incorrect gender trials look very much the same, which suggests no interaction effect of gender congruence with a concept type congruence effect.

For a preliminary analysis of a possible interaction of the factor Gender Congruence {correct, incorrect} with the factors Concept Type {sortal, individual, relational, functional} and Determiner Type {indefinite, definite, possessive} a repeated measures ANOVA was conducted. The no-determiner cases were excluded, as they cannot show any interaction. The ANOVA yielded no significant interaction[32], $F(4.54, 631.14) = .30$, $p = .897$. Therefore the factors Gender Congruence on one hand, and Determiner Type × Concept Type on the other hand were analyzed separately (including the no-determiner cases); the latter conforms to the procedure for experiments 1-3.

Concept Type and Determiner Type

In order to test, whether the described facilitation effects can be supported by statistical analyses, mean reaction times were submitted to *IBM SPSS Statistics* in order to conduct a repeated measures analysis of variance (ANOVA). The four by four repeated measures ANOVA was conducted with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(5) = 38.68$, $p = .000$, the main effect of Concept Type, $\chi^2(5) = 35.65$, $p = .000$, as well as for the interaction, $\chi^2(44) =$

[32] Sphericity was violated for the interaction analysis, $\chi^2(20) = 108.94$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .76$) was used to correct the degrees of freedom.

220.82, p = .000. For that reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom (ε = .83 for the main effect of Determiner Type, ε = .86 for the main effect of Concept Type, and ε = .69 for the interaction effect).

The results of the repeated measures ANOVA showed neither a significant main effect of Determiner Type, $F(2.50, 347.02) = .63$, $p = .566$, nor a significant interaction effect of the factors Determiner Type and Concept Type, $F(6.25, 868.66) = 1.93$, $p = .07$, though the data show a slight trend towards an interaction effect. There was, however, a significant strong main effect of Concept Type, $F(2.58, 358.74) = 50.92$, $p = .000$, $r = .52$ (see figure 2.19).

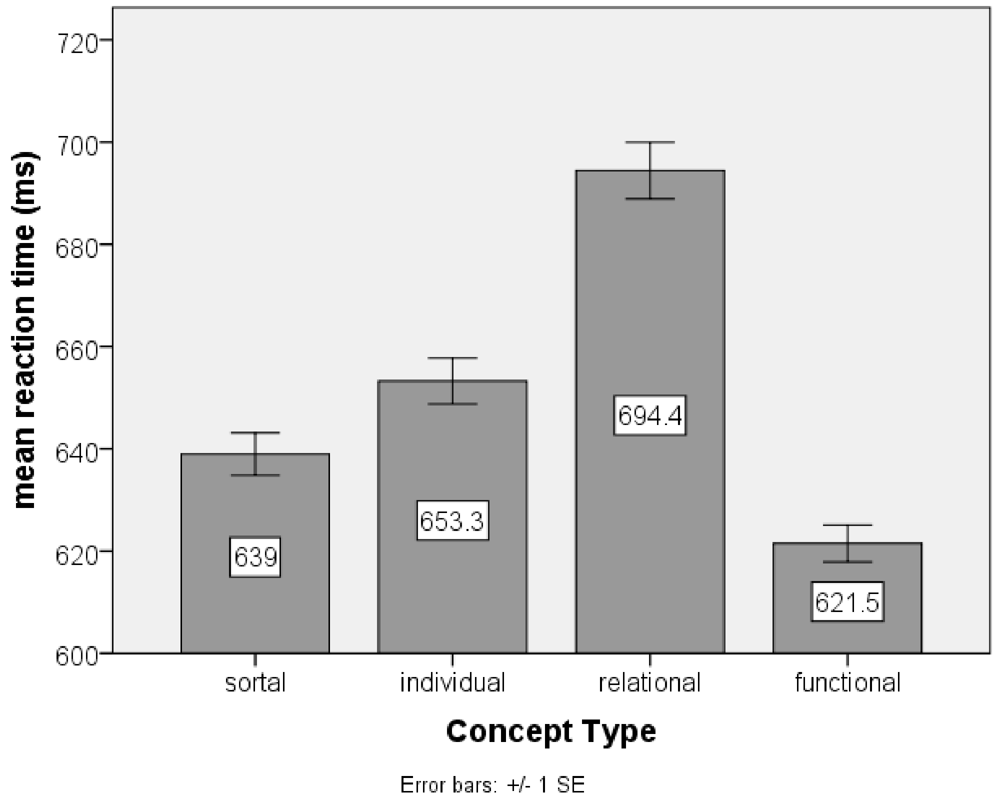

Figure 2.19: Lexical decision latencies for different concept types in German visual LDT

Planned contrasts showed the same pattern as the respective results of experiment 3: There were significantly faster responses for sortal nouns compared to individual, $F(1,139) = 5.75$, $p = .018$, $r = .20$, and relational nouns $F(1,139) = 71.35$, $p = .000$, $r = .58$. However, functional nouns had significantly faster responses compared to sortal nouns, $F(1,139) = 14.94$, $p = .000$, $r = .31$. Post hoc pairwise comparisons (with Bonferroni's α-correction) additionally show that individual and functional nouns yielded faster responses than relational nouns, and functional nouns yielded faster responses than individual nouns (for all comparisons $p = .000$).

As for previous experiments, a more general analysis of overall congruence (comparing all congruent combinations with all incongruent combinations and using the no-determiner condition as a control) might more explicitly show the nature of the congruence effect.

Overall Congruence and Gender Congruence

For the overall congruence analysis of experiment 4 the same categories were grouped together as described in the respective section of experiment 1. The expected pattern for this analysis is facilitation for congruent combinations and a possible inhibition for incongruent combinations, or at least an equal mean lexical decision time as for the neutral baseline condition. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2), a linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none\_}mean / RT_{none\_}mean\_by\_concept\_type$). Surprisingly, figure 2.20 shows the reverse pattern compared to the expected outcome for the overall data (including correct and incorrect gender trials): the bar chart suggests facilitation for incongruent conditions compared to both, congruent and no-determiner conditions, whereas there is almost no difference between congruent and no-determiner conditions.

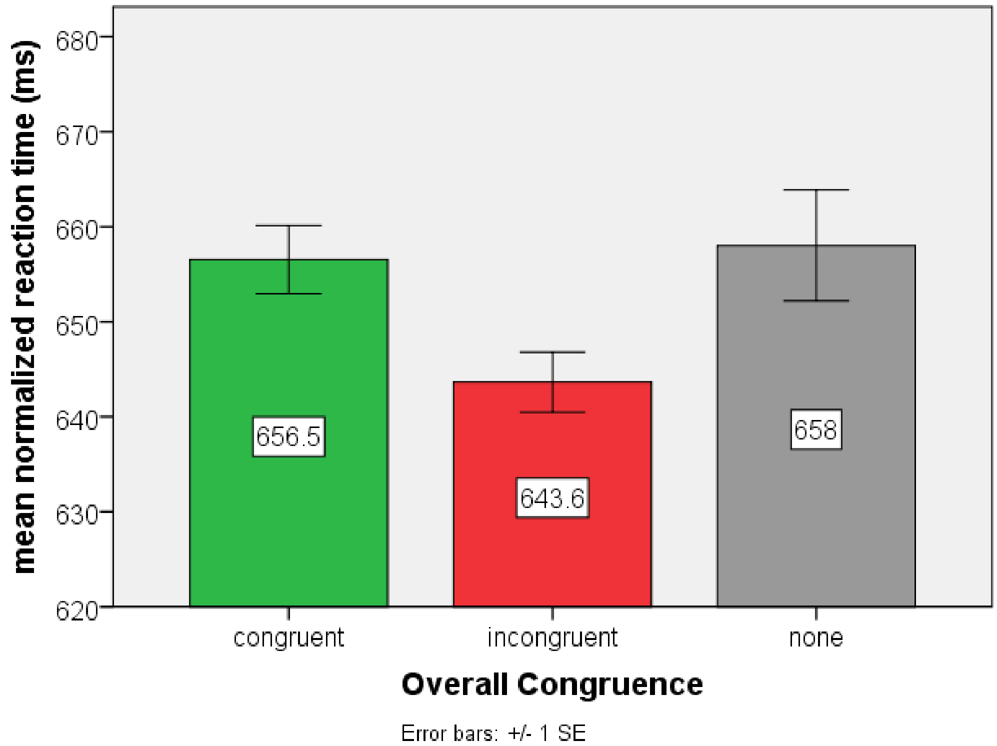

Figure 2.20: Lexical decision latencies for nouns used with congruent, incongruent and no-determiner in German visual LDT (overall)

If the incorrect gender trials are excluded (figure 2.21), the pattern is similar, however, the reverse effect becomes smaller. The difference between the faster incongruent and the slower congruent cases is reduced – although still visible, and overall a slight facilitation can be seen for congruent cases if compared to the no-determiner conditions.

A preliminary analysis of a possible interaction of the factors Gender Congruence and Overall (conceptual) Congruence – the no-determiner cases were excluded, as they cannot show any interaction (the neutral baseline condition is the same for Gender as well as Overall (CT) Congruence) – yielded no significant interaction, $F(1, 139) = .97$, $p = .327$. Therefore the factors Gender Congruence and Overall Congruence are analyzed and reported separately (including the no-determiner cases) and the factor Overall Congruence will be conducted for the complete data set (as the lack of interaction with Gender Congruence spares the separation of data into correct vs. incorrect gender cases).

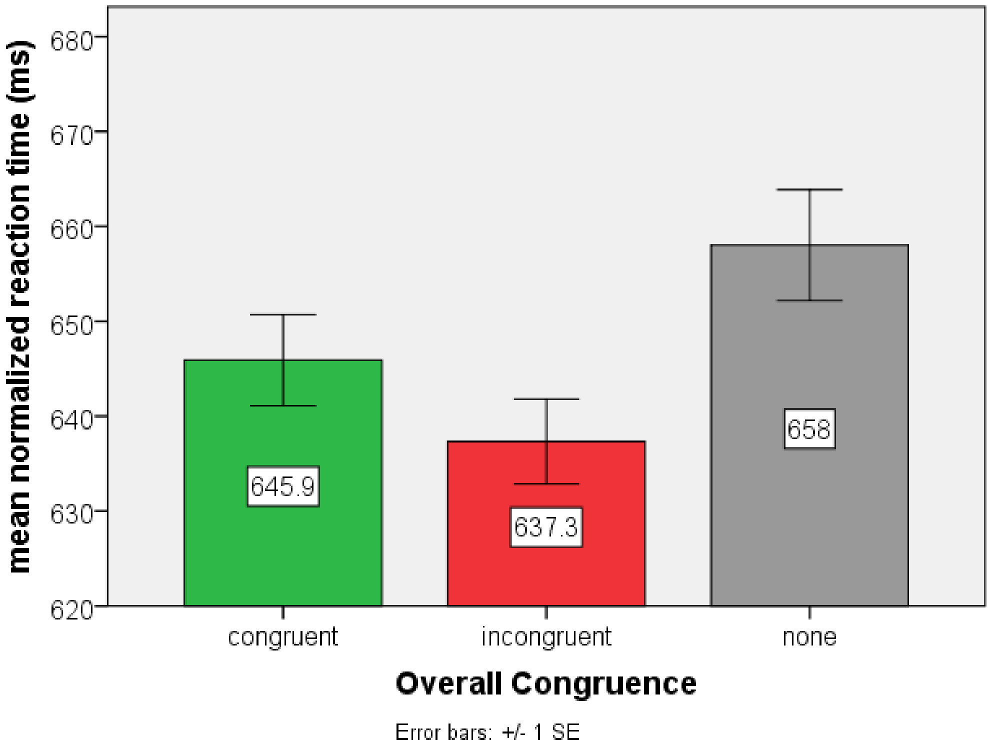

Figure 2.21: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT (only for correct gender trials)

Overall Congruence

In order to test the significance of the described reverse congruency effect, a one-way repeated measures ANOVA was conducted with the factor Overall Congruence {incongruent, congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence, $\chi^2(2) = 14.84$, $p = .001$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .91$) was used to correct the degrees of freedom. The results of the ANOVA showed a significant effect of Overall Congruence, $F(1.82, 252.28) = 4.23$, $p = .019$, $r = .17$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases but no influence or an inhibition by incongruent cases (vs. none), and revealed significantly faster responses for incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 139) = 5.93$, $p = .003$, $r = .20$, and, surprisingly, also compared to congruent combinations, $F(1, 139) = 9.08$, $p = .016$, $r = .25$.

Gender Congruence

This experiment incorporated a gender congruence variable that manipulated gender correctness. Incorrect gender trials were added and were expected to show slower reaction times compared to correct gender trials, and a possible inhibitory effect for incorrect gender compared to no determiner – studies on lexical gender information showed varying results concerning a facilitating effect of correct gender and/or an inhibitory effect of incorrect gender, as described in section 1.2.1.

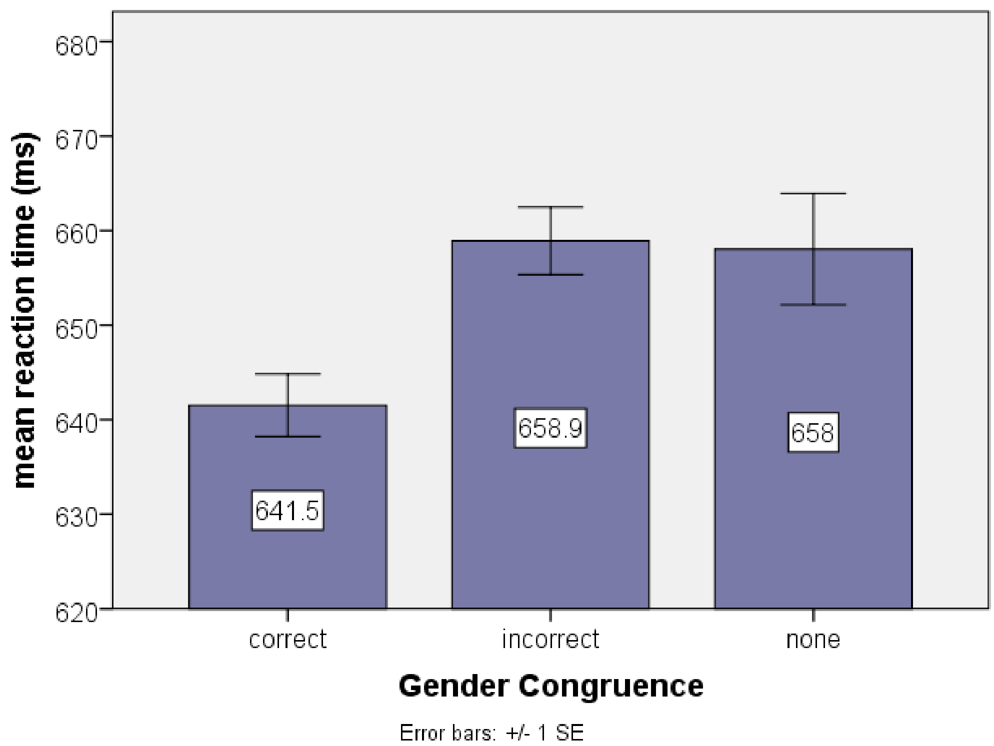

Figure 2.22: Lexical decision latencies for nouns used with congruent and incongruent gender, and no determiner in German visual LDT

The lexical decision time data of experiment 4 (shown in figure 2.22) suggest that the previously reported gender facilitation effect of congruent gender information can be validated by our data, while there does not seem to be any difference between incorrect gender and no-determiner cases.

In order to show if the described facilitation effect of correct gender can be supported by statistics, a one-way repeated measures ANOVA was conducted with the factor Gender Congruence {incorrect, correct, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Gender Congruence, $\chi^2(2) = 50.85$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .76$) was used to correct the degrees of freedom.

The results of the one-way repeated measures ANOVA showed a significant effect of Gender Congruence, $F(1.53, 212.51) = 7.57$, $p = .002$, $r = .23$. Planned contrasts (simple (last)) compared correct and incorrect gender cases to no-determiner cases, and revealed significantly faster responses for matching gender (gender congruent) noun-determiner combinations compared to the cases where no determiner was used, $F(1, 139) = 7.18$, $p = .008$, $r = .22$. The contrast of mismatching gender (gender incongruent) compared to no-determiner cases yielded no difference, $F(1, 139) = 0.16$, $p = .69$.

Additionally, a selective post hoc comparison of correct vs. incorrect gender cases showed significantly faster responses for noun-determiner combinations carrying correct gender information ($p = .000$). Thus the results of the ANOVA support the findings of Bölte and Connine (2004) and others (cf. section 1.2), who found (only) a facilitating effect of correct gender but no inhibitory effect of incorrect gender.

2.3.2.3 Summary and Intermediate Discussion

Experiment 4 investigated the nature as well as a possible interaction of the gender congruence effect on the concept type congruence effect. The results showed a significant gender congruence effect, in that processing of nouns preceded by a matching gender determiner was facilitated in comparison to nouns presented with mismatching gender. Compared to the no-determiner condition, there was no inhibitory effect of mismatching gender information. This finding is in line with the nature of the gender effect found by Bölte and Connine (2004) as well as others (cf. section 1.2.1), who also found a facilitating effect of matching gender information but no inhibitory effect of mismatching gender. Like in the previous experiment there was the same concept type effect to be found that showed faster responses for sortal and functional nouns compared to individual and relational (cf. section 2.2.1.3), however, the results lack an effect of determiner type.

The gender effect did not interact with the combination of concept type and determiner type or the overall congruence effect. The latter was statistically significant, but – very surprisingly – showed a pattern that was opposite from what was expected. Incongruent determiner-noun combinations (with respect to conceptual congruence) showed faster responses than congruent combinations, while the latter did not differ from the baseline condition. These findings are not in line with the results of experiment 2 or the CTD. Apparently, the presence of gender manipulation in the preceding determiner influences the processing of conceptual type information. But why is it that this manipulation causes a facilitation of concept type incongruent determiner-noun combinations and (compared to experiment 1-3) an inhibition of congruent combinations? From the present point of view, no sensible explanation can be stipulated for this finding, but this issue might be resumed in the final discussion, if further experiments yield clarifying results. Admittedly, the experiment might have shown different results, had the auditory lexical decision paradigm been used, and in retrospect, it would have been sensible to replicate it in the auditory modality. However, in this line of research, another logical step was pursued.

In summary, experiment 4 showed a clear gender effect of approximately 20 ms, hence we can conclude that the concept type congruence data of all German experiments contain an additive gender effect. Experiments 1 and

2 were replicated for the English language that does not mark grammatical gender (see following section 2.4) in order to explore the concept type congruence effect devoid of the gender effect. Conducting the experiments in a different language also allowed for a comparison of the effects across languages, and thus shows if conceptual type information is utilized in English, and if so, whether the same patterns are visible as in German.

Summarizing all German experiments reported so far, it can be said that for German lexical decision experiments a reliable concept type congruence effect could only be obtained in the auditory modality. The results of experiment 2 show an overall congruence effect as well as the expected detailed effects for the different determiner and concept type/referential property combinations. Why these results could not be shown with the same significance for German visual lexical decision experiments remains an open question.

2.4 English Experiments[33]

The English lexical decision experiments in this section allow for a comparison of the previously shown congruence effects. Experiments 5 and 6 were designed to replicate experiments 1 and 2 in a language that does not mark grammatical gender and to show to which extent the congruence effects, that were observed in the German (auditory) lexical decision experiments, arose due to an added gender effect. Furthermore, the possibility of an inhibition of incongruent determiner-noun combinations was investigated.

The following two experiments were conducted using the same participants (who participated in both experiments), the English visual lexical decision task in experiment 5, as well as the English auditory lexical decision task in experiment 6. Therefore, I choose a different approach to

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[33] English lexical decision experiments in this section were conducted in collaboration with Prof. Dr. Guillaume Thierry from the School of Psychology @Bangor University, United Kingdom (http://www.bangor.ac.uk/psychology/index.php.en)

report the experiments and to present the data. First, the methods of the two experiments are presented separately, in order to clarify how each experiment (or experiment part) was conducted (cf. sections 2.4.1 and 2.4.2).

Afterwards the results for both experiments will be presented in section 2.4.3. Task order (i.e. the order in which the subjects performed the two parts of the experiment) was balanced. Due to the modality difference between German and English lexical decision experiments, a modality effect can be expected for the English lexical decision experiments, too. As for the previous experiments, a compact overview of the results of these two experiments will be given in chapter 2.5.

2.4.1 Experiment 5: English Visual Lexical Decision – Material and Methods

Participants

Experiment 5 tested 96 native speakers of English, mostly students of Bangor University, Wales (70 women, 26 men; mean age M = 19.77 years, SD = 2.69). They were paid a small fee for their participation.

Materials

The materials of experiment 5 (which are also used in experiment 6) partly consisted of translations of nouns used in the German lexical decision experiments. Due to the concept type balancing requirements (frequency in CELEX database, number of letters, phonemes and syllables) not all nouns from the German experiments could be used, thus they were substituted with a new set of nouns. The concept type classification of complementary nouns was based on the independent semantic evaluation of two annotators.

The author and a native English speaker[34] both used the following brief version of the annotation manual by Horn (2012, submitted):

Guidelines for Annotation
(shortened and modified version of Horn (2012, submitted))

1. Consider the meaning variant in the following sentence at the beginning of a story: „This is the X." Does this use trigger intuitive questions for more information?

- No for [+U, -R] → individual nouns like *sun* (e.g. in *This is the sun*.), as they leave no doubt about the referent and do not have any inherent relationship.
- Yes – various choices possible including which? Whose? By/for whom? Between what? With respect to what? Why?

2. Relationality: [+R] or [-R]?

- Potential referent has an inherent kind of relationship to another entity
  Yes → [+R]
  - part-of (*branch* (*of a tree*)),
  - kinship-term (*uncle*)
  - related by emotion (*pet*)
  - body-part (*arm*) or extension (*wheel chair*)
  - social roles (*president*)
  - spatial relations (*beginning*)
  - limited access (*password*, *website*)
  - personal data and documents (*passport*, *age*)
- Nominalization of a ditransitive verb (here the inherent verb arguments may be passed over to the noun)
  Yes → [+R] (?)
  - description of a process, result of process or state (*observe* – *observation*);
  - verbal counterparts with same stem and closely related meaning
    (*(the) cook* – *to cook* vs. *(the) man* –**to man*);
- Existence of a non-relational counterpart (*mother* – *woman*)
  Yes → [+R];

3. Uniqueness: [+U] or [-U]?

- How many arguments does the noun exhibit?
  - flower (x): 1 argument

[34] Special thanks to Dr. Ian Fitzpatrick from project A04 of the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en) & Donders Institute for Brain, Cognition, and Behaviour, Nijmegen, The Netherlands (http://www.ru.nl/donders/) for his annotation and consultation.

- sister (x, y): 2 arguments (*sister of Thea*);
- distance (x, y, z): 3 arguments (*distance between Nijmegen and Düsseldorf*)

- For [–R] a.k.a. 1-place nouns: Is there only one referent independent of the context in which the noun occurs?
  - Yes → [+U] as there is only one *God*, *sun*
  - No → [–U] as there is more than one *stone*, *tree*
- For [+R] a.k.a. 2/3-place nouns: Is there only one referent if possessor is uniquely determined?
  - Yes → [+U] as there is only one *mother (of Thea)*, *president (of USA);*
  - No → [–U] as there could be more than one *brother (of Thea), member (of the SFB)*

This guideline allowed a proper annotation process, by providing criteria for deciding about the features of nouns. With the given criteria and examples the respective questions could be answered sequentially, and, as a result, following the (implicit) decision tree allowed determining the values of both features.

According to the procedure for experiments 1-4, the nouns that were selected from the annotated list of nouns (a list of all target stimuli used in experiments 5 and 6 is provided in Appendix II) were matched for lexical frequency in CELEX database (Baayen, Piepenbrock, and Gulikers, 1995), number of letters, number of phonemes, and number of syllables. As in the German lexical decision experiments, the nouns were combined with indefinite (*a/an*), definite (*the*), and possessive (*his*) determiners. As the fourth "type" of determination or rather the neutral baseline *xxxx* was used again. A set of 80 pseudowords was created from the word stimuli using the software Wuggy[35], which is a multilingual pseudoword generator designed to generate non-word stimuli for psycholinguistic experiments, which respect the phonotactic rules of the target language (Keuleers and Brysbaert, 2010). The further procedure for processing the experimental materials (creating input lists, counterbalancing conditions, randomization, etc.) corresponds to the procedure described in experiment 1.

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[35] http://crr.ugent.be/programs-data/wuggy

Procedure and Apparatus

Experiment 5 used the same set-up and apparatus as experiment 1, except for the lack of a sound attenuated booth. Instead participants were seated in a separate experiment room, where – after having received the experimental instructions – they were alone for the duration of the experiment. As in the previous experiments written instructions were used to convey the lexical decision task:

Instructions

This experiment consists of about 180 trials, in each of which you will see 3 items sequentially presented on the computer screen:

- *a cross that marks the beginning of a trial*
- *1. one of the words "a/an", "the" or "his" or the string "xxxx"*
- *2. a string of letters which can either be an existing English word or a nonsense word, that might look like an English word.*

The cross as well as the first word ("a/an", "the", "his" or "xxxx") is just for you to read. On the second word your task is to decide whether this string of letters is an existing English word or not. If you think it is an existing English word, please click the ***yellow*** *(yes) button. If you think it is not an existing English word, thus a nonsense word, please click the* ***blue*** *(no) button.*

Examples:

Trial	*1*	*2*	*3*	*4*
cross	**+**	**+**	**+**	**+**
1. word	***a***	***the***	***his***	***xxxx***
2. word or nonsense word	***mouse***	***levantion***	***petriller***	***car***
correct button	***Yes, English word***	***No, nonsense word***	***No, nonsense word***	***Yes, English Word***

If you are sure that the word exists, even though you don't know its exact meaning, you may still respond "yes" and click the yellow button. But if you are not sure if it is an existing word, you should respond "no" by clicking the blue button. As soon as you make your decision and press a button, the following trial begins. In case you think you might have pressed the wrong button: don`t worry, hap-

pens to anyone. Just continue with the following trials. Also if you can't make a decision on one of the trials, the following trial will be presented automatically after a few seconds. Please answer as ***quickly*** *and as* ***accurately*** *as possible. We will start with a few warming up trials, so you can familiarize yourself with the experimental setup. After that you get a small break, just in case you have further questions. If everything is clear, we can then start the experiment.*

Like in the German experiments, they were given the opportunity to ask questions after they read the written instructions and after they finished the practice trials. The assignment of the left and right button to word or pseudoword answers was counterbalanced, and reaction times were measured from target onset.

2.4.2 Experiment 6: English Auditory Lexical Decision – Material and Methods

Participants

Experiment 6 tested the same 96 native speakers of English (as experiment 5), mostly students of Bangor University, Wales (70 women, 26 men; mean age M = 19.77 years, SD = 2.69). They were paid a small fee for their participation.

Materials

In experiment 6 the same materials as in experiment 5 (nouns, pseudowords, warm-ups, determiners and lists) were used. However, as experiment 6 was designed as an auditory lexical decision experiment, the materials were spoken, recorded and processed as sound stimuli, which were then presented via headphones. All experimental items (word and pseudoword stimuli, determiners and warm-ups) were spoken by a male English native speaker[36] and were recorded in a sound attenuated booth.

[36] Special thanks to Ian Fitzpatrick, who gave this experiment his voice.

The technical specifications and procedure for recording and further processing of the sound stimuli were equivalent to the procedural method described in experiment 2. For experiment 6 the same conditions and lists were used as in experiment 5, but as a fourth type of determination, the no-determiner or baseline condition, a noise stimulus was used as an equivalent for the previously used visual filler stimulus *xxxx*. This stimulus was constructed by using brown noise with the same length as the mean length of the determiner stimuli. As an equivalent to the visual fixation cross in experiment 5 the warning beep sound (standard Windows XP beep sound) was used – as in experiment 2.

Procedure and Apparatus

Experiment 6 used the same set-up and apparatus as experiment 5 except for the additional headphones. As in experiment 5, participants were given written instructions to inform them about the task they were asked to do:

> ***Instructions***
> *This auditory experiment consists of about 180 trials, in each of which you will hear 3 items sequentially presented via the headphones:*
>
> - *a short beep sound that marks the beginning of a trial*
> - *1. one of the words "a/an", "the" or "his" or a noise sound*
> - *2. a word which can either be an existing English word or a nonsense word, that might sound like an English word.*
>
> *The beep sound as well as the first word (a/an, the, his or noise) is just for you to listen to. On the second word your task is to decide whether this item is an existing English word or not. If you think it is an existing English word, please click the* ***yellow*** *(yes) button. If you think it is not an existing English word, thus a nonsense word, please click the* ***blue*** *(no) button.*
>
> ***Examples:***

Trial	*1*	*2*	*3*	*4*
beep	*beep*	*beep*	*beep*	*beep*
1. word	***a***	***the***	***his***	**noise**
2. word or nonsense word	***mouse***	***levantion***	***petriller***	***car***
correct button	***Yes, English word***	***No, nonsense word***	***No, nonsense word***	***Yes, English Word***

If you are sure that the word exists, even though you don't know its exact meaning, you may still respond "yes" and click the yellow button. But if you are not sure if it is an existing word, you should respond "no" by clicking the blue button. As soon as you make your decision and press a button, the following trial begins. In case you think you might have pressed the wrong button: don`t worry, happens to anyone. Just continue with the following trials. Also if you can't make a decision on one of the trials, the following trial will be presented automatically after a few seconds. Please answer as ***quickly*** *and as* ***accurately*** *as possible. We will start with a few warming up trials, so you can familiarize yourself with the experimental setup. After that you get a small break, just in case you have further questions. If everything is clear, we can then start the experiment.*

Again, like in experiment 5, participants were given the opportunity to ask questions after they read the written instructions and after they finished the practice trials. The assignment of the left and right button to word or pseudoword answers was counterbalanced, and reaction times were measured from target onset.

2.4.3 Experiments 5 and 6: Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (RT longer than 3000 ms for visual LDT and longer than 5000 ms for auditory LDT) were excluded from all analyses (overall error and time-out rate: 2.45%). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject, modality and concept type) in both directions were removed (outlier rate: 1.01% of all correct answers).

Concept Type, Determiner Type and Modality

Looking at the data of the English lexical decision experiments – first in an overall manner, i.e. combining the data for visual and auditory lexical decision experiments – figure 2.23 suggests a difference in the distribution of the concept types across the reaction time scale. While in the German data relational nouns were the slowest of all concept types, followed by individual nouns, in English apparently functional nouns – the fastest nouns in German experiments – seem to be the slowest nouns, followed by relational and then individual nouns, while sortal nouns with some distance seem to be the fastest to process.

Concerning the combination of the four concept types with the four determiner types, the first impression is a clear effect for individual and relational nouns and rather diffuse results for functional and sortal nouns, perceivable in the form of rather flat lines in the graph. In order to examine the visible effects, a short summary of the expected effects shall be recapitulated. We expect facilitation for congruent determiner-noun combinations (and a possible inhibition for incongruent determiner-noun combinations). For the four concept types this means:

- facilitation by indefinite determiner for sortal nouns (and inhibition by definite and possessive determiner)
- facilitation by definite determiner for individual nouns (and inhibition by indefinite and possessive determiner)
- facilitation by indefinite and possessive determiner for relational nouns (and inhibition by definite determiner)
- facilitation by definite and possessive determiner for functional nouns (and inhibition by indefinite determiner)

Examining the lexical decision data across both modalities, figure 2.23 suggests only some of the expected effects, however, not for all concept types (in the examination of each concept type mean reaction times for all determiners were compared to the no-determiner condition). As mentioned before, the flat line for sortal nouns (yellow line) indicated that the interaction effect of concept type and determiner type is very small. A closer look reveals facilitation for sortal nouns in combination with any determiner type in comparison to the no-determiner condition. This is surprising for English, considering that the determiner does not convey any gender information or other morphological cues. The “strongest” facilitation was caused by the congruent indefinite determiner, which is in line with the expected outcome. However, there is only a very small difference to the other determiners.

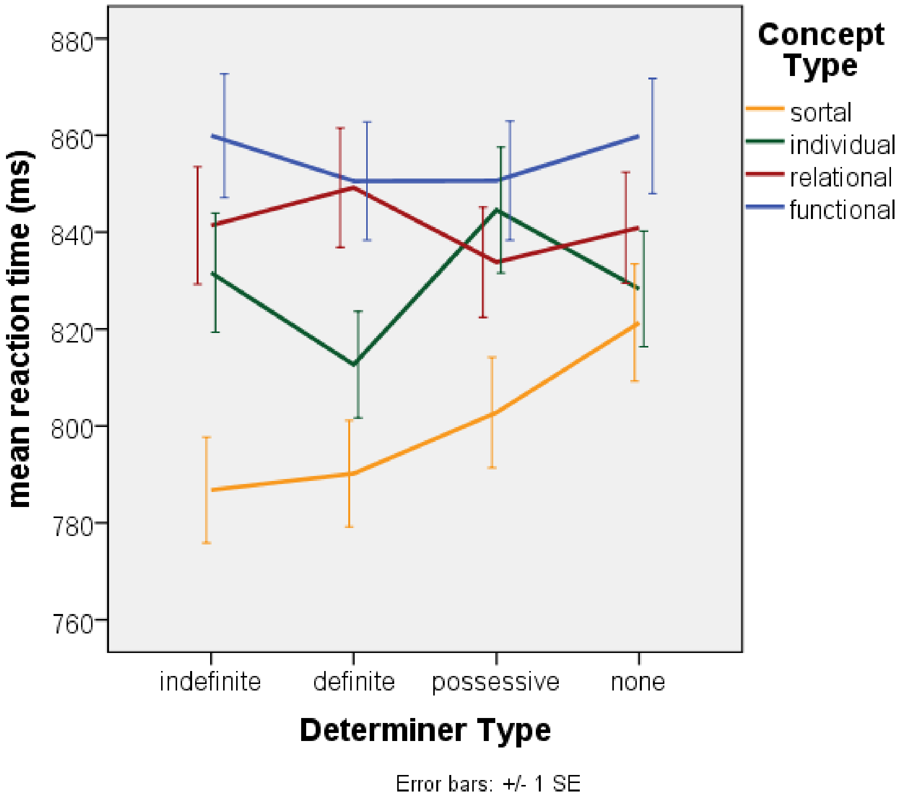

Figure 2.23: Lexical decision latencies for nouns of different concept types in combination with different determiner types in English visual and auditory LDT (overall)

For individual nouns (green line), the graph shows facilitation for the congruent definite determiner, a slight inhibition for the incongruent possessive determiner, and no effect for the incongruent indefinite determiner. For relational nouns (red line), the inverse pattern is visible: the graph shows a slight facilitation by both congruent determiners, indefinite and possessive, and a slight inhibition by the incongruent definite determiner. Functional nouns (blue line) yield even fewer differences than sortal nouns: A minimal facilitation might be observed for the congruent definite and possessive determiner, and no effect for the indefinite determiner, however, the facilitation effect of the congruent determiners is barely visible.

These data show a trend towards some of our expected effects, but the results for some of the concept types seem to be rather flat. As we have seen major differences in the results of visual and auditory data in the German lexical decision results, modality might play a role in English lexical decision experiments as well. Therefore a separate examination for the visual and the auditory modality might shed more light on the data. Comparing the data for the visual modality in figure 2.24 and the data for the auditory modality in figure 2.25 clear differences are visible. It is evident that the overall flat configuration of the visual data contrasts with the very pronounced effects visible in the auditory data.

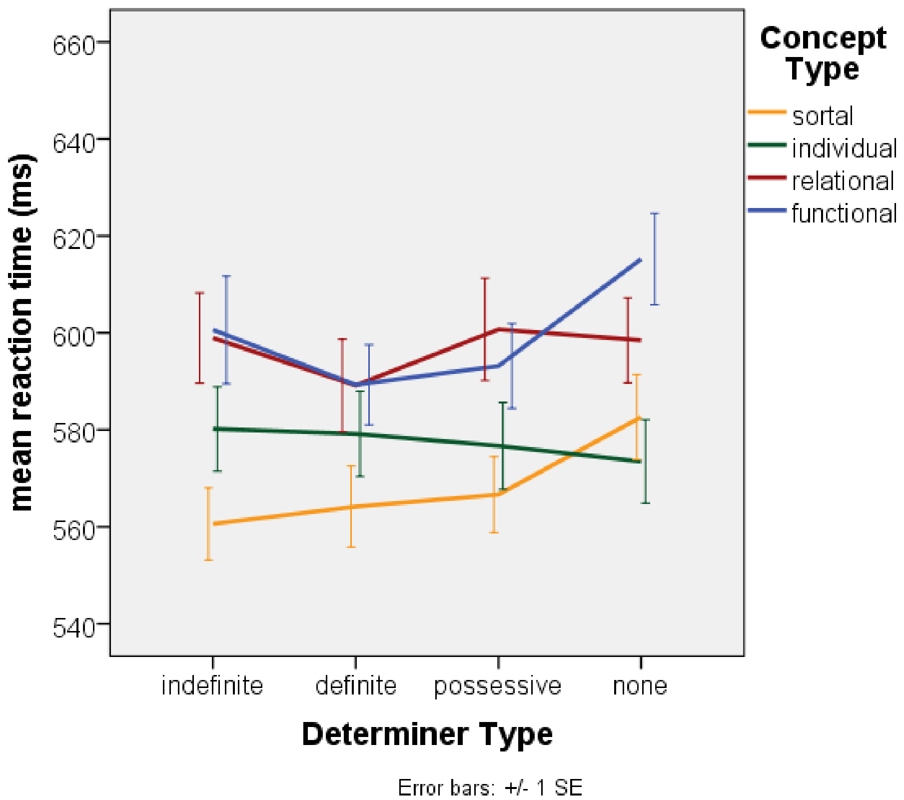

Figure 2.24: Lexical decision latencies for nouns of different concept types in combination with different determiner types for English visual LDT

For sortal nouns (yellow line), in the visual experiment (see figure 2.24) the lexical decision times for congruent and incongruent determiners are similar to the overall data. All determiners slightly facilitate the lexical decision on sortal nouns, but only a very minimal advantage of congruent, indefinite determination is visible compared to incongruent, definite and possessive determination. Individual nouns (green line) surprisingly show no facilitation effect of the determiners at all. Mean reaction times for congruent definite and incongruent, indefinite and possessive determination rather show a slight inhibition compared to the no-determiner condition (strongest for indefinite, definite and possessive almost equal).

Relational nouns (red line) show a very slight facilitation caused by the incongruent definite compared to the no-determiner condition, while the two congruent determiners, indefinite and possessive, caused longer latencies, that were equal to the no-determiner condition. For functional nouns (blue line) all determiners caused facilitation, with the strongest effect caused by the congruent determiners, definite and possessive. However, the difference to the mean lexical decision time caused by the indefinite determiner is also very small. In summary, English visual lexical decision data shows very few of the expected effects and if so, the differences to the other conditions are minute.

A closer look at the lexical decision latencies of the English auditory lexical decision experiment (figure 2.25) shows quite pronounced effects. Sortal nouns (yellow line) were again facilitated by all determiners compared to the no-determiner condition. The strongest facilitation of sortal nouns was caused by the congruent, indefinite as well as the incongruent, definite article in comparison to the no-determiner condition. Individual nouns (green line) – as expected –show a strong facilitation caused by the congruent, definite determiner. Incongruent indefinite determination did not cause any difference compared to presenting the noun without any determiner, and the incongruent possessive determiner even caused a clear inhibition of individual nouns, which is one of the few cases where this line of research found an inhibition effect at all.

Relational nouns (red line) again show the reverse pattern. Processing of relational nouns is facilitated by indefinite and possessive determination – both congruent – and slightly inhibited by incongruent definite determination. This is also in line with our hypotheses. In the case of functional nouns (blue line) figure 2.25 shows a rather flat line that only indicates a very minimal facilitation by the congruent possessive determiner, but an inhibition by both, the incongruent indefinite article as well as the congruent definite article, which contrasts the hypothesis for functional nouns and the definite determiner.

Comparing figure 2.24 and 2.25 reveals a further difference between the modalities: visual noun recognition seems to happen in the 600 ms range, while at about 1050 ms auditory noun recognition takes considerably longer.

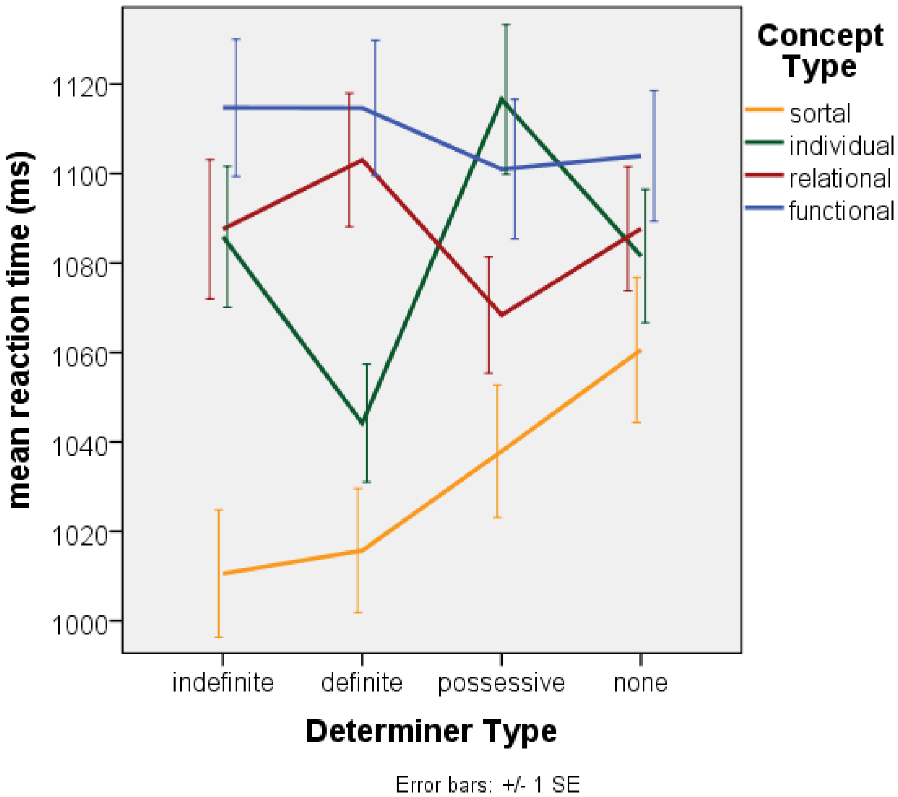

Figure 2.25: Lexical decision latencies for nouns of different concept types in combination with different determiner types for English auditory LDT

In order to test, whether the described effects can be supported by statistical analyses mean, reaction times were submitted to *IBM SPSS Statistics* in order to conduct a repeated measures analysis of variance (ANOVA). The two by four by four repeated measures ANOVA was conducted with the factors Modality {visual, auditory} × Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(5) = 18.93$, $p = .002$, for the 2-way interaction of Determiner Type and Concept Type, $\chi^2(44) = 130.33$, $p = .000$, and for the 3-way interaction of Modality, Determiner Type and Concept Type, $\chi^2(44) = 85.10$, $p = .000$. For that reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .87$ for the main effect of Determiner Type, $\varepsilon = .75$ for the 2-way interaction of Determiner Type and Concept Type, and $\varepsilon = .82$ for the 3-way interaction of Modality, Determiner Type and Concept Type).

The results of the repeated measures ANOVA showed that apart from the non-significant interaction of Modality and Determiner Type, $F(3, 285) = .44$, $p = .727$, and the marginal main effect of Determiner Type, $F(2.66, 252.54) = 2.45$, $p = .071$, all effects were significant (at $p < .05$).

There was a significant, large main effect of Modality, $F(1, 95) = 1221.22$, $p = .000$, $r = .96$, in that the auditory data showed slower responses than the visual data by almost 500 ms: the mean reaction time (in ms) for visual LDT was $M = 585.45$ ($SD = 2.25$), whereas the mean reaction time (in ms) for auditory LDT was $M = 1076.49$ ($SD = 3.74$).

There was also a significant, large main effect of Concept Type, $F(3, 285) = 37.27$, $p = .000$, $r = .53$ (see figure 2.26 below). Planned contrasts revealed significantly faster responses for sortal nouns compared to individual, $F(1, 95) = 27.98$, $p = .000$, $r = .48$, relational, $F(1, 95) = 53.92$, $p = .000$, $r = .60$, and functional nouns, $F(1, 95) = 94.20$, $p = .000$, $r = .71$. Additionally, post hoc comparisons (with Bonferroni's α-correction) showed that individual and relational nouns were processed significantly faster than functional nouns ($p = .000$ and $p = .030$).

The factor of Concept Type also showed a significant 2-way interaction with the factor of Modality, $F(3, 285) = 7.32$, $p = .000$, $r = .27$. Therefore the factor Concept Type will be revisited in the separate analyses for the visual and auditory data (see below).

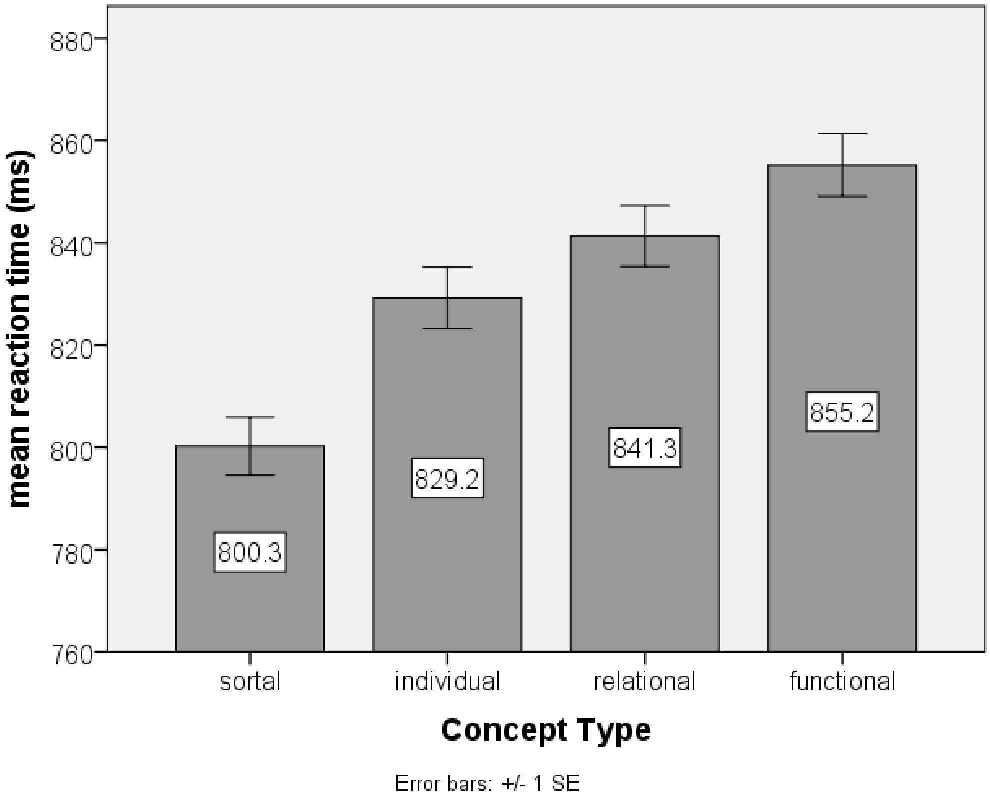

Figure 2.26: Lexical decision latencies for nouns of different concept types in English visual and auditory LDT (overall)

The (overall) results furthermore showed a small but significant interaction between Determiner Type and Concept Type, $F(6.78, 644.20) = 2.49$, $p = .017$, $r = .16$. Additionally, a small but significant interaction could be found between Modality, Determiner Type and Concept Type, $F(7.40, 702.90) = 2.31$, $p = .022$, $r = .16$. Due to the interaction with the factor Modality – which was also reflected in the heterogeneous patterns comparing figures 2.24 and 2.25 – and in order to examine, which Modality level caused the interaction, separate repeated measures ANOVAs with the factors Concept Type × Determiner Type were conducted for the visual and the auditory data in the following two sub-sections.

Concept Type and Determiner Type for English Visual Lexical Decision Experiment

In order to test, whether there is any significant outcome for the rather flat looking English visual lexical decision data (see figure 2.24), mean reaction times for visual LDT were extracted for a repeated measures analysis of variance (ANOVA) with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(5) = 33.16$, $p = .000$, as well as for the interaction, $\chi^2(44) = 210.21$, $p = .000$, thus the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .84$ for the main effect of Determiner Type, and $\varepsilon = .59$ for the interaction).

The results of the repeated measures ANOVA showed that the main effect of Determiner Type, $F(2.52, 239.56) = 2.08$, $p = .115$, and the interaction of Concept Type and Determiner Type, $F(5.29, 502.53) = .90$, $p = .487$, were not significant.

There was, however, a significant main effect of Concept Type, $F(3, 285) = 12.64$, $p = .000$, $r = .34$ (see figure 2.27). Planned contrasts (simple (first)) compared each concept type to sortal concepts, and revealed significantly faster responses for sortal nouns compared to relational, $F(1, 95) = 17.42$, $p = .000$, $r = .39$, and functional nouns, $F(1, 95) = 32.39$, $p = .000$, $r = .50$. There was no significant difference comparing sortal and individual nouns, $F(1, 95) = 2.46$, $p = .120$. Post hoc pairwise comparisons (with Bonferroni's α-correction) additionally showed that responses for individual nouns were significantly faster than for relational and functional nouns (for both comparisons $p = .046$ and $p = .001$).

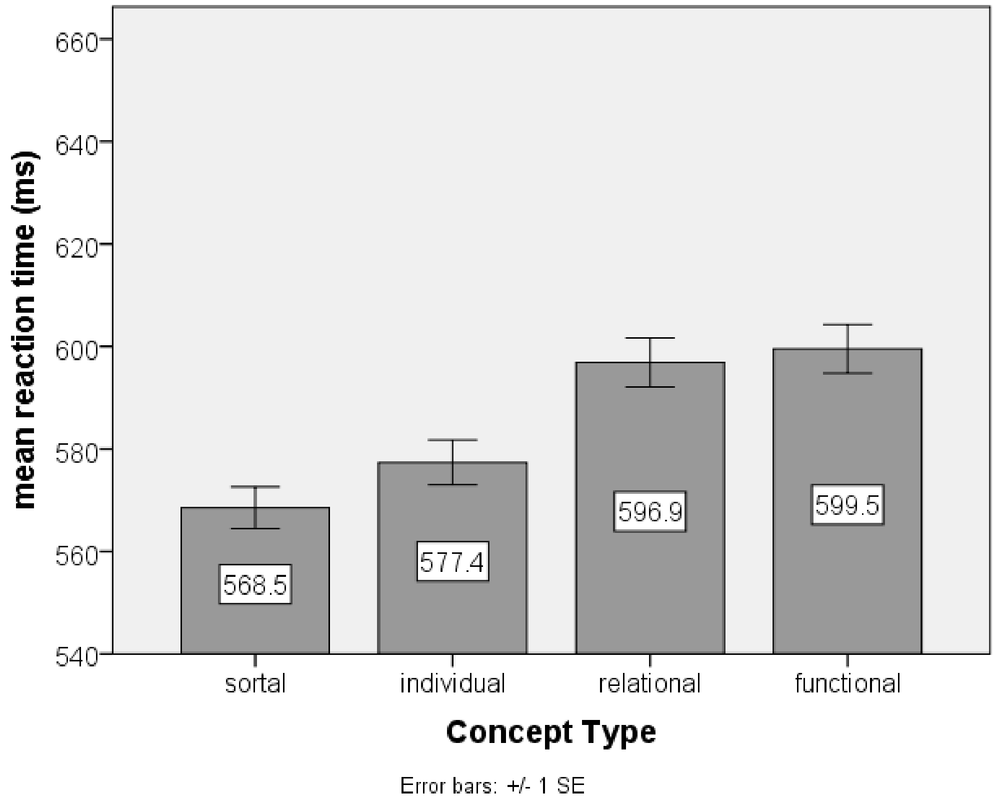

Figure 2.27: Lexical decision latencies for nouns of different concept types in English visual LDT

Concept Type and Determiner Type for English Auditory Lexical Decision Experiment

As the lexical decision data for the auditory part of the experiment showed stronger effects for the interaction between determiner type and concept type (see figure 2.25), and the overall ANOVA showed a significant interaction with modality, in this section the auditory data shall be examined. In order to test, whether the described facilitation effects for the English auditory lexical decision data can be supported by statistical analyses a repeated measures ANOVA was conducted with the factors Concept Type {sortal, individual, relational, functional} × Determiner Type {indefinite, definite, possessive, none} for the auditory reaction time data only.

Maulchy`s test for the factors Determiner Type and Concept Type indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(5) = 11.90$, $p = .036$, for the main effect of Concept Type, $\chi^2(5) = 15.13$, $p = .010$, as well as the interaction between the factors Determiner Type and Concept Type, $\chi^2(44) = 108.45$, $p = .000$, thus the Greenhouse-Geisser estimates of sphericity was used to correct the degrees of freedom ($\varepsilon = .92$ for the main effect of Determiner Type, $\varepsilon = .90$ for the main effect of Concept Type, and $\varepsilon = .81$ for the interaction).

The results of the repeated measures ANOVA showed that the main effect of Determiner Type was not significant, $F(2.77, 262.96) = 1.38$, $p = .250$. There was a significant, medium main effect of Concept Type, $F(2.71, 257.25) = 25.94$, $p = .000$, $r = .46$ (see figure 2.28).

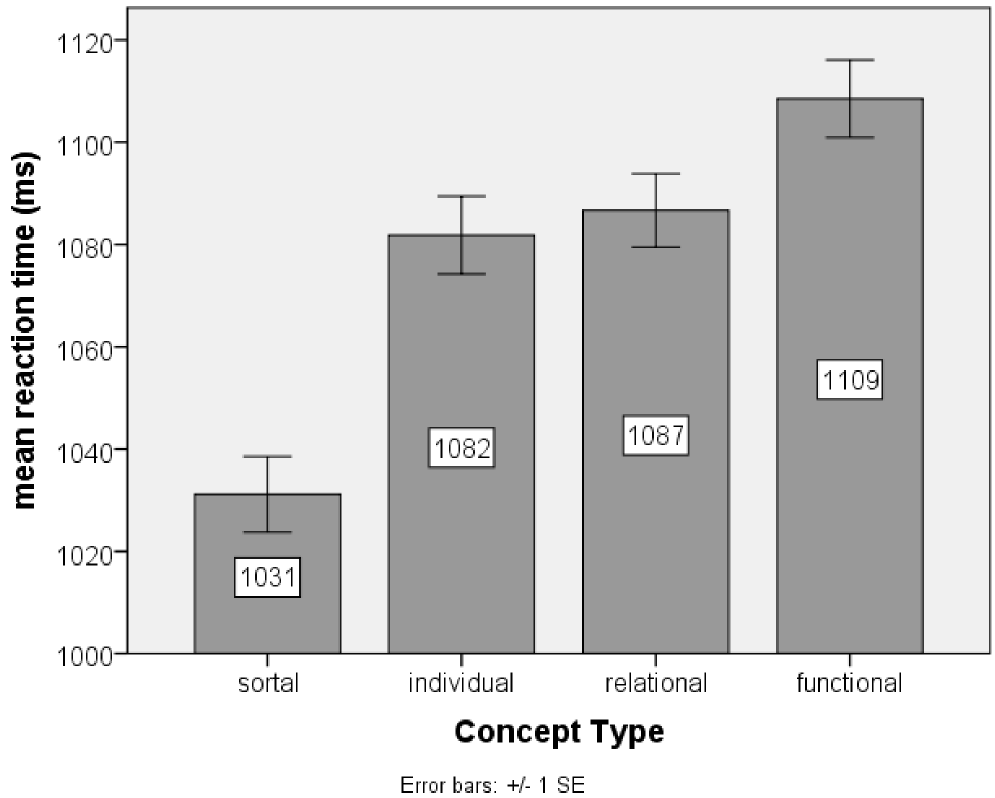

Figure 2.28: Lexical decision latencies for different concept types in English auditory LDT

Planned contrasts (simple (first)) compared each concept type to sortal concepts, and revealed significantly faster responses for sortal nouns compared to any other concept type, $F(1, 95) = 23.75$, $p = .000$, $r = .45$ for the contrast individual vs. sortal; $F(1, 95) = 41.83$, $p = .000$, $r = .55$ for the contrast relational vs. sortal, and $F(1, 95) = 66.07$, $p = .000$, $r = .64$ for the contrast functional vs. sortal. Additionally, post hoc comparisons (with

Bonferroni's α-correction) showed that responses for individual and relational nouns were faster than for functional nouns (p = .007 and p = .028).

The results also showed a significant interaction between the factors Determiner Type and Concept Type, $F(7.32, 695.73) = 2.98$, $p = .004$, $r = .17$ (cf. figure 2.25). In order to analyze which of the factor levels caused the interaction effect, separate one-way ANOVAs were conducted analyzing the factor of Determiner Type {indefinite, definite, possessive, none} at for the factor levels of Concept Type.

A one-way repeated measures ANOVA with the factor Determiner Type {indefinite, definite, possessive, none} was conducted for sortal nouns. Maulchy`s test indicated that the assumption of sphericity had been violated for the effect of Determiner Type, $\chi^2(5) = 37.01$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity was used to correct the degrees of freedom ($\varepsilon = .79$). The results of the one-way repeated measures ANOVA showed a significant effect of Determiner Type, $F(2.36, 224.29) = 3.97$, $p = .015$, $r = .20$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline, and revealed significantly faster responses for indefinite and definite determiner compared to no determiner, $F(1, 95) = 14.01$, $p = .000$, $r = .36$ and $F(1, 95) = 6.37$, $p = .013$, $r = .25$. Possessive determiner cases did not differ significantly from no-determiner cases, $F(1, 95) = 1.25$, $p = .266$.

For individual nouns, the results of the one-way repeated measures ANOVA also showed a significant effect of Determiner Type, $F(3, 285) = 5.03$, $p = .002$, $r = .22$. Planned contrasts (simple (last)) compared each determiner to the no-determiner condition as a baseline, and revealed significantly faster responses only for definite determiner compared to no determiner, $F(1, 95) = 5.46$, $p = .022$, $r = .23$. Indefinite and possessive determiners did not differ significantly from no-determiner cases, $F(1, 95) = .08$, $p = .781$ and $F(1, 95) = 2.90$, $p = .092$.

A one-way repeated measures ANOVA with the factor Determiner Type {indefinite, definite, possessive, none} was also conducted for relational nouns. Maulchy`s test indicated that the assumption of sphericity had been violated for the effect of Determiner Type, $\chi^2(5) = 11.37$, $p = .044$, thus the Greenhouse-Geisser estimate of sphericity was used to correct the degrees of freedom ($\varepsilon = .92$). The results of ANOVA showed no significant effect of Determiner Type, $F(2.77, 262.68) = 1.63$, $p = .188$.

A one-way repeated measures ANOVA with the factor Determiner Type {indefinite, definite, possessive, none} was also conducted for functional nouns. Maulchy`s test indicated that the assumption of sphericity had been violated for the effect of Determiner Type, $\chi^2(5) = 12.62$, $p = .027$, the Greenhouse-Geisser estimate of sphericity was used to correct the degrees of freedom ($\varepsilon = .93$). The results of the one-way repeated measures ANOVA showed no significant effect of Determiner Type, $F(2.78, 264.30) = .17$, $p = .904$.

As for the previous experiments, a more general analysis of overall congruence (comparing all congruent combinations with all incongruent combinations using the no-determiner condition as a neutral baseline) should more explicitly show the nature of the congruence effect.

Overall Congruence and Modality

For the overall congruence analysis of the English data the same categories were grouped together as described in the respective section of experiment 1. The expected pattern for this analysis is facilitation for congruent combinations and possible inhibition for incongruent combinations or at least an equal mean lexical decision time as for the no-determiner condition. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2) a linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none\_}mean / RT_{none\_}mean\_by\_modality\&concept\_type$).

Figure 2.29 shows the combined data for visual and auditory lexical decision experiments. The bar chart suggests the expected facilitation for congruent conditions compared to both, incongruent and no-determiner conditions, whereas there is only a slight difference between incongruent and no-determiner conditions. As we have seen in the previous section, the determiner type by concept type view of the English visual lexical decision data was less informative than the same view of the English auditory lexical decision data. Thus a separate examination of the modalities might show a clearer picture.

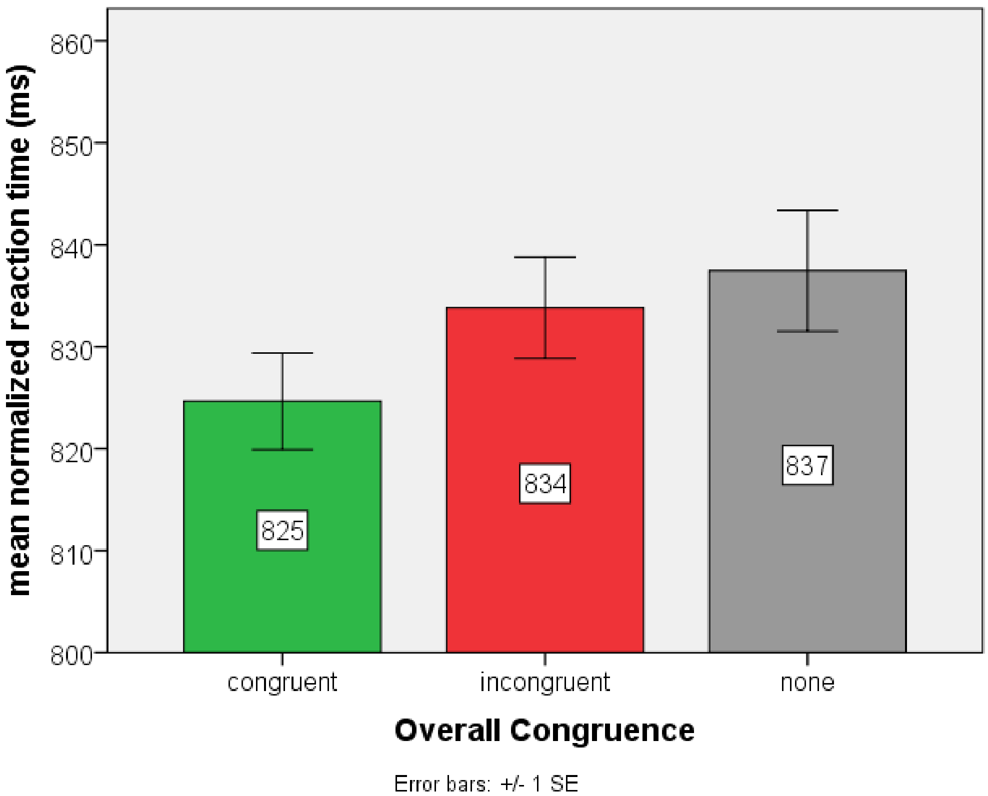

Figure 2.29: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English visual & auditory LDT (overall)

A separate look at the visual data in figure 2.30 shows the same pattern as the German visual lexical decision data of experiment 1 (see chapter 2.2.1.2, section *Overall Congruence*, figure 2.4): Congruent as well as incongruent combinations seem to be facilitated in comparison to the no-determiner condition, but the expected difference between congruent and incongruent cases is not present in the data of the visual version of the experiment (experiment 5).

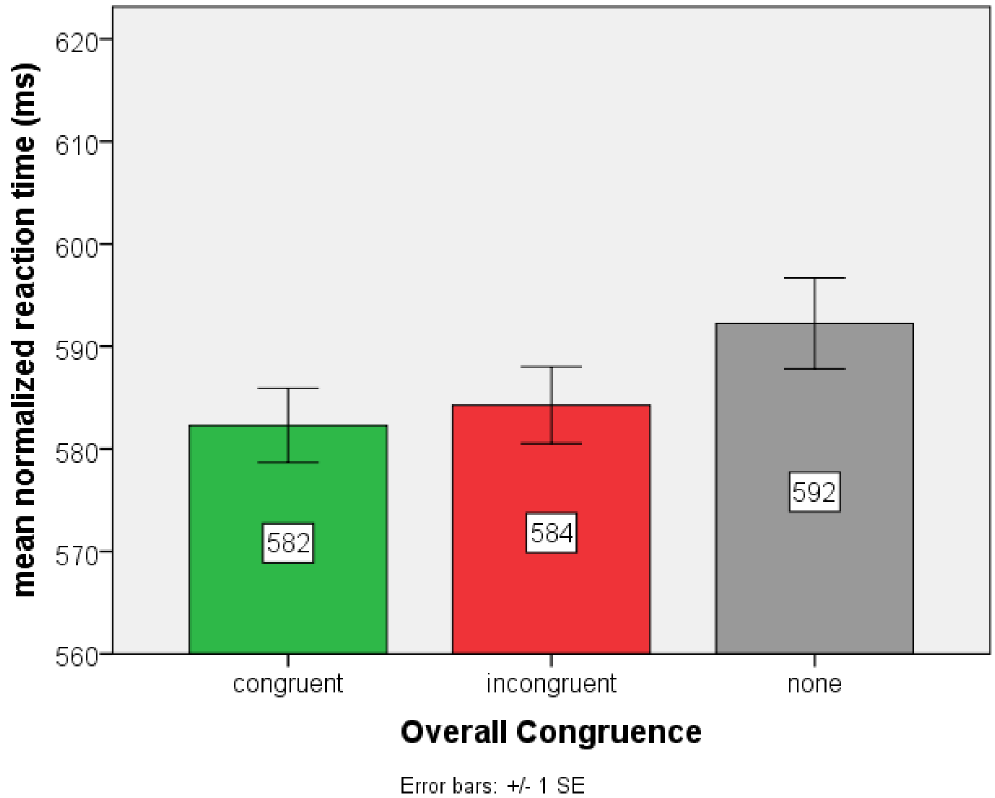

Figure 2.30: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English visual LDT

A comparative look at the English auditory data in figure 2.31 suggests the expected congruence pattern, in that there is a visible facilitation for congruent trials in comparison to no determiner trials as well as incongruent trials, and there is (almost) no difference between incongruent and no-determiner cases. These results resemble the German auditory lexical decision data of experiment 2 (see chapter 2.2.2.2, section *Overall Congruence* above, figure 2.10).

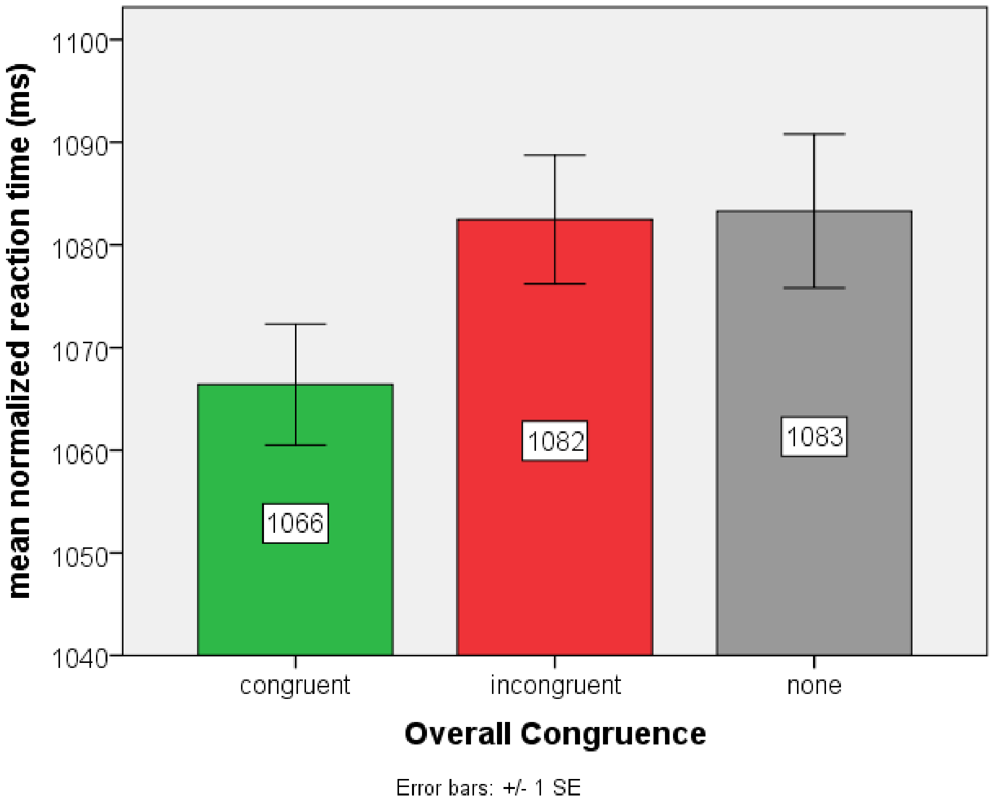

Figure 2.31: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English auditory LDT

In order to test, whether the described effects can be validated by statistically significant results, a repeated measures ANOVA was conducted with the factors Modality {visual, auditory} × Overall Congruence {incongruent, congruent, none}. Despite the differences that figure 2.24 and 2.25 suggested, the results of the ANOVA revealed no significant interaction effect of Modality and Overall Congruence, $F(2, 190) = .98$, $p = .378$.

As in the previous analyses there was a strong main effect of Modality, $F(1, 95) = 1197.30$, $p = .000$, $r = .96$ (details for the nature of the Modality effect can be found in this chapter, in the section *Modality, Determiner Type and Concept Type* above). For the main effect of Overall Congruence, Maulchy's test indicated that the assumption of sphericity had been violated, $\chi^2(5) = 6.31$, $p = .043$, the Greenhouse-Geisser estimate of sphericity was used to correct the degrees of freedom ($\varepsilon = .94$). There was a significant main effect of Overall Congruence, $F(1.88, 178.42) = 3.55$, $p = .034$, $r = .19$. Planned contrasts for the factor Overall Congruence compared congruent and no-determiner cases to the incongruent ones, as a facilitation by congruent (vs. incongruent) cases but no influence or an inhibition by incongruent cases (vs. none) was expected. The contrasts showed only a trend for faster responses for nouns presented with a preceding congruent determiner compared to incongruent determiner-noun combinations $F(1, 95) = 3.57$, $p = .062$. No significant difference was found between incongruent and no-determiner cases, $F(1, 95) = .58$, $p = .448$. A selective post hoc comparison of congruent and no-determiner cases showed significantly faster responses for congruent noun-determiner combinations compared to the cases where no determiner was used ($p = .006$). Therefore, the data support the expected facilitatory effect of congruent determiners.

Referential Properties, Determiner Types and Modality

For the analysis of the referential properties the same categories were grouped together as described in the respective section of experiment 1. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2), a linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none}\_mean / RT_{none}\_mean\_by\_modality\&concept\_type$).

Uniqueness, Determiner Type and Modality

Figure 2.32 combines the reaction time data for visual and auditory lexical decision experiments (experiments 5 and 6), and shows the results for unique and non-unique nouns in combination with the indefinite and definite article, and the no-determiner conditions. The expected effects were

- facilitation for unique nouns used with definite determination (and possible inhibition by indefinite determination)
- facilitation for non-unique nouns used with indefinite determination (and possible inhibition by definite determination)

The bar chart suggests the expected facilitation effects only for the indefinite determiner. There seems to be a facilitation effect for non-unique nouns used with the indefinite determiner (congruent), while – as expected – the indefinite article does not seem to show any influence on unique nouns. For nouns used with the definite determiner the graph shows the same amount of slight facilitation for both, unique (congruent) and non-unique (incongruent) nouns, compared to the use with no determiner. As the data in the previous sections showed major differences between visual and auditory data, this approach shall look at the data of the different modalities separately as well.

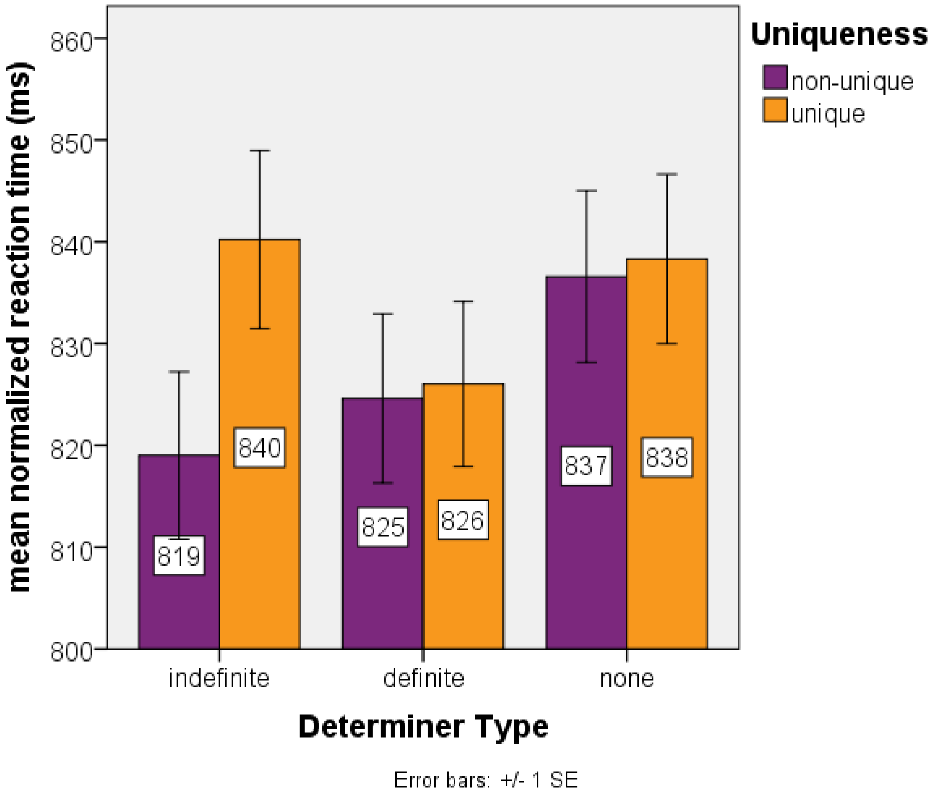

Figure 2.32: Lexical decision latencies for unique and non-unique nouns used with indefinite, definite and no determiner in English visual & auditory LDT (overall)

Figure 2.33 shows the data of the visual lexical decision experiment. However, no clear effect is visible. In general non-unique nouns seem to be processed slightly faster, but the difference to unique nouns is just a few milliseconds in both determiner conditions (indefinite and definite).

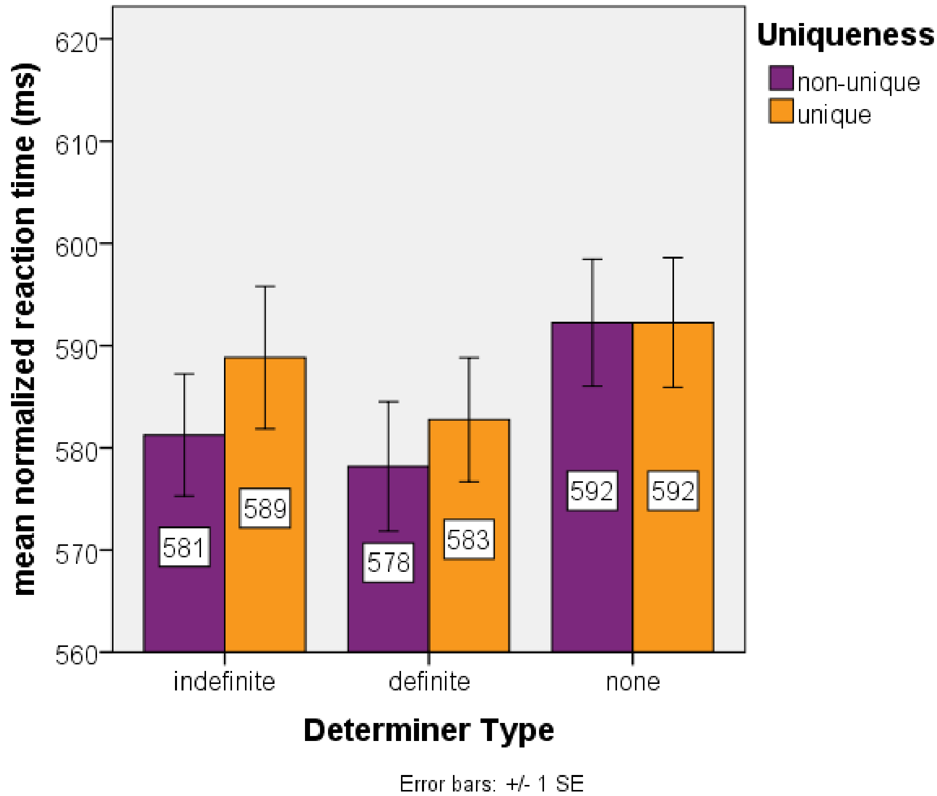

Figure 2.33: Lexical decision latencies for unique and non-unique nouns used with indefinite, definite and no determiner in English visual LDT

Figure 2.34 shows the data of the auditory lexical decision experiment. The bar chart shows a more pronounced version of the effects described in the overall data (cf. figure 2.32 above). There seems to be a clear facilitation for non-unique nouns used with the congruent indefinite determiner, while the indefinite determiner has no effect (or even a slight inhibitory effect) on unique nouns. The definite determiner causes a slight facilitation for both, unique and non-unique nouns, compared to the no-determiner condition.

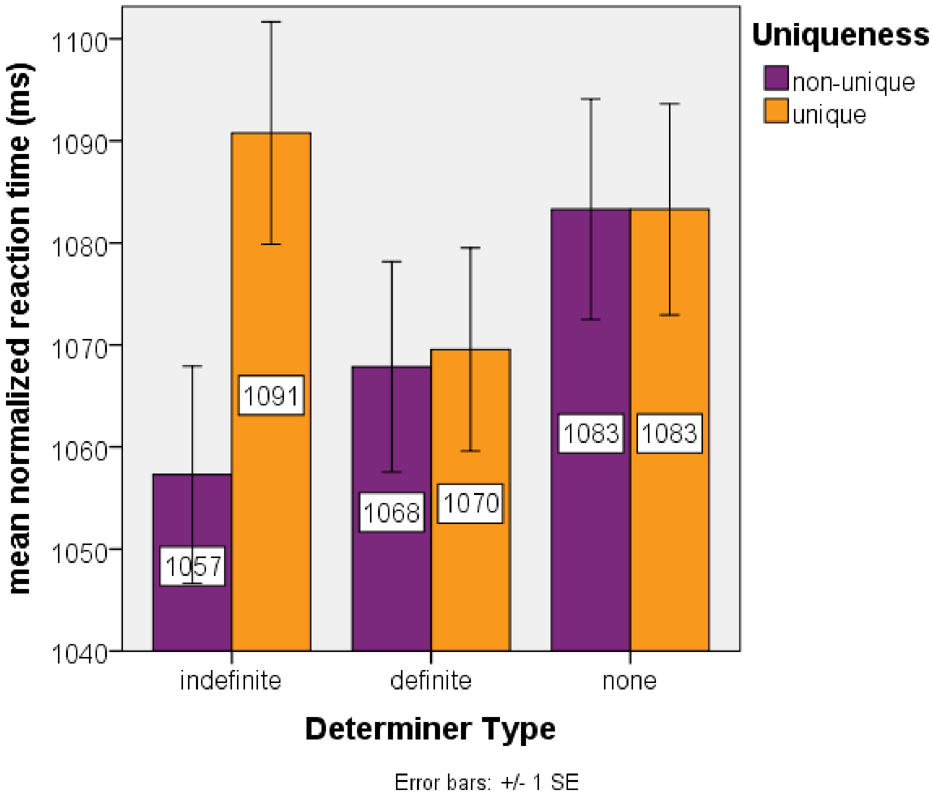

Figure 2.34: Lexical decision latencies for unique and non-unique nouns used with indefinite, definite and no determiner in English auditory LDT

In order to test, whether the described facilitation effects can be supported by statistical analyses, a repeated measures ANOVA was conducted with the factors Modality {visual, auditory} × Determiner Type {indefinite, definite, none} × Uniqueness {non-unique, unique}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Determiner Type, $\chi^2(2) = .82$, $p = .000$, and for the 2-way interaction of Determiner Type and Uniqueness, $\chi^2(2) = 11.88$, $p = .003$. Therefore, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .85$ for the main effect of Determiner Type, and $\varepsilon = .95$ for the 2-way interaction of Determiner Type and Uniqueness).

There was a strong main effect of Modality, $F(1, 95) = 1187.69$, $p = .000$, $r = .96$, in that visual processing was significantly faster than auditory (details for the nature of the Modality effect can be found in this section, under *Modality, Determiner Type and Concept Type* above).

Furthermore there was only a marginal main effect of Uniqueness, $F(1, 95) = 3.44$, $p = .067$, however, the main effect of Determiner Type was significant, $F(1.70, 161.29) = 3.68$, $p = .034$, $r = .19$. Planned contrasts (simple (last)) compared the determiners to the no-determiner condition as a baseline, and revealed significantly faster latencies only for definite vs. no determiner, $F(1, 95) = 5.56$, $p = .020$, $r = .24$.

The ANOVA showed no significant 2-way interaction of the factor Modality, neither with Determiner Type, $F(2, 190) = .28$, $p = .759$, nor with Uniqueness, $F(1, 95) = .67$, $p = .413$. There was no significant 2-way interaction between the factors Determiner Type and Uniqueness, $F(1.79, 169.84) = 2.41$, $p = .093$, and despite the above mentioned visible difference of latencies for visual and auditory lexical decision in figure 2.33 and 2.34, the results of the repeated measures ANOVA revealed no significant 3-way interaction effect of Modality, Determiner Type and Uniqueness, $F(2, 190) = 1.00$, $p = .369$.

In summary, the statistical analysis of the referential property Uniqueness did not yield significant results for the expected patterns, however, a visual inspection showed the expected (non-significant but measurable) facilitation for non-unique nouns preceded by the indefinite determiner, and this was especially pronounced in the auditory data.

Relationality, Determiner Type and Modality

Figure 2.35 shows the results of experiments 5 and 6 (overall) for relational and non-relational nouns in combination with the possessive determiner and the no-determiner condition. The expected effect is facilitation for relational nouns used with the possessive determiner.

The bar chart in figure 2.35 suggests a very slight difference between relational vs. non-relational nouns used with possessive determination, but the possessive determiner caused only slightly faster reaction times for relational nouns (congruent) compared to non-relational nouns (incongruent), as well as compared to the no-determiner condition. Again there might be a difference in the reaction time patterns of the visual and auditory data. Therefore, figures 2.36 and 2.37 show separate relationality bar charts for visual and auditory lexical decision.

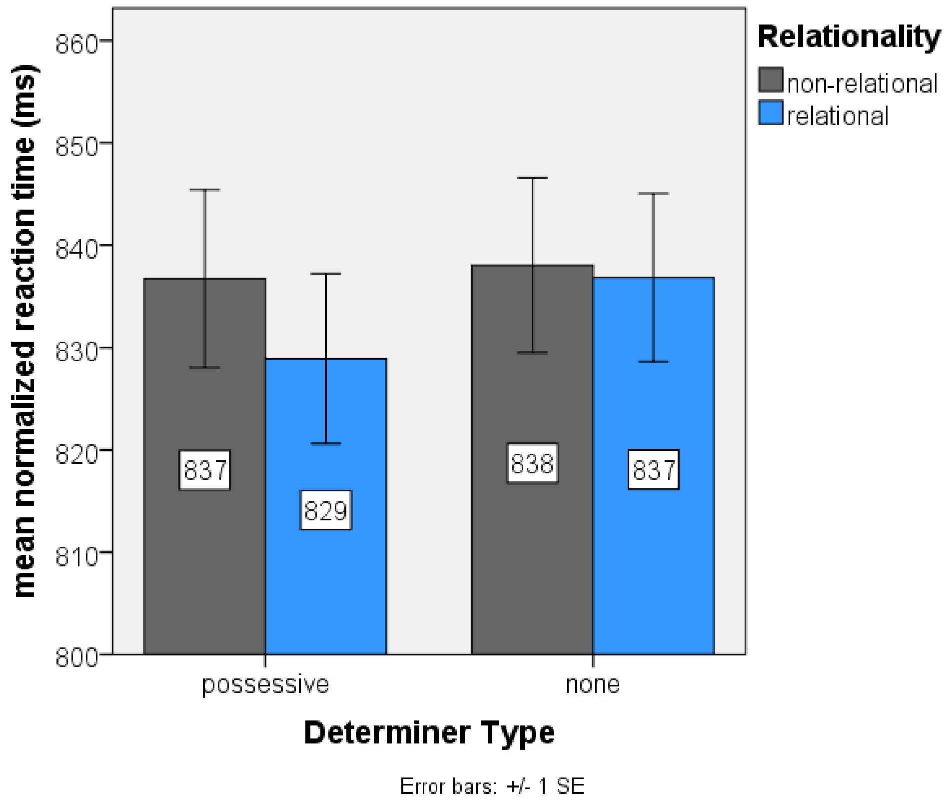

Figure 2.35: Lexical decision latencies for relational and non-relational nouns used with possessive and no determiner in English visual & auditory LDT (overall)

The bar chart in figure 2.36 for the visual lexical decision experiment shows very few differences. There is a slight facilitation for nouns used with the possessive determiner compared to the no-determiner conditions, but there is almost no difference between the congruent uses of the possessive determiner with relational nouns compared to the incongruent use with non-relational nouns.

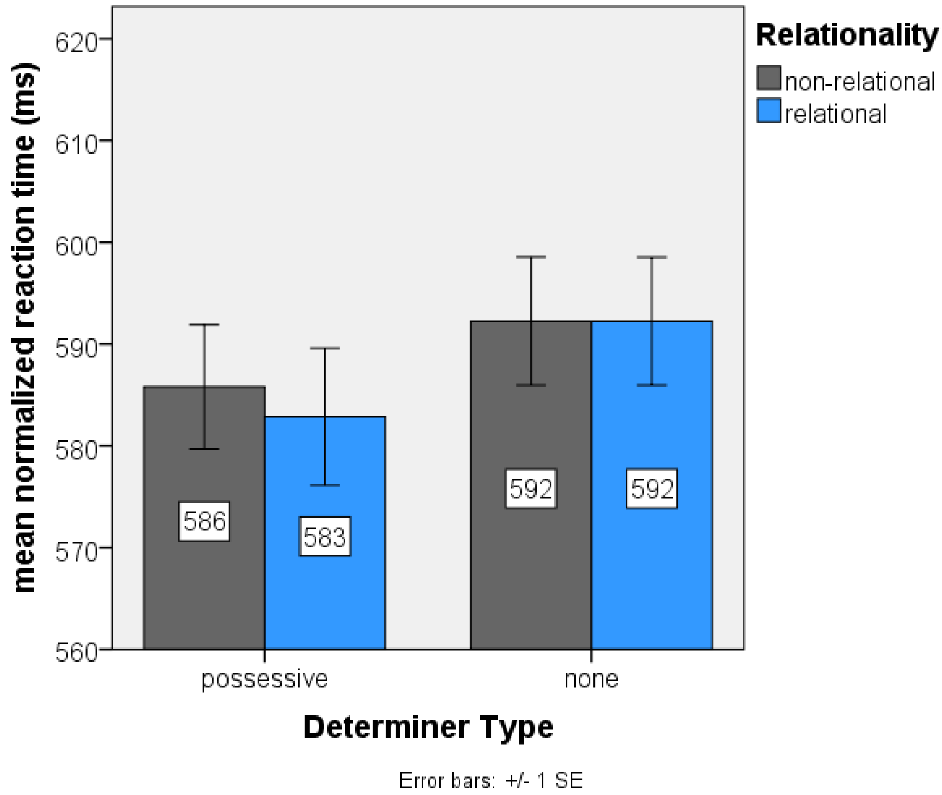

Figure 2.36: Lexical decision latencies for relational and non-relational nouns used with possessive and no determiner in English visual LDT

The bar chart in figure 2.37 for the auditory data shows a slightly more pronounced facilitation effect of the possessive determiner on relational nouns.

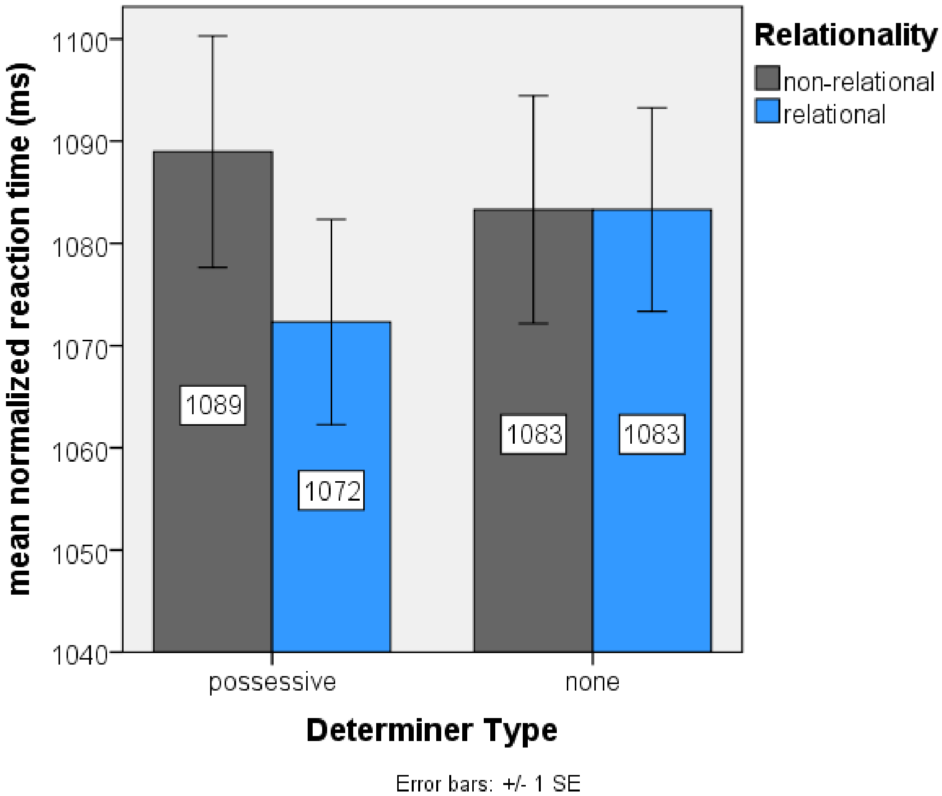

Figure 2.37: Lexical decision latencies for relational and non-relational nouns used with possessive and no determiner in English auditory LDT

In order to test, whether there is any statistically significant effect for relational nouns, a repeated measures ANOVA was conducted with the factors Modality {visual, auditory} × Determiner Type {possessive, none} × Relationality {non-relational, relational}. The results of the repeated measures ANOVA revealed that, apart from the unsurprising effect of Modality, $F(1, 95) = 1071.82$, $p = .000$, $r = .96$, none of the effects was significant, for Determiner Type, $F(1, 95) = 1.10$, $p = .298$; for Relationality, $F(1, 95) = .80$, $p = .375$; for Modality × Determiner Type, $F(1, 95) = .26$, $p = .611$; for Modality × Relationality, $F(1, 95) = .14$, $p = .709$; for Determiner Type × Relationality, $F(1, 95) = .65$, $p = .424$; for Modality × Determiner Type × Relationality, $F(1, 95) = .27$, $p = .609$.

2.4.4 Summary and Intermediate Discussion

The English lexical decision experiment consisted of a visual and an auditory lexical decision task and yielded results similar to those found in

German lexical decision experiments (experiment 1and 2). The influence of determiner type on recognition of the four noun types was analyzed separately for visual and auditory data, as there was an interaction with modality. The results showed an overall large effect of modality, as the mean reaction time (in ms) for visual LDT was M = 592.38 (SD = 2.39), whereas the mean reaction time for auditory LDT was M = 1071.71 (SD = 3.62). These modality specific differences might be related to the uniqueness-point aspect. The recognition point might be later for auditory stimuli due to the later uniqueness-point, while in visual tasks the noun stimuli were instantly available (cf. section 2.2.2.3). In the English lexical decision experiment the stimulus duration ranged from 451 to 1068 ms (M = 696.80, SD = 132.87). Again a mean uniqueness-point of about 500 ms or more is a plausible cause for the time differences.

Moreover, the results replicated the patterns of the visual and auditory experiments conducted with German nouns. While the visual results did not show the expected concept type congruence effect, the auditory experiment did show that concept types were influenced differentially by the determiner types. However, when examining the different concept types, only individual nouns preceded by definite determiner showed significantly faster responses. In the case of sortal nouns, indefinite and definite determiners elicited faster responses, and no influence of any determiner type could be found for relational and functional nouns, although a visual inspection of the data showed a slight tendency towards most of the expected effects.

Interestingly the observed concept type effect showed a different pattern from the German results: sortal and individual nouns yielded the fastest responses, while relational and functional nouns yielded the slowest. Thus comparing the German and English data, we see reversed results in the following concept type order (concerning speed of recognition):

- German: FC = SC < IC = RC
- English: SC < IC = RC < FC

Disregarding the German order, a CTD-interpretation of the English concept type order could be that sortal nouns are the easiest to process, because sortal nouns neither have the property of uniqueness nor of relationality (i.e. a negative value of these two properties[37]). Functional nouns have both of these properties, thus have positive values for both, uniqueness and relationality. The data could be interpreted as a higher processing effort for functional nouns due to the positive value of both features. And lastly, individual and relational nouns both have one positive value of the properties – individual nouns are unique (but non-relational), and relational nouns are relational (but non-unique), which makes their processing "semi-fast". In summary, the concept type effect in English could be interpreted in the realm of the CTD, and lead to the hypothesis that the reaction times vary in dependence of the inherent referential property values, if – and only if – the English concept type order had been mirrored in the German results. This, however, is not the case (cf. above). Hence, the concept type effect has probably been caused by the choice of words within the concept types and/or by (language specific) frequency matching issues.

A separate analysis of the influence of determiner type on the referential properties did not yield significant results for the expected patterns, however, a visual inspection (cf. figures 2.32–2.37) showed the expected (non-significant but measurable) facilitation for non-unique nouns preceded by the indefinite determiner as well as for relational nouns preceded by the possessive determiner – especially pronounced in the auditory data.

The overall congruence effect (shown for visual and auditory data overall, as there was no interaction effect with modality) yielded the expected significant difference between nouns preceded by congruent vs. incongruent concept type cues. Similar to the findings of experiment 2, the results of the English lexical decision data (especially well visible in the auditory data in figure 2.31) show a significant facilitation for nouns preceded by

[37] Generally, in Linguistics (e.g. Phonology), the negative value of a binary feature is called the *unmarked*, *default* case, while the positive value is assumed to be more marked (in the sense of grammatical markedness).

congruent determiners, but no difference between incongruent and no determiner.

These results support the results found in the German lexical decision experiment (although not all predicted effects could be shown). Furthermore, as in the English data the congruence effect yielded a facilitation effect of congruent determiners, but did not show inhibition for incongruent determiners, hence, a mere gender effect explanation of the concept type congruence effect found in German experiments can be ruled out.

Summarizing findings of German and English lexical decision experiments, it became clear, that the results of German and English are fairly similar: statistically significant congruence effects could only be reported for the auditory experiments 2 (German) and 6 (English), but not for the visual experiments 1, 3, 4 and 5.

The following section gives an overview of the German and English results for concept type and determiner type (section 2.5.1) as well as for congruence (section 2.5.2). In order to examine the stage at which the observed congruence effects arise, i.e. to answer the question at which level of noun processing conceptual information is utilized, a German phoneme monitoring experiment was designed (see section 2.6.1).

2.5 Intermezzo: Overview of German and English Results

The results of German and English results have been comparatively discussed in the intermediate summaries and will be resumed in the final discussion. This section gives a compact overview of the results so far, comprising the main results from experiments 1-6. Table 2.6 in section 2.5.1 gives an overview of the results for the analysis of determiner type and concept type combinations, while table 2.7 in section 2.5.2 gives an overview of the results for the overall congruence analysis. A legend for the symbols used in both tables can be found in table 2.5 below.

<	a < b	a vs. b	a faster than b
<	a < b, c	a vs. b, c	a faster than b and a faster than c
>	a > b	a vs. b	a slower than b
=	=	a vs. b	no significant difference between a and b
			expected results
(!)			(very) unexpected results

Table 2.5: Legend for overview tables 2.6 & 2.7

2.5.1 Compact Overview I: Determiner Type and Concept Type

	Experiment	**Experiment 1**	**Experiment 2**	**Experiment 3**	**Experiment 4**	**Experiment 5**	**Experiment 6**
	Task	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision
	Language	German	German	German	German	English	English
	Modality	visual, pilot	auditory	visual, longer ISI	visual, gender manip.	visual	auditory
	Mean (SE)	570.17 (1.96)	887.48 (2.54)	589.27 (1.88)	651.32 (2.25)	585.45 (2.25)	1076.84 (3.74)
Determiner Type	Main effect of DT	yes	yes	yes	no	no	no
	significant DT contrasts	any DT < none	def, poss < none; indef = none;	any DT < none	---	---	---
	additional comparisons	poss < indef, def	---	---	---	---	---
Concept Type	Main effect of CT	yes	yes	yes	yes	yes	yes
	significant CT contrasts	SC < IC, RC SC = FC	SC < IC, RC SC = FC	SC < IC, RC FC < SC	SC < IC, RC FC < SC	SC < RC, FC SC = IC	SC < any other CT
	additional comparisons	FC < IC, RC IC < RC	(SC,) FC < IC, RC	IC, FC < RC FC < IC	IC, FC < RC FC < IC	IC < RC, FC	IC, RC < FC
Determiner Type × Concept Type	Interaction DT × CT	no	yes	no	no (trend)	no	yes
	Main effect of DT for SC		yes				yes
	DT contrasts for SC		indef < none				indef, def < none
	additional comparisons		indef < poss				---
	Main effect of DT for IC		yes				yes
	DT contrasts for IC		def < none				def < none
	additional comparisons		def < indef				---
	Main effect of DT for RC		no (trend)				no
	DT contrasts for RC		---				---
	additional comparisons		---				---
	Main effect of DT for FC		yes				no
	DT contrasts for FC		poss < none				---
	additional comparisons		---				---

Table 2.6: Results for the analysis of the combination of Determiner Type and Concept Type

2.5.2 Compact Overview II: Overall Congruence

	Experiment	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5 & 6
	Task	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision
	Language	German	German	German	German	German
	Modality	visual	auditory	visual	visual	visual & auditory
Overall Congruence	significant effect of Overall Congruence	yes	yes	yes	yes	yes
	congruent vs. incongruent	=	<	=	> (!)	= (trend for <)
	incongruent vs. none	<	=	<	<	=
	congruent vs. none	<	<	<	=	<
Gender Congruence (only Experiment 4)	significant effect of Gender Congruence				yes	
	correct vs. Incorrect				<	
	incorrect vs. none				=	
	correct vs. none				<	
	interaction with Overall Congruence				no	
	interaction with Determiner Type & Concept Type				no	
Modality (only Experiment 5 & 6)	significant effect of Modality					yes
	interaction with Overall Congruence					no

Table 2.7: Results for the analysis of Overall Congruence

2.6 German Experiments III

This last set of experiments was conducted in order to identify the status of the conceptual congruence effect found in auditory lexical decision experiments (experiments 2 and 6). Experiment 7 used the phoneme monitoring paradigm In order to test, whether conceptual type information could be shown to operate on a lexical level of processing. A complementary auditory lexical decision experiment (experiment 8) used the real word stimuli that were used in experiment 7, and was conducted to ensure, that the previously reported overall congruence effect was replicable using the phoneme monitoring stimuli.

2.6.1 Experiment 7: German Phoneme Monitoring

Experiment 7 was conducted in order to determine, whether the observed overall congruence effect occurs at a lexical level. “[P]honeme monitoring reflects the integration of acoustic-phonetic and lexical representations” (Bölte and Connine, 2003: 1020), thus it is a task that is sensitive to the stages of lexical processing, but does not include a post-lexical component. This method is a good measure for the investigation of the locus of the congruence effect.

A well-known effect shown in phoneme monitoring by Connine et al. (1997) is the *similarity effect*, which showed that reaction times for pseudowords vary depending on their phonological similarity to real words. For the present phoneme monitoring effect a replication of the similarity effect is expected. Moreover, if conceptual information is utilized at the lexical level, the facilitation effect, which occurred for congruent determiner-noun pairs, should also be visible in phoneme monitoring, and if so it might interact with the similarity effect. If neither the expected overall congruence effect nor an interaction with the similarity effect can be shown, then we can infer that conceptual type information comes to play only at a later, post-lexical, level of noun recognition.

For the present experiment a generalized phoneme monitoring design was used, similar to Bölte and Connine (2004). Frauenfelder and Segui (1989) showed that this variation of the standard phoneme monitoring paradigm, in which the target phoneme location is varied, evokes context effects, while the standard version does not. As the present experiment investigates the role of conceptual context information, this method was the right choice.

2.6.1.1 Material and Methods

Participants

Experiment 7 tested 240 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (159 women, 81 men; mean age M = 24.94 years, SD = 5.96). They were paid a small fee for their participation.

Materials

Five groups of German nouns of at least three syllables were selected as "base words"[38]. The last consonants of the nouns were the target phonemes. The phoneme monitoring task requires several groups of nouns with different final consonants, thus five groups of base words with the following final consonants were selected: /k/, /t/, /s/, /n/, /l/. These consonants are frequent endings in German nouns without bearing the phoneme-grapheme discrepancy caused by the phonological rule of neutralization (*Auslautverhärtung* in German), which neutralizes the contrast between voiced and voiceless stops (cf. for example <*Hut*> → /hu:t/ → [hu:t], but <*Hund*> → /hʊnd/ → [hʊnt]). The CELEX database (Baayen, Piepenbrock, and Gulikers, 1995) was used as a base, from which all German nouns with more than three syllables were extracted. Compounds, polysemous nouns and otherwise unusable nouns were excluded (e.g. [ts] and [t] sounds that result from neutralized word endings as in *Hund* (pho-

[38] The term *base* words has been adapted from Bölte and Connine (2004).

netic transcription: [hʊnt]) were excluded in order to avoid interference or confusion due to a diverging written form). Furthermore, it was ensured that the target sound did only occur once per stimulus. The remaining list of nouns was handed to two independent annotators[39], who annotated the nouns' concept types according to the annotation manual proposed by Horn (2012, submitted).

From this annotated set of nouns a total of 84 German nouns were selected as base words – equally distributed among the concept types (21 nouns per concept type). According to the procedure for experiments 1-6, lexical frequency of occurrence in CELEX database (Baayen, Piepenbrock, and Gulikers, 1995), number of letters, number of phonemes, and number of syllables were matched. However, due to the phonological distribution within German nouns, the concept types could not be equally distributed within the target phoneme groups:

target consonant	**total**	**SC**	**IC**	**RC**	**FC**
t	27	6	7	9	5
s	15	5	3	2	5
k	12	4	6	1	1
n	18	2	4	7	5
l	12	4	1	2	5
total	**84**	**21**	**21**	**21**	**21**

Table 2.8: Number of stimuli of different concept types with different word-final target sounds in phoneme monitoring

Starting from the chosen base words the pseudowords were constructed by changing one phonological feature of the base words' initial phonemes to create a minimal pseudoword, and two or more to create a maximal pseudoword (see a list of all target stimuli in Appendix III). The 84 base words, 84 minimal and 84 maximal pseudoword stimuli were distributed over three lists (28 base words, 28 minimal and 28 maximal pseudoword

[39] Special thanks to Christian Horn and his annotation team from Project C02 within the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en).

stimuli per list). Of a German noun set {base word and corresponding minimal pseudo and maximal pseudo}, the input lists contained only one "version", thus participants heard either the base word itself, the corresponding minimal pseudo or the maximal pseudo. Per list four variations were prepared, each combining the target stimuli with yet another one of the four determiner types, thus a total of 12 lists. The number of determiners per determiner type was balanced within and between lists. Furthermore, four nouns (no specific selection criteria) and four pseudonouns (created like mentioned above) were added as warm-up stimuli.

Filler words and filler pseudowords were also combined with the four determiner types (balanced), and were added to all lists of target stimuli in order to balance out different features: 28 Filler words containing the respective final consonant were added to the respective groups of target stimuli, in order to balance the number of pseudowords within the targets (28 minimal + 28 maximal = 56 pseudowords vs. 28 "real" basewords). 56 Fillers words and 56 Filler pseudowords containing the respective consonant in initial position were added, in order to vary the position of the monitored phoneme. Additionally, 112 filler words (no specific selection criteria, leftovers from the initial selection process), and 112 filler pseudowords (created with the same method as in experiment 1), that did not contain the respective target sound, were subjoined. In the end, the lists contained a total of 448 trials, which were pseudo-randomized, so that no more than three 'word', 'minimal' or 'maximal pseudoword' answers followed each other. It was also ensured that no more than three trials using the same concept type or determiner type followed each other. The experimental trials were preceded by the same set of eight warm-up trials.

All experimental items (word and pseudoword stimuli, determiners and warm-ups) were spoken by a male German native speaker[40] and were recorded in a sound attenuated booth. The technical specifications and

[40] Special thanks to Mark Wellers for giving my experiment its/his voice – again.

procedure for recording and further processing of the sound stimuli were equivalent to the procedural method described in experiment 2.

Procedure and Apparatus

Experiment 7 used the same set-up as experiment 2. A total of 448 trials (excl. warm-ups) per list were presented in five blocks according to the target phoneme groups. Printed instructions were handed to participants before the experiment began:

> ***Aufgabe – Hörst du den Laut?***
> *Setze bitte vor Beginn des Experiments die Kopfhörer auf.*
> *Das Experiment besteht aus 5 Blöcken. Du kannst zwischen den Blöcken eine Pause oder direkt weiter machen (Anweisungen gibt es auf dem Bildschirm). Du hörst in jedem Durchgang nacheinander einen Piepton und ein Wortpaar. Der Piepton zeigt dir immer an, dass ein neues Wortpaar folgt. Nach dem Piepton hörst du Wortpaare bestehend aus*
> *1. einem der Artikel ein(e), der, die, das, sein(e) oder ein *Rauschen**
> *2. einem echten oder erfundenen Substantiv wie z.B. Maus, Schicksal (=echt) oder Wulter, Stunne (=erfunden).*
> *Ein Beispiel für einen Durchgang wäre also z.B. Piepton + seine + Maus. Deine Aufgabe ist es nun, auf das zweite Wort, also das Substantiv zu achten und genau hinzuhören, ob du den gesuchten Laut gehört hast. Welcher Laut gesucht wird? Lies einfach die Anleitungen auf dem Bildschirm. Sie werden dir vor jedem der 5 großen Blöcke verraten, um welchen Laut es in dem folgenden Block jeweils geht. Wenn du den gesuchten Laut hörst, drücke bitte die **GELBE** Taste. Wenn du den Laut nicht gehört hast, drücke bitte die **BLAUE** Taste. Versuche Deine Entscheidung so schnell wie möglich, aber dennoch auch so richtig wie möglich, zu treffen.*
>
> ***Beispiele: 1. Block: Hörst du den Laut [m]?***

1. Durchgang:	*Piepton*	*der*	***Wulter***	***BLAUE** Taste*
2. Durchgang:	*Piepton*	*Rauschen*	***Maus***	***GELBE** Taste*
3. Durchgang:	*Piepton*	*ein*	***Schicksal***	***BLAUE** Taste*

> ***Maus** in b) enthält [m], man müsste bei diesem Beispiel also die **GELBE** Taste drücken. In a) **Wulter** und c) **Schicksal** ist der Laut jedoch nicht enthalten, daher wäre die **BLAUE** Taste richtig. Sobald du eine der Tasten gedrückt hast, wird der nächste Durchgang (das*

nächste Wortpaar) präsentiert. Falls du keine Taste drückst oder zu langsam bist, wird direkt das nächste Wortpaar präsentiert – aber keine Panik, einfach weitermachen☺. Du erhältst zuerst einige Übungswörter. Anschließend gibt es eine kurze Pause, in der Du eventuelle Fragen an den Versuchsleiter loswerden kannst, bevor es dann richtig losgeht. Also Kopfhörer auf und los geht`s! [41]

In the course of the experiment participants received written instructions for each block on the computer screen that instructed them which phoneme they should monitor in the following block. The experimental trials were preceded by a warm-up phase, after which participants were given the opportunity to ask questions before the main experiment began.

2.6.1.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (RTs longer than 5000ms) were excluded from all analyses (overall error and time-out rate: 9.63%). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 0.89% of all correct answers).

---

[41] English translation: Task – *Do you hear the sound? Please put on the headphones before the experiment begins. The experiment consists of 5 blocks. Between the blocks you may have a rest or proceed directly with the next block (instructions will appear on the computer monitor). In each trial you will hear a beep followed by a word pair. The beep shows you, that a new word pair is coming up. After the beep you will hear 1. one of the words "a/an", "the" or "his" or a noise sound and 2. a real or made-up noun [examples]. An example for a trial would be "beep + his + mouse". Your task is to monitor the second word, the noun, and carefully listen, if you hear the required sound. Which sound is required? Just read the instructions that will appear on the computer monitor. Before each of the 5 experimental blocks* begins the *instructions will let you know which sound we are looking for in the following block. If you think you heard the required sound, please press the yellow button. If you think you did not hear the required sound, please press the blue button. Try to make your decisions as quickly but also as accurately as possible. [Examples] As soon as you press one of the buttons, the next word-pair will be presented automatically. In case you do not press any button or if your reaction is too slow, the next word-pair will be presented automatically – but do not panic, just go ahead. In the beginning you will hear a few practice trials after which you will have a short break to ask any questions before the main experiment begins. So put on the headphones and let's begin. Thank you for your participation.*

Similarity and Overall Congruence

For the analysis of overall congruence and similarity of the results the same categories were grouped together as described in section 2.2.1.2. The expected pattern for this analysis is facilitation for congruent combinations and a possible inhibition for incongruent combinations, or at least an equal mean lexical decision time as for the no-determiner condition. For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2) a linear normalization was applied to the reaction times ($RT_{norm} = RT * RT_{none}\_mean / RT_{none}\_mean\_by\_concept\_type$).

As a first overview we shall look at the data in a combined manner: figure 2.38 shows phoneme monitoring latencies for overall congruence conditions by similarity (or word status) levels.

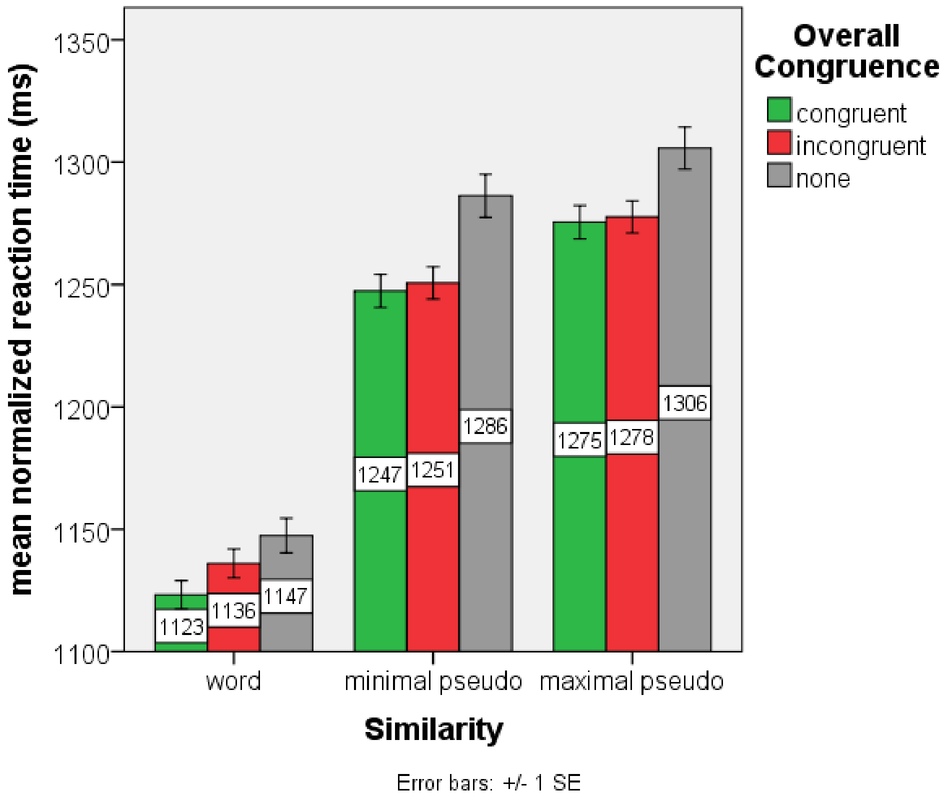

Figure 2.38: Phoneme monitoring latencies for similarity and overall congruence in German phoneme monitoring

The bar chart suggests generally faster latencies for real word stimuli, and among the different word status categories there seem to be faster latencies for words that were presented after a determiner in comparison to the no determiner (noise) cases. The congruence pattern seems to have a parallel pattern in all three similarity categories, thus the graph does not suggest an interaction between similarity and overall congruence.

To gain a clearer view at the two factors, we can look at separate presentations of similarity on the one hand and overall congruence on the other hand.

Similarity

Figure 2.39 shows the distribution of latencies for the similarity variable and suggests the expected pattern of increasing phoneme monitoring time in dependence of pseusowords' similarity to real words, i.e. words were processed faster than minimal pseudos, and yet minimal pseudos were processed faster than maximal pseudos.

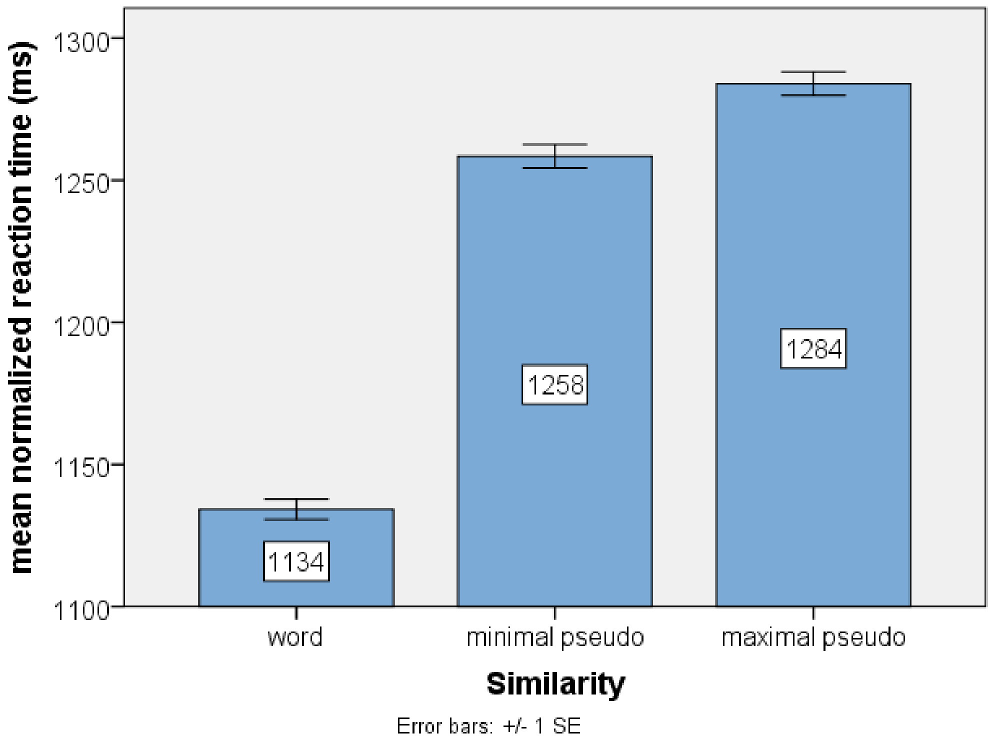

Figure 2.39: Phoneme monitoring latencies for words, minimal pseudowords and maximal pseudowords in German phoneme monitoring

Overall Congruence

Figure 2.40 shows the results for overall congruence and suggests a clear facilitation by determiners in general, but only a slight – probably not significant –advantage of congruent vs. incongruent conditions.

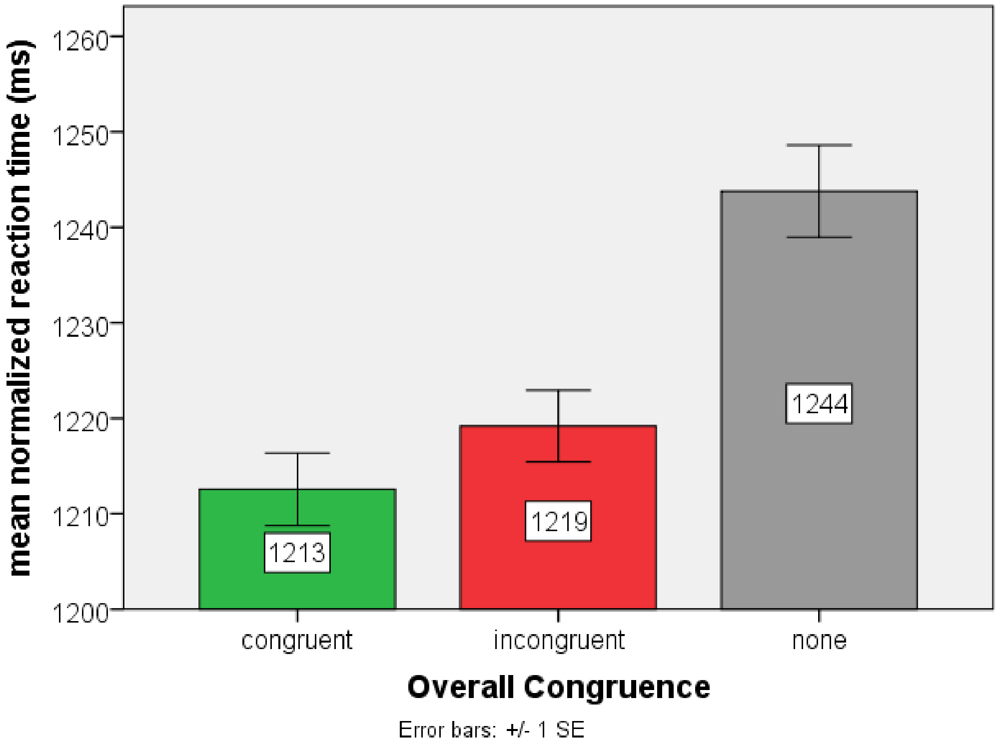

Figure 2.40: Phoneme monitoring latencies for nouns used with congruent, incongruent and no determiner in German phoneme monitoring (across similarity levels)

In order to test, whether the suggested effects are statistically significant, a repeated measures ANOVA was conducted with the factors Similarity {word, minimal pseudoword, maximal pseudoword} × Overall Congruence {incongruent, congruent, none}. Maulchy`s test indicated that the assumption of sphericity had been violated for the main effect of Similarity, $\chi^2(2) = 32.94$, $p = .000$, the main effect of Overall Congruence, $\chi^2(2) = 13.85$, $p = .001$, as well as for the interaction, $\chi^2(9) = 17.79$, $p = .038$. For that reason, the Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = .89$ for the main effect of Similarity, $\varepsilon = .95$ for the main effect of Congruence, and ε = .97 for the interaction). The results of the ANOVA revealed no significant interaction effect, $F(3.87, 923.87) = 1.12$, $p = .344$.

However, there was a very strong significant main effect of Similarity $F(1.77, 423.29) = 398.56$, $p = .000$, $r = .79$. Planned contrasts (simple (first)) compared mean reaction times of minimal and maximal pseudos to real words and revealed significantly faster responses for the real words compared to minimal pseudowords, $F(1, 239) = 434.05$, $p = .000$, $r = .80$, and maximal pseudowords, $F(1, 239) = 562.28$, $p = .000$, $r = .84$. Additionally, a selective post hoc comparison of minimal and maximal pseudo words showed significantly faster responses for minimal pseudowords compared to maximal pseudowords ($p = .000$).

There was also a significant main effect of Overall Congruence, $F(1.89, 452.42) = 19.41$, $p = .000$, $r = .27$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases but no influence or an inhibition by incongruent cases (vs. none). The planned contrasts only showed significantly faster responses for incongruent nouns compared to the baseline condition, $F(1, 239) = 29.80$, $p = .000$, $r = .33$, but no difference between incongruent and congruent combinations, $F(1, 239) = .11$, $p = .739$. Additionally, a selective post hoc comparison of congruent vs. no determiner showed significantly faster responses for congruent noun-determiner combinations ($p = .000$).

As there was no interaction between similarity and overall congruence, there was no statistical justification to conduct a separate analysis of only the real word stimuli. Although technically there is a significant congruence effect, the important difference between congruent and incongruent conditions (that was expected and was reported in experiment 2) is not present in the statistical data (although a slight measurable difference can be seen in figure 2.40).

2.6.1.3 Summary and Intermediate Discussion

Experiment 7 used the phoneme monitoring paradigm and investigated the locus of the conceptual congruence effect that was found in experiments 2 and 6. The results of experiment 7 showed the expected strong similarity effect, thus replicated the findings of Connine et al. (1996) as well as Bölte and Connine (2004) which showed that reaction times varied in dependence of the similarity of stimuli to real German words. The presence of this effect is an important indicator that the experiment actually activated lexical processing. The experiment showed no interaction between similarity and overall congruence.

There was an overall congruence effect that did not differ when pseudoword stimuli were included or excluded. However, the effect only showed faster responses for any determiner compared to none – similar to the findings of experiment 1, but no difference between congruent and incongruent determiner-noun combinations. The visual inspection of overall congruence did not show a notable difference, although for the sake of completeness it might be noted that mean reaction times to congruent determiner-noun combinations were 6 ms faster than incongruent combinations. Thus the experiment supports the assumption that some contextual information (provided by the preceding determiner) must have a helping effect on noun recognition, but did not elicit the expected form of the overall congruence effect.

From the findings of the experiments, that have been reported this far, we can conclude, that conceptual type information influences noun processing depending on the congruence with its concept type. However, it does not restrain the activation or selection of competing candidates (neither by eliminating lexical competitors nor by reducing lexical activation in the first place), which indicates a post-lexical rather than lexical locus of the concept type congruence effect. As previous results did not show any inhibitory effect, we might infer that conceptual information acts at the earlier post-lexical built up processing stage rather than at the later stage of post-lexical reanalysis.

In order to ensure that the absence of the overall congruence effect was not caused by the stimuli (which differed from the stimuli used in experiment 2), a complementary German lexical decision experiment was conducted with the noun stimuli used in experiment 7.

2.6.2 Experiment 8: Complementary German Auditory Lexical Decision

The aim of this auditory lexical decision experiment was to test if the overall congruence effect, which was shown in experiment 2, could be replicated with these stimuli in the same manner. From the previously reported phoneme monitoring experiment the real word stimuli were used as real word targets in this lexical decision experiment. It served to ensure the validity of the results and the conclusions drawn from the previously reported phoneme monitoring results.

2.6.2.1 Material and Methods

Participants

Experiment 8 tested 80 native speakers of German, mostly students of Heinrich-Heine-University Düsseldorf, Germany (52 women, 28 men; mean age M = 25.95 years, SD = 7.35). They were paid a small fee for their participation.

Materials, Procedure and Apparatus

Experiment 8 used stimulus material from experiment 7 for which new lists were created, analogous to the procedure for experiments 1-6. However, from the complete stimuli of experiment 7, only the 84 "real" nouns, as well as the same number of pseudowords were used for experiment 8. The experimental set-up, apparatus and procedure (including the written instructions) were the same as for experiment 2.

2.6.2.2 Results

For statistical analysis, lexical decision times were extracted only for the real word items. Erroneous answers (pseudoword decision on a real word) and time-out trials (RT longer than 5000 ms) were excluded from all analyses (overall error and time-out rate: 2.95%). Additionally, outlier trials with reaction times beyond three standard deviations from the mean reaction time (per subject and concept type) in both directions were removed (outlier rate: 1.03% of all correct answers).

Overall Congruence

For the same reasons mentioned in the results section of experiment 1 (see Section 2.2.1.2), a linear normalization was applied to the reaction times ($RT_{norm}= RT * RT_{none\_}mean/ RT_{none\_}mean\_by\_concept\_type$). The graphical representation of the results for the overall congruence analysis in figure 2.41 suggests an overall congruence effect in the expected form.

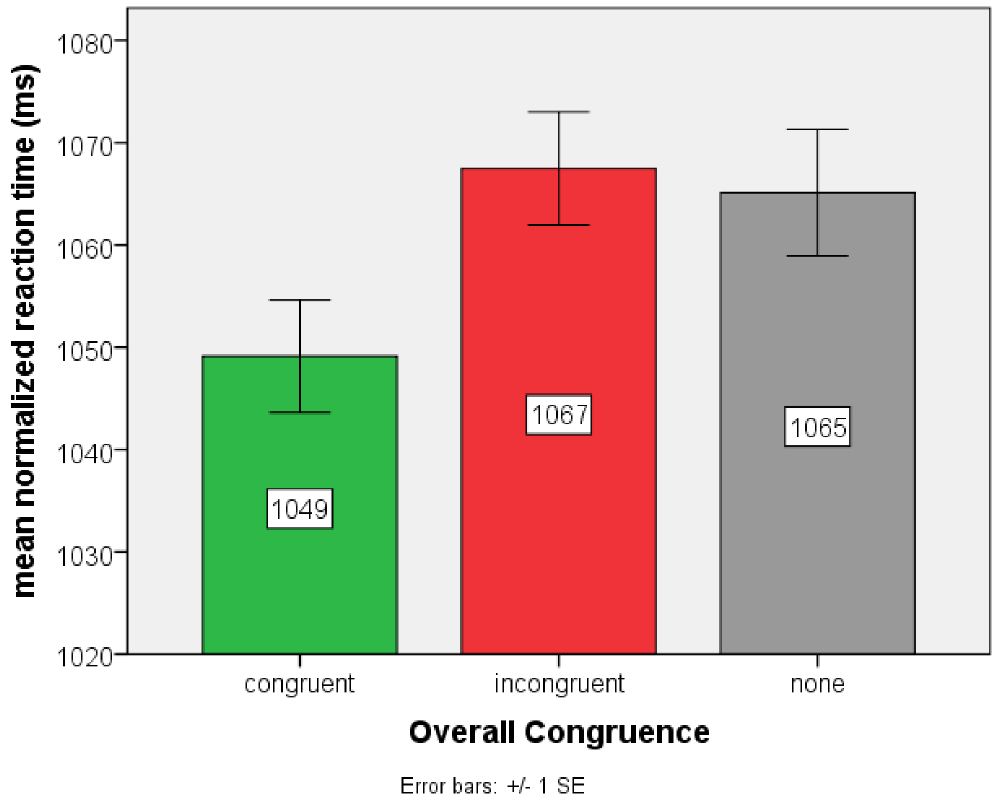

Figure 2.41: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German auditory LDT

The bar chart shows facilitation for congruent conditions (green bar), when compared to the incongruent as well as to the no-determiner conditions, whereas there is no difference between incongruent and no-determiner cases.

In order to test, whether the suggested effect could be validated by statistical data, a one-way repeated measures ANOVA was conducted with the factor Overall Congruence {incongruent, congruent, none}. Maulchy`s test of sphericity indicated that the assumption of sphericity had been violated for the main effect of Congruence, $\chi^2(2) = 11.16$, $p = .004$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .88$) was used to correct the degrees of freedom. The results of the ANOVA showed a significant effect of Overall Congruence, $F(1.77, 139.41) = 4.13$, $p = .022$, $r = .22$. Planned contrasts (simple (first)) compared lexical decision times of congruent and no-determiner cases to the incongruent ones, as we expected a facilitation by congruent (vs. incongruent) cases but no influence or an inhibition by incongruent cases (vs. none). The contrasts revealed that nouns presented with a preceding congruent determiner yielded faster responses than incongruent determiner-noun combinations, $F(1, 79) = 10.89$, $p = .001$, $r = .35$. No significant difference was found between incongruent and no-determiner cases, $F(1, 79) = .33$, $p = .570$. A selective post hoc comparison of congruent vs. no determiner showed a marginal advantage of congruent noun-determiner combinations ($p = .064$).

2.6.2.3 Summary and Intermediate Discussion

Experiment 8 used the auditory lexical decision paradigm with those determiner-noun combinations that were previously used in phoneme monitoring (experiment 7). The results of experiment 8 confirm the findings of experiment 2 and 6. The significant main effect of overall congruence shows significant differences for the expected pairs: congruent determination facilitates word recognition, while incongruent determination does not differ from using no determiner at all. These findings support the phoneme monitoring results (experiment 7), in that a conceptual congruence effect could be shown with these stimuli. The lack of this effect in phoneme monitoring can thus merely be attributed to the post-lexical locus at which conceptual type information seems to operate.

3. Digging Deeper – A More Extensive Look at the Data

Complementary to the experiment analyses in chapter 2 there are two aspects that shall be focused in this chapter. One aspect is the notion of Congruence which does not have a self-evident, clear definition within the CTD and thus shall be discussed in section 3.1. The second aspect is the possible reproach against the concept type congruence effect found in experiments 2, 6 and 8 of being the result of a mere frequency effect, which will be addressed in section 3.2.

3.1 A More Differentiated Take on Congruence

It has been briefly mentioned above (see section 2.2.1.2) that the notion of *congruence* is worthy of discussion and problematic to some extent. So far, it has been used to refer to combinations of determiners and nouns and to the aspect of whether both match or mismatch. But what are the exact criteria for deciding whether they match or mismatch? What is it that needs to match between determiner and noun in order to call the combination *congruent*? Does *congruence* require 1 or both referential properties to match between determiner and noun (or rather determiner type and concept type)? Do determiner types demand only one or both of the referential features to match in order to result in a congruent determiner-noun combination?

An attempt to approach these questions from an empirical perspective is presented in this section. Citations and possible interpretations from Löbner's work and others will be referenced and compared in order to dissect and pinpoint the three possible notions or interpretations of *congruence*. This excursus will focus on the congruence aspects that concern the three determiner types used in the above mentioned experiments. The three models of congruence will then be used For statistical analysis, and comparison of the reaction time data from the lexical decision experiments 1-6 and 8. An informative outcome would be a significant congruence 2 or 3 effect for experiments that have not shown a significant overall congruence effect in the previous analyses, which could be interpreted in favor of one of the additional versions of congruence.

3.1.1 Theoretical Issues

Löbner (2011) explains that concept types and determiner types can match with respect to their referential properties in which case we have congruent determiner-noun combinations. However, there are several passages in the respective paper as well as statements in other works (conference talks), that yield different interpretations concerning the requirements of the determiner types with respect to the referential properties. I have found three different paraphrases of *congruence*, which differ with respect to the (number of) included properties:

- *simple congruence* or *congruence 1*: requires one of the two features per determiner type to match the noun
- *graded congruence* or *congruence 2*: requires both features per determiner type to match the noun
- *mixed congruence* or *congruence 3*: requires one feature for indefinite and definite determination, but both features for possessive determination

These three congruence “models” will be discussed below.

3.1.1.1 Congruence 1 (1 feature, a.k.a. Overall Congruence)

This first notion of *congruence 1* (previously named *overall congruence*) was used as a kind of “default” definition/interpretation of congruence in the analyses of all experiments within this work and is mainly based on an interpretation of the concept type table by Löbner (2011: 307 and table 1.1). In this interpretation congruence between determiner type and concept type is based on one of the two features (or rather its value):

- indefinite determination is congruent with [–U] (SC and RC)
- definite determination is congruent with [+U] (IC and FC)
- possessive determination is congruent with [+R] (RC and FC)

Indefinite determination requires a [–U] noun, definite determination requires a [+U] noun and possessive determination requires a [+R] noun. Thus, according to the notion of *congruence 1,* congruent combinations are: indefinite determiner combined with sortal or relational concepts, definite determiner combined with individual or functional concepts, and possessive determiner combined with relational or functional concepts (see table 3.1, congruent combinations marked green; incongruent combinations marked red).

<table>
<tr><th colspan="2"></th><th colspan="2">Uniqueness</th></tr>
<tr><th colspan="2"></th><th>non-unique [–U]</th><th>inherently unique [+U]</th></tr>
<tr><th rowspan="2">Relationality</th><th>non-relational [–R]</th><td>SORTAL
Apfel / apple
ein Apfel/ an apple
der Apfel/the apple
sein Apfel/his apple
xxxx Apfel/xxxx apple</td><td>INDIVIUDAL
Papst/ pope
ein Papst/a pope
der Papst/ the pope
sein Papst/ his pope
xxxx Papst/ xxxx pope</td></tr>
<tr><th>Inherently relational [+R]</th><td>RELATIONAL
Arm/ arm
ein Arm/ an arm
der Arm/ the arm
sein Arm/ his arm
xxxx Arm/ xxxx arm</td><td>FUNCTIONAL
Mutter/mother
eine Mutter/ a mother
die Mutter/ the mother
seine Mutter/ his mother
xxxx Mutter/xxxx mother</td></tr>
</table>

Table 3.1: Concept types & congruent/incongruent determination for congruence 1 (overall congruence)

Support for this interpretation of congruence can be found in several sources. Firstly, a quote from the original paper by Löbner (2011) might be interpreted as relating the determination types to one of the referential properties:

> “The properties that distinguish the types of nouns, that is, uniqueness and relationality, correspond to types of determination and reference. Clearly, uniqueness is linked to definiteness, and relationality to possessive determination” (Löbner 2011: 287).

The same holds for the CTD-table that was introduced in chapter 1 (see section 1.1.1 and 1.2.2, and original CTD-table by Löbner 2011: 307). Secondly, there are further references that support the 1-feature interpretation of congruence given by Löbner (2012) in a presentation. First he introduces another version of his CTD-table, in which he again lists the congruent determination types for the different concept (or noun) types.

[–U]	[+U] conceptually unique	
sortal nouns *girl book water* ✓indefinite ✓absolute	**individual nouns** *pope Jo she* ✓definite ✓absolute	**[–R]**
relational nouns *uncle part kin* ✓indefinite ✓possessive	**functional nouns** *mother mouth amount* ✓definite ✓possessive	**[+R] conceptually relational**

Table 3.2: Noun types and unmarked determination in a talk by Löbner (slightly reduced version of Löbner 2012: slide 5)

To complement the table, he explicitly lists the different concept types with their congruent and incongruent determination (Löbner 2012: slides 11f):

CNP types	**congruent determination**
Sortal	indefinite absolute
Individual	definite absolute
Relational	indefinite possessive
Functional	definite possessive

CNP type	**incongruent determination**
Sortal	definite possessive
Individual	indefinite possessive
Relational	definite absolute
Functional	indefinite absolute

As indefinite determination is listed to be congruent with sortal and relational nouns (both [–U]), definite determination is listed to be congruent with individual and definite determination (both [+U]), and possessive determination is listed to be congruent with relational and functional nouns (both [+R]), we can infer that only one of the two features (or rather its value) is required to match in order to have a congruent determiner-noun combination.

A further hint for an argument against the uniqueness of possessive constructions by Haspelmath (1999) can be found in Abbott (2006b: 122):

> "Possessive NPs have been included in the table since they are almost universally considered to be definite. However, Haspelmath (1999[…]) argued that possessives are not inherently definite but merely typically so."

Looking at Haspelmath's (1999: 231) remarks on the definiteness of possessive NPs he states that "possessed noun phrases are not necessarily definite, they are only highly likely to be definite". In a typological analysis he shows that definite and possessive determination show complementary distribution in most languages, but not because possessive NPs are inherently definite (or unique) but because of economic reasons, because possessive NPs "have a preference for definiteness" (ibid.). Furthermore he shows several examples (e.g. Italian, Greek cf. Haspelmath, 1999: 228) where the definite article is used in definite possessive constructions. In Löbner's terms, the definite determiner – in addition to the possessive pronoun – is used in order to change the uniqueness value of the head noun to [+U].

3.1.1.2 Congruence 2 (2 features)

In this interpretation congruence between determiner type and concept type is based on both features – or rather their values:

- indefinite determination is congruent with [-U][-R] (SC)
- definite determination is congruent with [+U][-R] (IC)
- possessive determination is congruent with [+U][+R] (FC)

Indefinite determination requires a [–U, –R] noun, definite determination requires a [+U, –R] noun and possessive determination requires a [+U, +R] noun. Thus, according to the notion of *congruence 2* congruent combinations are: indefinite determiner combined with sortal concepts, definite determiner combined with individual concepts, and possessive determiner combined with functional concepts (cf table 3.3, congruent combinations marked green, incongruent combinations marked red). Due to the logic of this notion of *congruence*, there are not only (fully) congruent vs. incongruent cases but also partly (in)congruent combinations, in the cases where only one of the two required features match (marked blue in table 3.3).

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**non-relational [–R]**	**SORTAL** ***Apfel / apple*** ein Apfel/ an apple der Apfel/the apple sein Apfel/his apple xxxx Apfel/xxxx apple	**INDIVIUDAL** ***Papst/ pope*** ein Papst/a pope der Papst/ the pope sein Papst/ his pope xxxx Papst/ xxxx pope
	Inherently relational [+R]	**RELATIONAL** ***Arm/ arm*** ein Arm/ an arm der Arm/ the arm sein Arm/ his arm xxxx Arm/ xxxx arm	**FUNCTIONAL** **Mutter/mother** eine Mutter/ a mother die Mutter/ the mother seine Mutter/ his mother xxxx Mutter/xxxx mother

Table 3.3: Concept types and congruent vs. incongruent determiner types according to the notion of "graded" congruence 2 (2 features)

Support for this interpretation can be found in the original paper by Löbner (2011):

> "[The] three elementary types of determination [indefinite, definite and possessive determination] are in harmony with sortal [-U][-R], individual [+U][-R], and functional [+U][+R] nouns, respectively. There is, however, no simple type of determination in harmony with relational [-U][+R] nouns [...]" (Löbner 2011: 306).

If the expression "are in harmony with" in this quote might be interpreted as "are congruent with", congruence can be interpreted in the form of congruence 2 which states that the determination types require both referential properties to match in a noun in order to construct a congruent determiner-noun combination (cf. above for detailed requirements of the different determiner types).

Further evidence for this notion/definition/ interpretation stems from citations of Löbner (2011). An example that is frequently cited by linguists, who work within the CTD-framework, is *mother*, a functional noun, and its congruent and incongruent uses. For example, Gerland and Horn (2010) explain, that *mother* is used congruently when used in a possessive construction, as in *meine Mutter*. If *mother* is used with an indefinite article, as in *eine Mutter* it is reported to be shifted to a sortal noun (ibid.). If we look at this example, where a functional noun (i.e. a noun with the properties [+U, +R]) is shifted to a sortal noun (i.e. a noun with the properties [–U, –R]) by the means of an indefinite article, it stands to reason, that the indefinite article is responsible for the change of values of *both* features, not just of uniqueness.

Support for the 2-feature requirements of possessive determination can be found in Löbner (2011: 304): "[determiner possessives] impose definiteness on the possessum noun" and "poss. pron. [+U] [+R]". This quote can also be used to account for the 2-feature requirements of possessive determination in the following definition of congruence 3.

The hypotheses and predicted effects for the reaction time data analyzed for this interpretation of congruence, congruence 2, are:

- facilitation for fully congruent cases compared to no-determiner condition
- faster responses for fully congruent compared to fully incongruent and partly (in)congruent cases
- faster responses for partly (in)congruent compared to fully incongruent cases
- no difference or inhibition for fully incongruent cases compared to no-determiner condition

3.1.1.3 Congruence 3 (1 / 2 features)

In this, third, interpretation, congruence between determiner type and concept type is based on one feature for indefinite and definite determination and on both features for possessive determination:

- indefinite determination is congruent with [–U] (SC and RC)
- definite determination is congruent with [+U] (IC and FC)
- possessive determination is congruent with [+U, +R] (FC)

Thus, according to the notion of *congruence 3*, congruent combinations are: indefinite determiner combined with sortal or relational concepts, definite determiner combined with individual or functional concepts and possessive determiner combined with functional concepts (cf. table 3.4, congruent combinations marked green; incongruent combinations marked red).

		Uniqueness	
		non-unique [–U]	**inherently unique [+U]**
Relationality	**non-relational [–R]**	**SORTAL** ***Apfel / apple*** ein Apfel/ an apple der Apfel/the apple sein Apfel/his apple xxxx Apfel/xxxx apple	**INDIVIUDAL** ***Papst/ pope*** ein Papst/a pope der Papst/ the pope sein Papst/ his pope xxxx Papst/ xxxx pope
	Inherently relational [+R]	**RELATIONAL** ***Arm/ arm*** ein Arm/ an arm der Arm/ the arm sein Arm/ his arm xxxx Arm/ xxxx arm	**FUNCTIONAL** **Mutter/mother** eine Mutter/ a mother die Mutter/ the mother seine Mutter/ his mother xxxx Mutter/xxxx mother

Table 3.4: Concept types and congruent vs. incongruent determiner types according to the notion of "mixed" congruence 3

The “mixed” idea behind this interpretation of congruence stems from a discussion with my colleague Christian Horn[42]. He argued that, rather than opting for 1 or 2 feature interpretations, he would suggest a mixed version of defining *congruence*, thus the *congruence 3* version. The [R]-values for indefinite and definite determination might be seen as either not required, as underspecified or as implicitly [–R]. There is no clear definition in Löbner’s work. Support from Löbner for the 2-value requirement of possessive determination has already been quoted at the end of the previous subsection. The hypotheses for the reaction time data analyzed for congruence 3 are:

- facilitation for congruent cases compared to no-determiner condition
- faster responses for congruent compared to incongruent cases
- no difference or inhibition for incongruent cases compared to no-determiner condition

3.1.2 Statistical Analysis of Congruence 2 and 3

As for the following congruence analyses the nouns of the four concept types were grouped together (according to congruent vs. incongruent determiner-noun combinations) and, more importantly, the concept types were not equally distributed over congruence groupings (see also Section 2.2.1), the same linear normalization was applied to the reaction times for the following congruence 2 and 3 analyses, as was used to conduct the overall congruence (1) analyses for all experiments (formula: $RT_{norm} = RT * RT_{none}\_mean / RT_{none}\_mean\_by\_concept\_type$). A compact overview of the results of all tree congruence analyses will be given in chapter 3.1.3.

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[42] from Project C02 *Conceptual Shifts: Statistical Evidence* within the Collaborative Research Center No. 991 @Heinrich-Heine-University Düsseldorf, Germany (http://www.sfb991.uni-duesseldorf.de/en)

3.1.2.1 Congruence 2 (graded/ 2 features)

Experiment 1 – German Visual Lexical Decision Experiment

Looking at figure 3.1, that displays the graded congruence (2) view of the data from experiment 1, a German visual lexical decision experiment, the most obvious aspect is a general facilitation for any determiner in comparison to the no-determiner condition. Among the congruence steps, fully congruent determiners caused the strongest facilitation of noun processing, which is in line with the hypotheses for congruence 2. The difference to partly and fully incongruent determiner-noun combinations is visible but not massive, and interestingly fully incongruent determiner-noun combinations were processed slightly faster than partly (in)congruent ones, although the opposite distribution was expected.

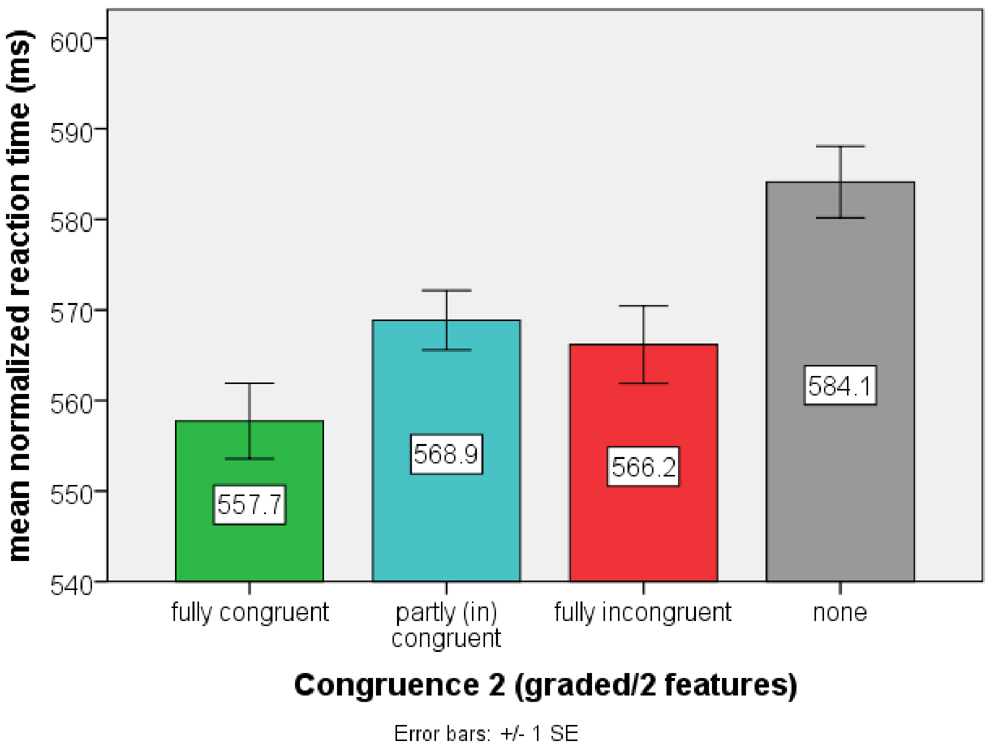

Figure 3.1: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German visual LDT

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none}. The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 2, $F(3, 285) = 13.17$, $p = .000$, $r = .35$.

Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations and no-determiner cases with fully incongruent combinations, and revealed significantly faster responses for fully congruent noun-determiner combinations compared to fully incongruent cases, $F(1, 95) = 4.02$, $p = .048$, $r = .20$.

Furthermore, fully incongruent noun-determiner pairs yielded significantly faster responses compared to no-determiner cases, $F(1, 95) = 17.64$, $p = .000$, $r = .40$. The analysis showed no significant difference between fully incongruent versus partly (in)congruent cases $F(1, 95) = .41$, $p = .524$. Additionally, a selective post hoc comparison of fully congruent cases with partly (in)congruent and no-determiner cases, showed significantly faster responses for congruent noun-determiner combinations compared to the neutral baseline condition, $p = .001$, as well as compared to partly (in)congruent cases, $p = .011$ (to correct for the multiple (2) comparisons, a significance threshold of $p = .025$ was assumed).

Experiment 2 – German Auditory Lexical Decision Experiment

Figure 3.2 displays the graded congruence (2) view of the data from experiment 2, a German auditory lexical decision experiment. The distribution of mean normalized lexical decision times looks very much like the visualization of the hypotheses and predictions for congruence 2, which were mentioned in section 3.1.1.2: fully congruent determiners caused a clear facilitation of noun processing (compared to the no-determiner condition). Partly (in)congruent determiner-noun combinations showed a smaller facilitation, and almost no difference could be found between fully incongruent and no determiner uses of nouns.

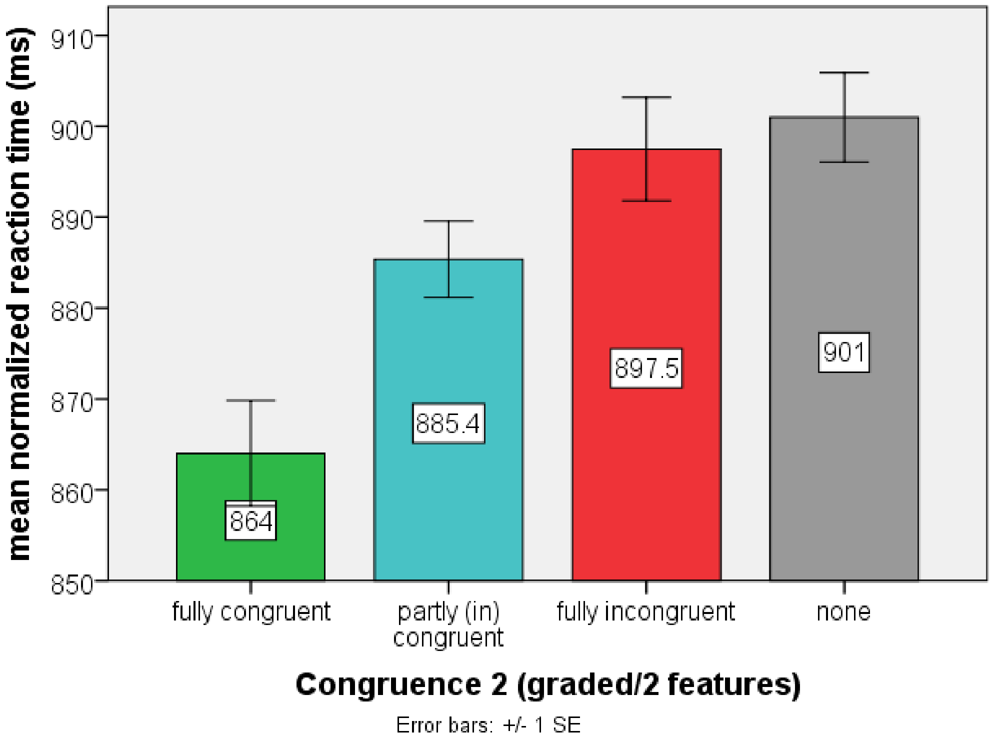

Figure 3.2: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German auditory LDT

In order to test, whether the observed facilitation effects could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 2, $\chi^2(5) = 13.90$, $p = .016$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .92$) was used to correct the degrees of freedom.

The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 2, $F(2.76, 261.73) = 12.18$, $p = .000$, $r = .34$. Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations and no-determiner cases with fully incongruent combinations, and revealed significantly faster responses for fully congruent noun-determiner combinations compared to fully incongruent cases, $F(1, 95) = 20.65$, $p = .000$, $r = .42$.

Furthermore, partly (in)congruent noun-determiner combinations yield significantly faster responses compared to fully incongruent cases, $F(1, 95) = 4.00$, $p = .048$, $r = .20$. No significant difference was found between fully incongruent and no-determiner cases, $F(1, 95) = .46$, $p = .498$. Additionally, a selective post hoc comparison of fully congruent cases with partly (in)congruent and no-determiner cases, showed significantly faster responses for congruent noun-determiner combinations compared to the no-determiner cases, $p = .000$, as well as compared to partly (in)congruent cases, $p = .001$ (to correct for the multiple (2) comparisons, a significance threshold of $p = .025$ was assumed).

Experiment 3 – German Visual Lexical Decision Experiment

Looking at figure 3.3, that displays the graded congruence (2) view of the data from experiment 3, a German visual lexical decision experiment, the most obvious aspect is a general facilitation for any determiner in comparison to the no-determiner condition. Among the congruence categories, fully congruent determiners caused the strongest facilitation of noun processing, which is in line with the hypotheses for congruence 2. However, the difference between fully congruent and partly/fully incongruent determiner-noun combinations is visible but rather small. Interestingly, fully incongruent determiner-noun combinations were processed slightly faster than partly (in)congruent ones, although the opposite distribution was expected.

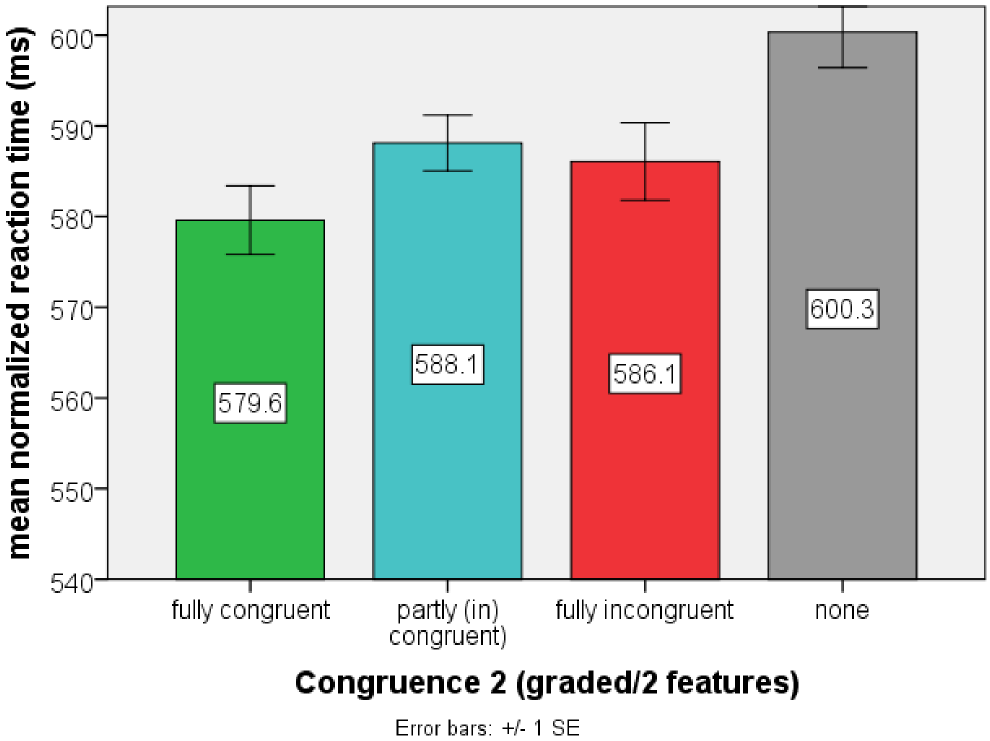

Figure 3.3: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German visual LDT

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 2, $\chi^2(5) = 16.74$, $p = .005$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .89$) was used to correct the degrees of freedom. The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 2, $F(2.66, 252.96) = 8.50$, $p = .000$, $r = .29$. Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations and no-determiner cases with fully incongruent combinations, and revealed significantly faster responses only for fully incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 95) = 9.90$, $p = .002$, $r = .31$.

However, the results did neither show a significant difference between fully congruent vs. fully incongruent cases, $F(1, 95) = 2.47$, $p = .119$, nor between partly (in)congruent vs. fully incongruent combinations, $F(1, 95) = .51$, $p = .479$. Selective post hoc comparisons of fully congruent cases with partly (in)congruent and no-determiner cases showed significantly faster responses only for congruent noun-determiner combinations compared to the no-determiner cases, $p = .000$. Fully congruent compared to partly (in)congruent cases were not significant, $p = .049$ (to correct for the multiple (2) comparisons, a significance threshold of $p = .025$ was assumed).

Experiment 4 – German Visual Lexical Decision Experiment

Figure 3.4 displays the graded congruence (2) view of the data from experiment 4, a German visual lexical decision experiment. The most surprising aspect is, that fully incongruent determiner-noun combinations have the shortest latencies, thus the strongest facilitation compared to the no-determiner condition[43]. Fully congruent determiners caused a slight facilitation and shorter latencies than partly (in-congruent) determiners, which only slightly facilitated the processing of nouns during the lexical decision experiment. The graph shows results that are quite diverging from the hypotheses.

[43] Compared to the hypotheses for congruence 2 the results are surprising, however, already the concept type and determiner type as well as the overall congruence (1) data showed this reverse pattern (see results section in section 2.3.2).

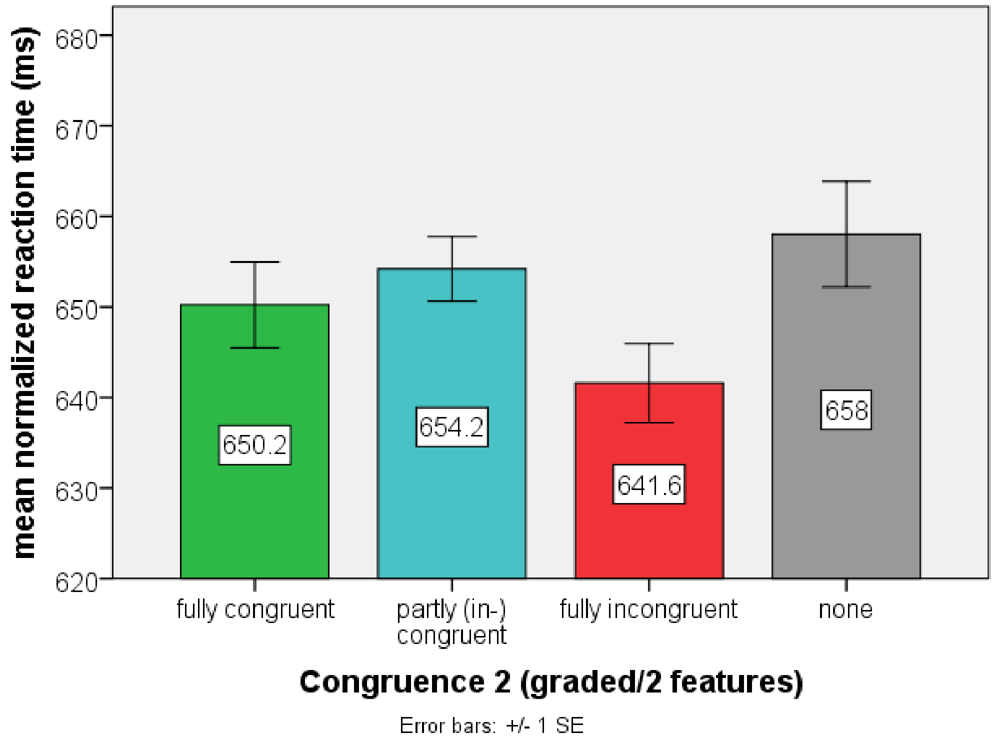

Figure 3.4: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German visual LDT (correct and incorrect gender)

If the incorrect gender trials are excluded, the resulting graph displays results similar to the overall view. There is a facilitation caused by any determiner compared to the no-determiner condition. Fully incongruent determiners cause the strongest facilitation, followed by partly (in)congruent and fully congruent determiners, thus the data show an oppositional distribution if compared to the hypotheses.

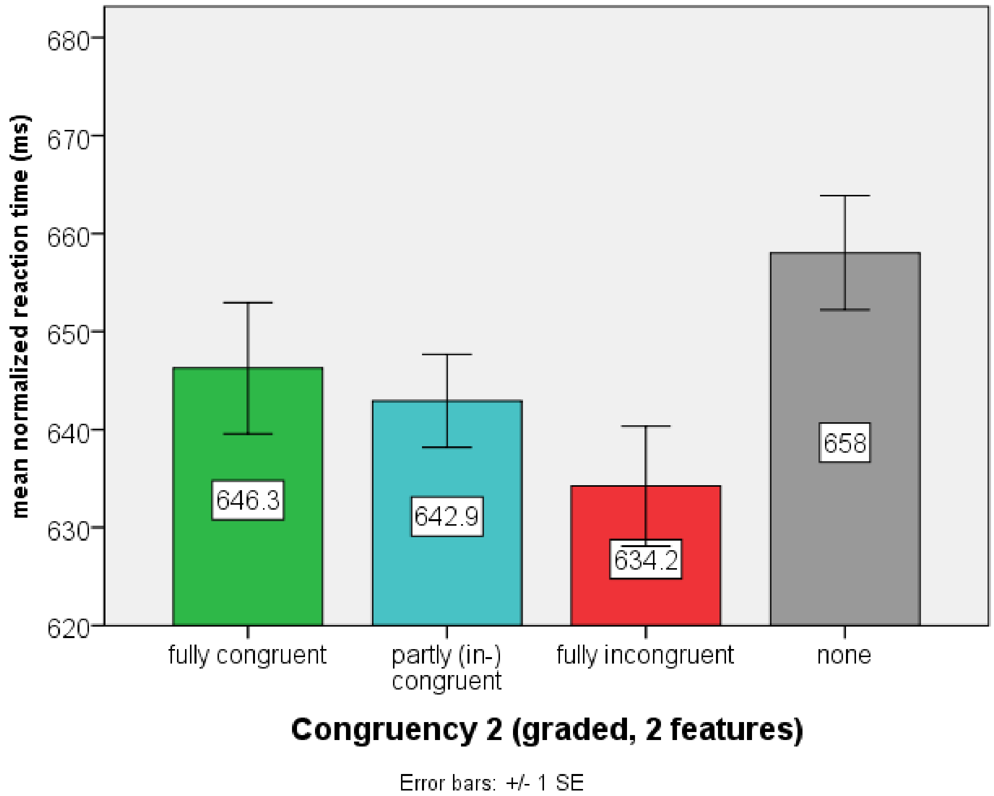

Figure 3.5: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German visual LDT (only correct gender)

In order to test, whether the observed reverse effects could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none}. (A preliminary analysis (no-determiner cases were excluded) of a possible interaction of the factors Gender Congruence and Congruence 2 yielded no significant interaction, $F(1,139) = 1.32$, $p = .270$. Therefore the factor Congruence 2 is analyzed and reported separately here (including the no-determiner cases), analogous to the procedure for experiments 1-3.)

Maulchy`s test of sphericity was significant, thus indicated a violation of the assumption of sphericity for the main effect of Congruence 2, $\chi^2(5) = 32.60$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .85$) was used to correct the degrees of freedom. The results of the one-way repeated measures ANOVA showed a significant effect of Congruence

2, $F(2.56, 356.25) = 3.17$, $p = .031$, $r = .15$. Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations and no-determiner cases with fully incongruent combinations, and revealed significantly faster responses for fully incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 139) = 7.46$, $p = .007$, $r = .23$, and, surprisingly, also compared to the partly incongruent combinations, $F(1, 139) = 8.20$, $p = .005$, $r = .24$. Even more surprising was the contrast of fully incongruent vs. fully congruent combinations: it was not significant, $F(1, 139) = 2.95$, $p = .068$, but yielded a slight trend towards faster responses for fully incongruent cases.

Experiment 8 – German Auditory Lexical Decision Experiment

Figure 3.6 displays the graded congruence (2) view of the data from experiment 8, a German auditory lexical decision experiment. There is a general, however, quite small facilitation for any determiner in comparison to the no-determiner condition. Among the congruence categories, fully congruent determiners caused the strongest facilitation of noun processing, which is in line with the hypotheses for congruence 2. The difference to partly and fully incongruent determiner-noun combinations, however, is very small. There was (almost) no difference between partly and fully incongruent determiner-noun combinations. The differences between the categories are so small, that the effect might probably be disregarded– unless statistic tests below tell a different story, which is unlikely.

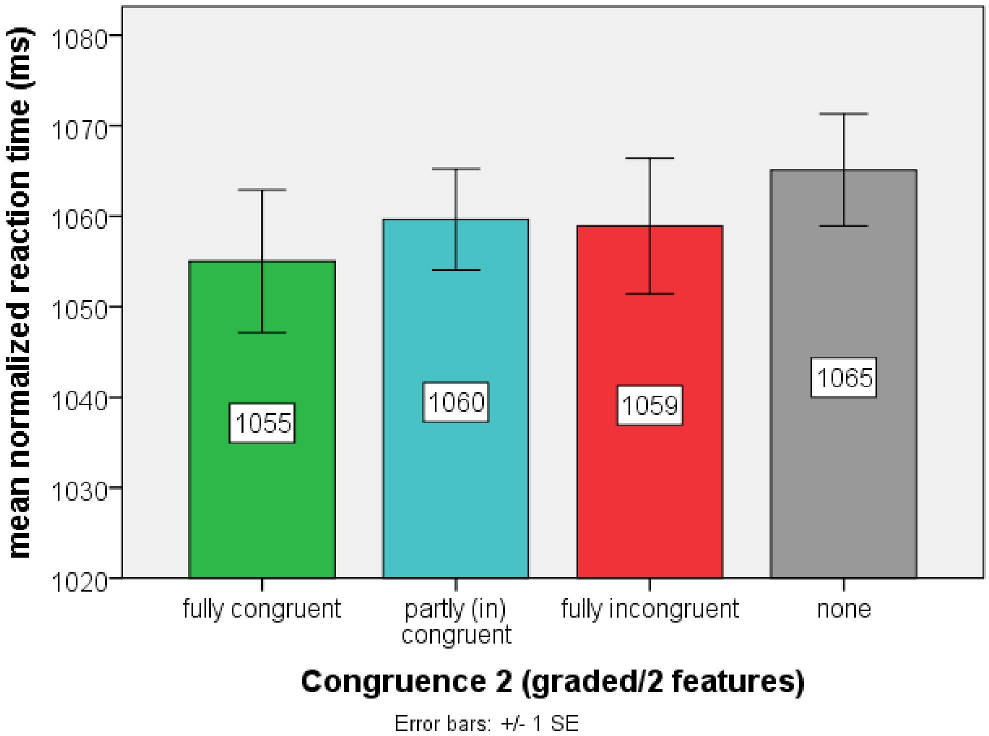

Figure 3.6: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in German auditory LDT

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none}. The results of the one-way repeated measures ANOVA showed no significant effect of Congruence 2, $F(3, 237) = .52$, $p = .669$.

Experiments 5 and 6 – English Visual and Auditory Lexical Decision Experiment

Figure 3.7 displays the graded congruence (2) view of the data from experiment 5 and 6 (overall), thus combines the English visual and auditory lexical decision data. With one exception, the distribution of mean normalized lexical decision times looks very much like the results of experiment 2. Fully congruent determiners caused a clear facilitation of noun processing (compared to the no-determiner condition). Partly (in)congruent determiner-noun combinations showed just a minimal facilitation, and the same holds for fully incongruent combinations; between these two groups the graph does not show any difference. The lack of clear facilitation for partly (in)congruent cases differs from the hypotheses, which expected a facilitation compared to no-determiner cases (albeit a smaller facilitation than for fully congruent cases).

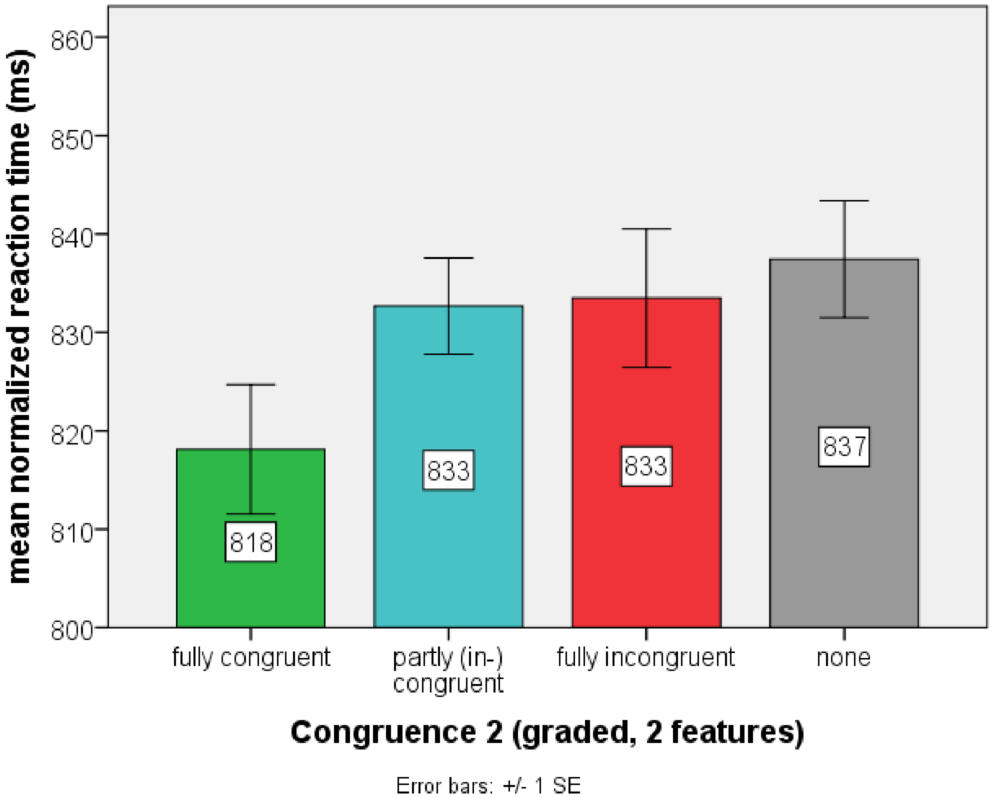

Figure 3.7: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in English visual & auditory LDT (overall)

Some of the previous analyses of experiments 5 and 6 showed major differences between the modalities, thus this analysis will probably show the same variation and shall therefore also show the data split into the two modalities. Figure 3.8 shows the data for the visual experiment. All three congruence categories have shorter latencies than the no-determiner condition. There seems to be a minimally stronger facilitation for fully congruent and fully incongruent combinations compared to the partly (in)congruent cases, however, all differences are very small.

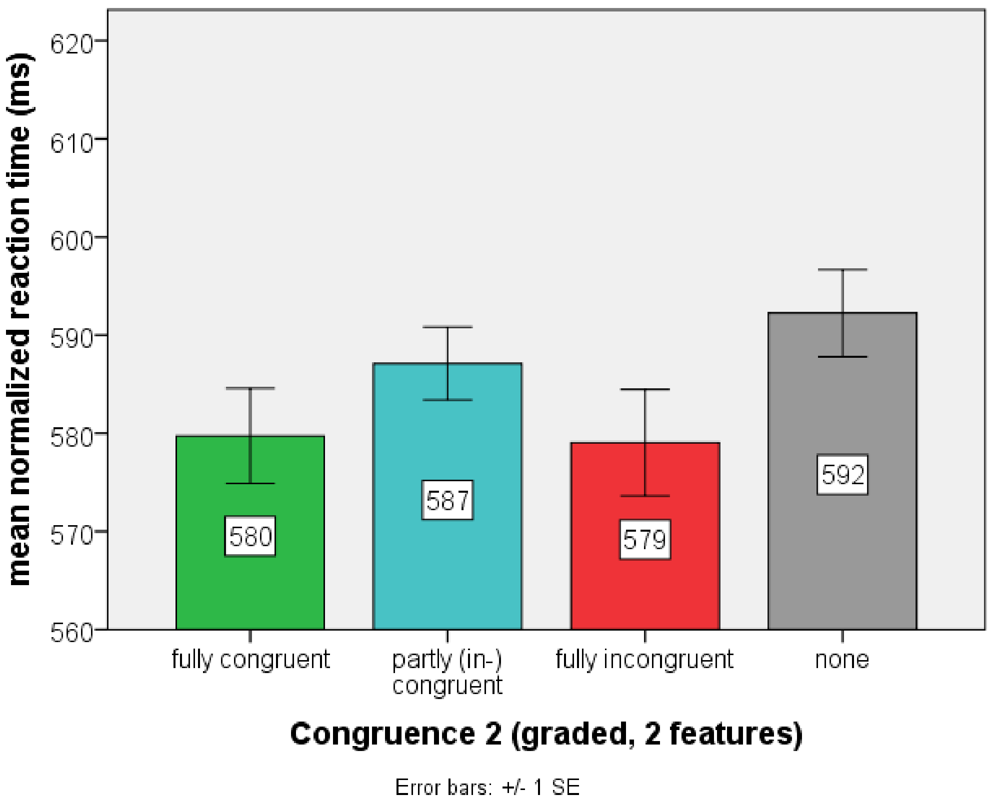

Figure 3.8: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in English visual LDT

Figure 3.9 displays the auditory data, which show a clear facilitation for fully congruent determiner-noun combinations compared to the no-determiner condition. Partly (in)congruent and fully incongruent cases show no difference compared to the no-determiner cases. With the expected facilitation of fully congruent combinations, the pattern of the auditory data only partly fulfills the hypotheses for congruence 3.

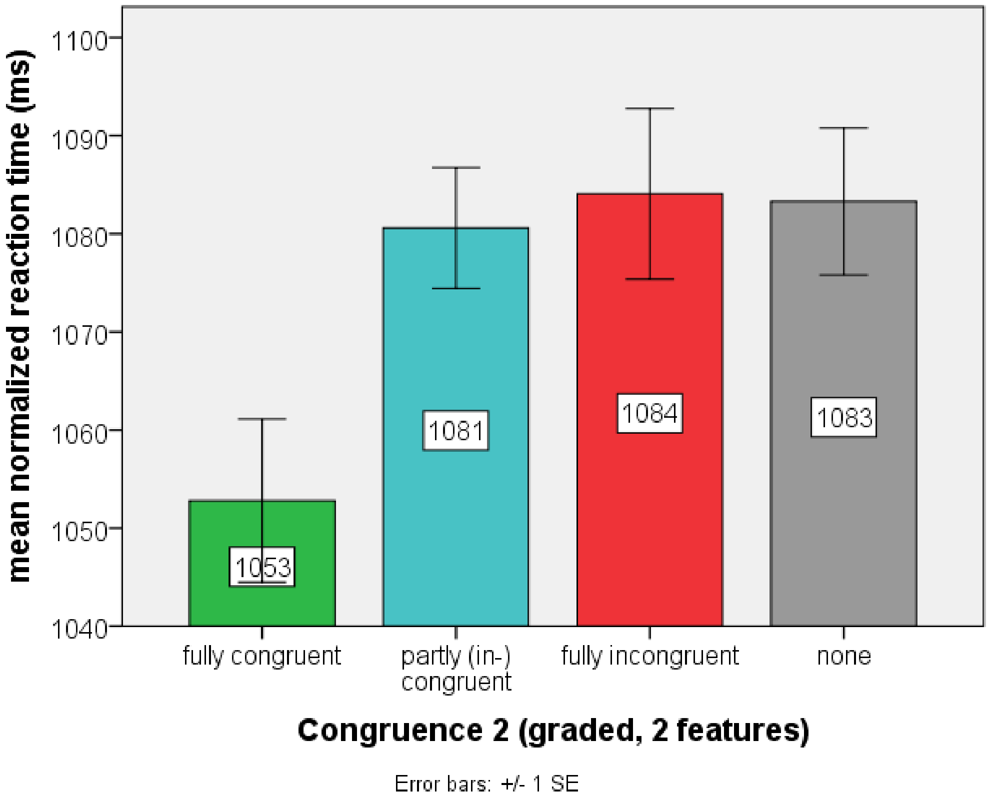

Figure 3.9: Lexical decision latencies for nouns used with fully congruent, fully incongruent, partly (in)congruent and no determiner in English auditory LDT

In order to test, whether the observed differences could be validated by statistical analysis, a repeated measures ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly incongruent, fully congruent, none} and Modality {visual, auditory}. The ANOVA was conducted including the factor Modality, in order to check for a possible interaction of the factor Congruence 2 with the previously mentioned factor Modality (see Section 2.3.3). Unsurprisingly, there was a significant main effect of Modality, $F(1, 95) = 1233.08$, $p = .000$, $r = .96$, (for details cf. section 2.4.3). In these experiments there was also an interaction of the factors Modality and Congruence 2, $F(3, 285) = 3.44$, $p = .017$, $r = .19$.

First the overall results of Congruence 2 will be reported. In a second step, results for visual and auditory data are reported separately, due to the interaction with the factor Modality – which was also reflected in the heterogeneous patterns comparing figures 2.18 and 2.19, and in order to examine which modality caused the interaction.

For the main effect of Congruence 2, Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated, $\chi^2(5) = 38.78$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .79$) was used to correct the degrees of freedom. The results revealed a significant main effect of Congruence 2, $F(2.38, 225.97) = 4.75$, $p = .006$, $r = .22$. Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations, and no-determiner cases with fully incongruent combinations, and revealed significantly faster responses for fully congruent noun-determiner combinations compared to fully incongruent cases, $F(1, 95) = 4.23$, $p = .042$, $r = .21$. The ANOVA showed no significant difference between fully incongruent and partly (in)congruent, $F(1, 95) = .064$, $p = .801$, or no-determiner cases, respectively, $F(1, 95) = .736$, $p = .393$. Additionally, selective post hoc comparisons of congruent determiner-noun combinations with partly incongruent and no-determiner cases showed significantly faster responses for fully congruent noun-determiner combination than for partly congruent ($p = .001$) and no-determiner cases ($p = .000$) (to correct for the two post hoc comparisons a significance threshold of $p = .025$ was assumed).

For the visual data the ANOVA was conducted with the factor Congruence 2 {fully incongruent, partly (in)congruent, fully congruent, none}. Maulchy`s test of sphericity was significant for the effect of Congruence, thus indicated that the assumption of sphericity had been violated, $\chi^2(5) = 18.77$, $p = .002$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .89$) was used to correct the degrees of freedom. The results of the ANOVA showed no significant effect of Congruence 2 for the visual data, $F(2.68, 254.47) = 2.08$, $p = .110$.

For the auditory data the ANOVA was also conducted with the factor Congruence 2 {fully incongruent, partly (in)congruent, fully congruent, none}. Maulchy`s test of sphericity was significant for the effect of Congruence, thus indicated that the assumption of sphericity had been violated, $\chi^2(5) = 22.79$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity

(ε = .85) was used to correct the degrees of freedom. For the auditory data there was a significant effect of Congruence 2, $F(2.55, 242.40)$, $p = .003$, $r = .23$. Planned contrasts (simple (first)) compared fully congruent and partly (in)congruent determiner-noun combinations and no-determiner cases with fully incongruent combinations, and revealed the same pattern as the overall analysis: There were significantly faster responses for fully congruent noun-determiner combinations compared to fully incongruent cases, $F(1, 95) = 8.18$, $p = .005$, $r = .28$. The ANOVA showed no significant difference between fully incongruent and partly (in)congruent, $F(1, 95) = .31$, $p = .578$, or no-determiner cases, respectively, $F(1, 95) = .003$, $p = .958$. Additionally, selective post hoc comparisons of congruent determiner-noun combinations with partly incongruent and no-determiner cases showed significantly faster responses for fully congruent noun-determiner combinations compared to partly congruent ($p = .002$) and no-determiner cases ($p = .000$) (to correct for the two post hoc comparisons a significance threshold of 0.025 was assumed). Apart from the lack of difference between partly and fully incongruent conditions, the Congruence 2 effect shows the expected pattern.

3.1.2.2 Congruence 3 (1 or 2 features)

Experiment 1 – German Visual Lexical Decision Experiment

Figure 3.10 displays the mixed congruence (3) view of the data from experiment 1. It shows a general facilitation for any determiner in comparison to the no-determiner condition. As expected, latencies for congruent determiner-noun combinations are shorter than for incongruent ones; however, the difference is very small.

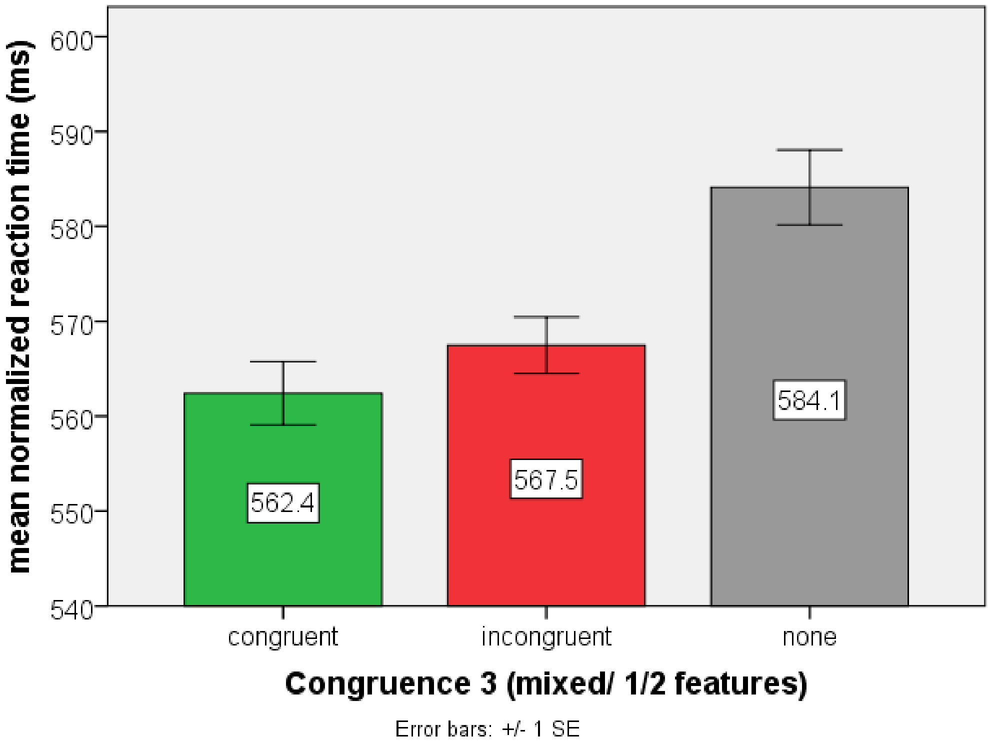

Figure 3.10: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 3 {incongruent, congruent, none}. The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 3, $F(2, 190) = 15.32$, $p = .000$, $r = .37$. Planned contrasts (simple (first)) compared congruent determiner-noun combinations and no-determiner cases with incongruent combinations, and revealed significantly faster responses only for incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 95) = 17.65$, $p = .000$, $r = .40$. However, there was no significant difference between congruent and incongruent cases, $F(1, 95) = 1.57$, $p = .214$. Additionally, a selective post hoc comparison of congruent vs. no-determiner conditions showed significantly faster responses for congruent noun-determiner combinations ($p = .000$).

Experiment 2 – German Auditory Lexical Decision Experiment

Figure 3.11 displays the mixed congruence (3) view of the data from experiment 2. It shows clear facilitation for nouns presented with congruent determiners in comparison to the no-determiner condition. Furthermore, latencies for congruent determiner-noun combinations were considerably shorter than for incongruent ones. There was also a slight facilitation caused by incongruent determiners. Apart from the slight facilitation effect, the distribution of lexical decision times is in line with the hypotheses for congruence 3.

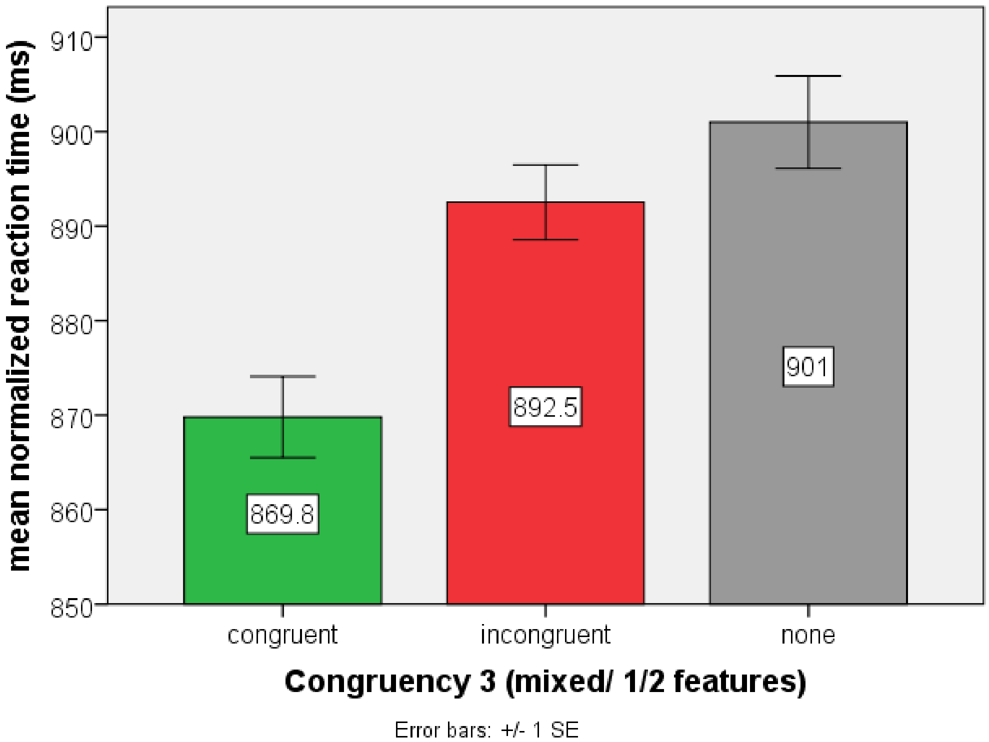

Figure 3.11: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German auditory LDT

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 3 {incongruent, congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 3, $\chi^2(2)$ =

15.28, p = .000, thus the Greenhouse-Geisser estimate of sphericity (ε = .87) was used to correct the degrees of freedom.

The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 3, $F(1.74, 165.21) = 13.90$, $p = .000$, $r = .36$. Planned contrasts (simple (first)) compared congruent determiner-noun combinations and no-determiner cases with incongruent combinations, and revealed that nouns presented with a preceding congruent determiner yielded faster responses than incongruent determiner-noun combinations, $F(1, 95) = 20.73$, $p = .000$, $r = .42$. No significant difference was found between incongruent and no-determiner cases, $F(1, 95) = 2.06$, $p = .154$. Additionally, a selective post hoc comparison of congruent vs. no determiner showed significantly faster responses for congruent noun-determiner combinations ($p = .000$).

Experiment 3 – German Visual Lexical Decision Experiment

Figure 3.12 displays the mixed congruence (3) view of the data from experiment 3, which look quite similar to the results of experiment 1, but are less pronounced. There is a general facilitation for any determiner in comparison to the no-determiner condition. As expected, latencies for congruent determiner-noun combinations are shorter than for incongruent ones; however, the difference is very small.

In order to test, whether the observed differences could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 3 {incongruent, congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 3, $\chi^2(2)$ = 9.35, p = .009, thus the Greenhouse-Geisser estimate of sphericity (ε = .91) was used to correct the degrees of freedom. The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 3, $F(1.83, 173.57) = 10.99$, $p = .000$, $r = .32$.

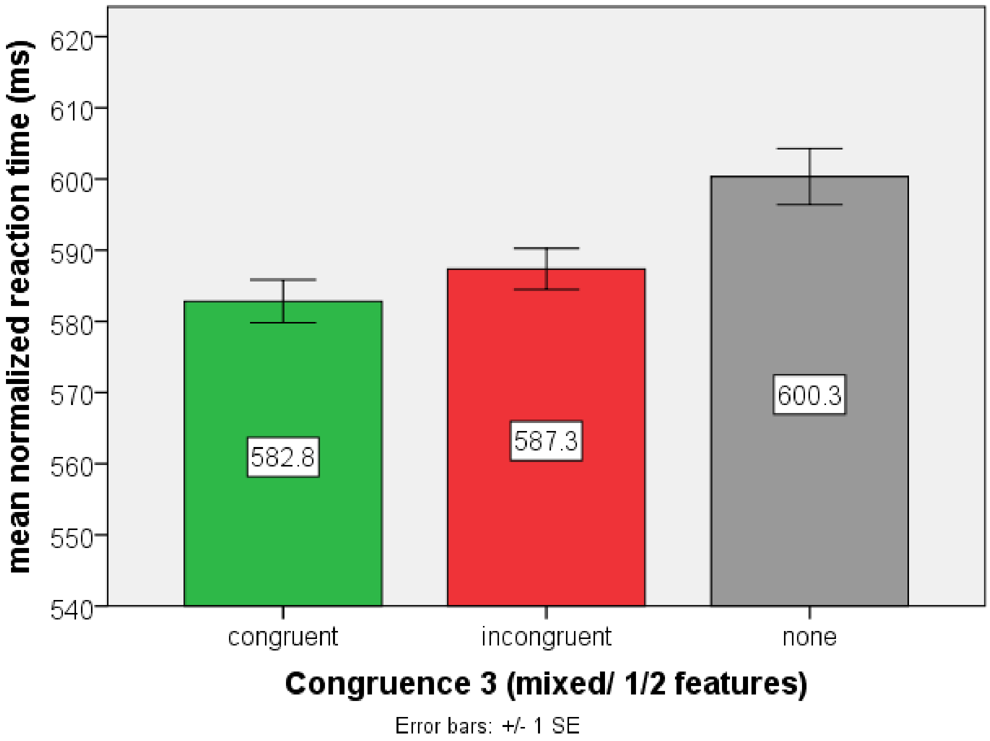

Figure 3.12: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT

Planned contrasts (simple (first)) compared congruent determiner-noun combinations and no-determiner cases with incongruent combinations, and significantly faster responses only for incongruent noun-determiner combinations compared to the no-determiner cases, $F(1, 95) = 12.15$, p = .001, r = .34, whereas there was no significant difference between congruent and incongruent cases $F(1, 95) = 1.57$, p = .213. Additionally, a selective post hoc comparison of congruent vs. no determiner showed significantly faster responses for congruent noun-determiner combinations (p = .000).

Experiment 4 – German Visual Lexical Decision Experiment

Figure 3.13 displays the mixed congruence (3) view of the data from experiment 4. It shows a general facilitation for any determiner in comparison to the no-determiner condition. Contrary to the expected pattern, latencies for incongruent determiner-noun combinations are shorter than for congruent ones; however, the difference is small.

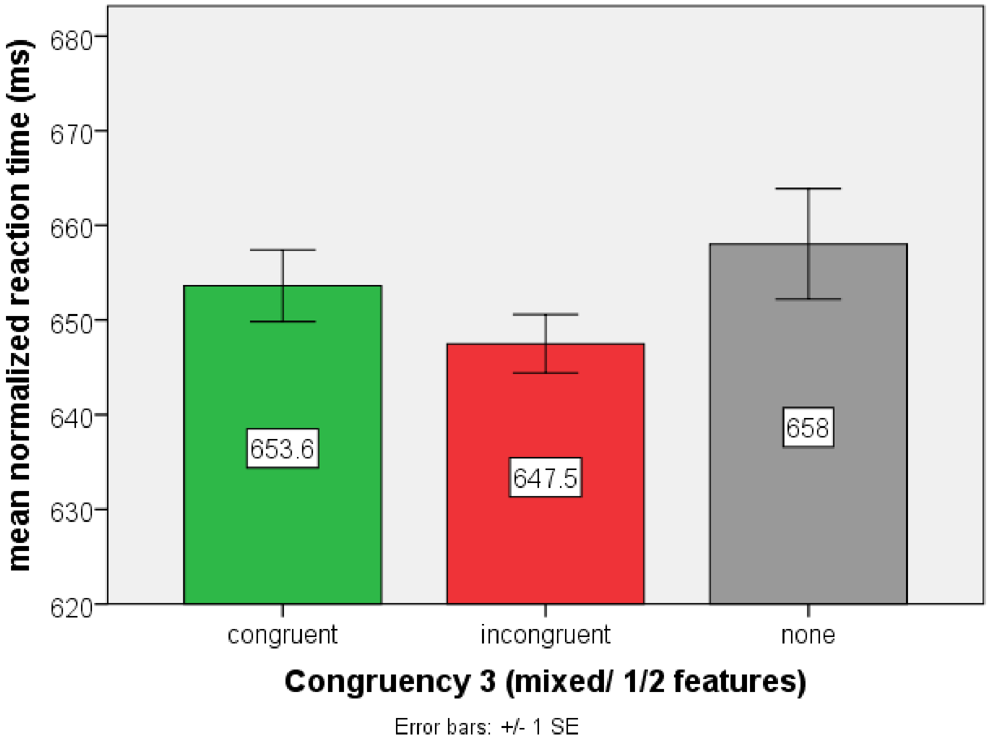

Figure 3.13: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT (correct & incorrect gender)

Looking at the data excluding incorrect gender trials (see figure 3.14), the pattern is the same but the overall facilitation effect of "real" determiners is more pronounced. In order to test, whether the observed reverse effects could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 3 {incongruent, congruent, none}. (A preliminary analysis (no-determiner cases were excluded) of a possible interaction of the factor Congruence 3 with the previously mentioned factor Gender Congruence (see Section 2.4.2) yielded no significant interaction, $F(1, 139) = .006$, $p = .940$. Therefore the factor Congruence 3 is analyzed and reported separately here (including the no-determiner cases), analogous to the procedure for experiments 1-3.)

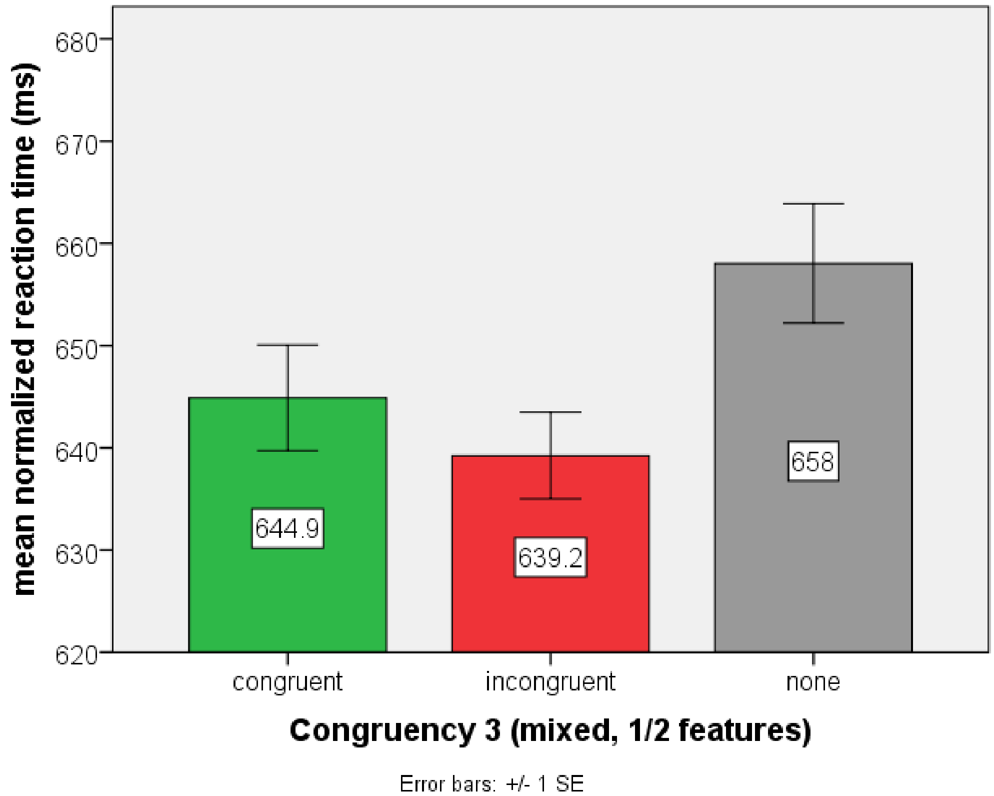

Figure 3.14: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German visual LDT (only correct gender)

Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 3, $\chi^2(2) = 34.36$, $p = .000$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .82$) was used to correct the degrees of freedom. The results of the one-way repeated measures ANOVA reveal no significant effect of Congruence 3 for experiment 4, $F(1.64, 227.79) = 2.00$, $p = .146$.

Experiment 8 – German Auditory Lexical Decision Experiment

Figure 3.15 displays the mixed congruence (3) view of the data from experiment 8. It shows clear facilitation for nouns presented with congruent determiners in comparison to the no-determiner condition. Furthermore, latencies for congruent determiner-noun combinations were considerably shorter than for incongruent ones. There was no facilitation caused by incongruent determiners, there is no visible difference between incongruent and no-determiner conditions. The distribution of lexical decision times for congruence 3 in the data of experiment 8 is in line with the hypotheses.

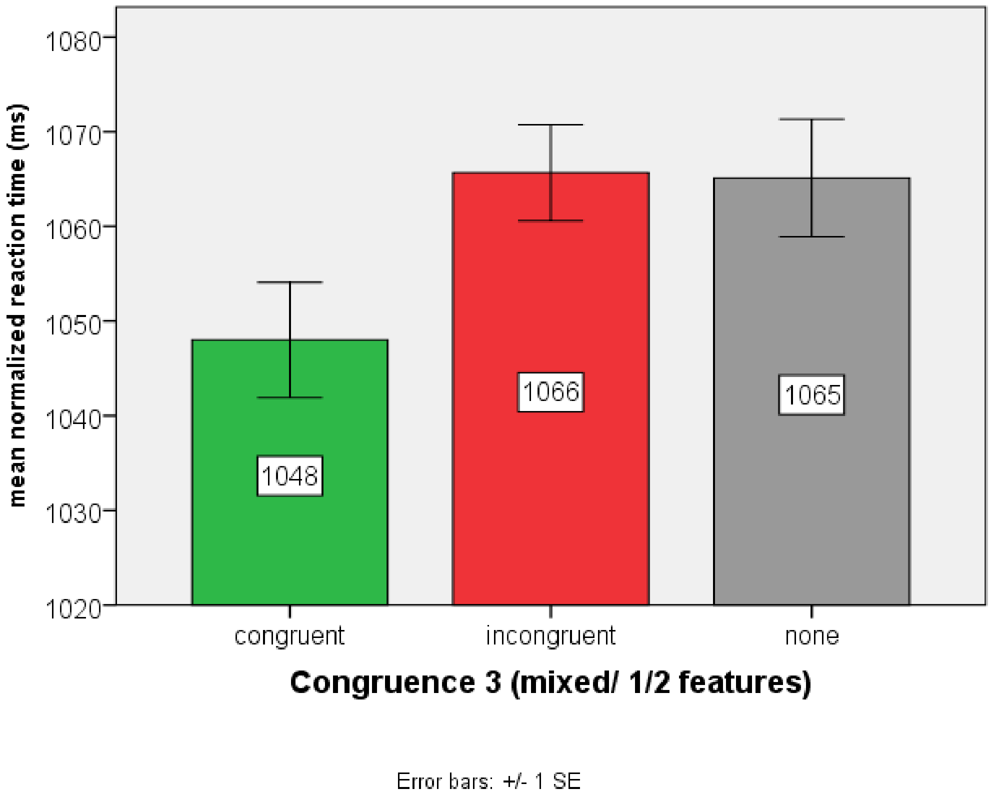

Figure 3.15: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in German auditory LDT

In order to test, whether the observed effect could be validated by statistical analysis, a one-way repeated measures ANOVA was conducted with the factor Congruence 3 {incongruent, congruent, none}. Maulchy`s test of sphericity was significant, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 3, $\chi^2(2) = 12.74$, $p = .002$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .87$) was used to correct the degrees of freedom.

The results of the one-way repeated measures ANOVA showed a significant effect of Congruence 3, $F(1.74, 137.31) = 3.40$, $p = .043$, $r = .20$. Planned contrasts (simple (first)) compared congruent determiner-noun combinations and no-determiner cases with incongruent combinations, and revealed that nouns presented with a preceding congruent determiner yielded faster responses than incongruent determiner-noun combinations, $F(1, 79) = 7.75$, $p = .007$, $r = .30$. There was no significant difference between incongruent and no-determiner cases, $F(1, 79) = .06$, $p = .812$. A selective post hoc comparison of congruent vs. no determiner showed a trend for faster responses for congruent combinations ($p = .072$).

Experiments 5 & 6 – English Visual and Auditory Lexical Decision Experiment

Figure 3.16 displays the mixed congruence (3) view of the data from the English experiments 5 and 6, which looks quite similar to the results of experiment 1, but less pronounced. There was a general facilitation for any determiner in comparison to the no-determiner condition. Latencies for congruent determiner-noun combinations were shorter than for incongruent ones. The facilitation for incongruent conditions compared to the no-determiner condition is visible but small.

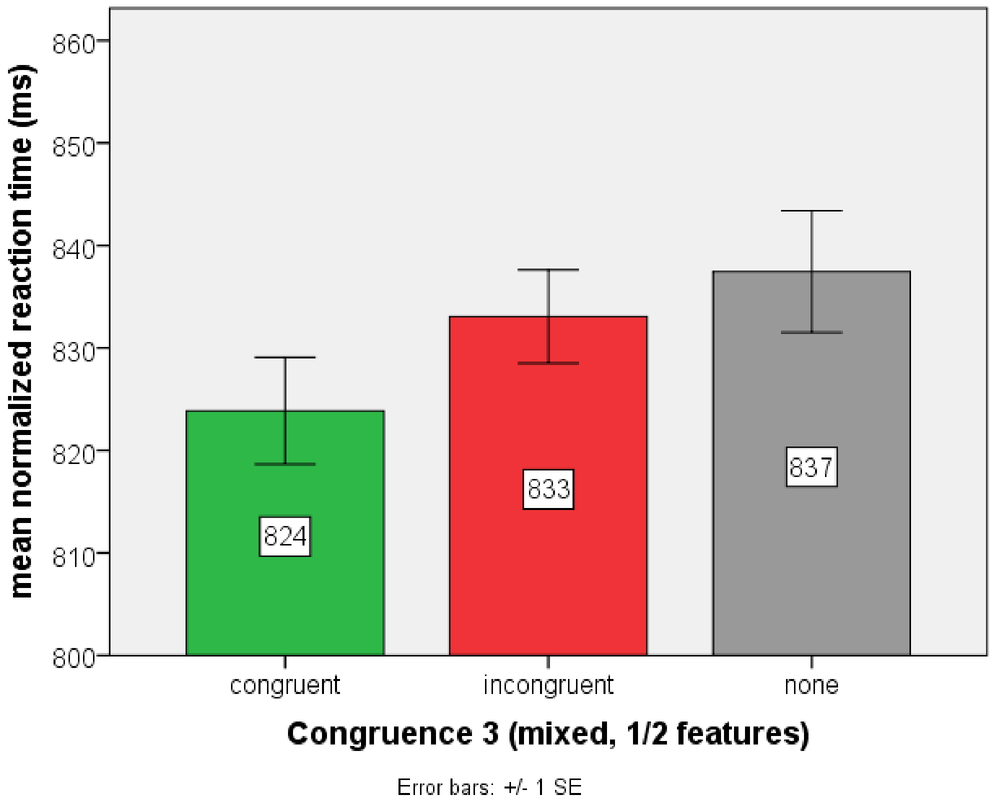

Figure 3.16: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English visual & auditory LDT (overall)

Figure 3.17 displays the mixed congruence (3) view of the visual data from experiment 5, which looks quite similar to the results of the German visual experiments 1 and 3. There was a general facilitation for any determiner in comparison to the no-determiner condition. Latencies for congruent determiner-noun combinations were shorter than for incongruent ones; yet, the difference is very small.

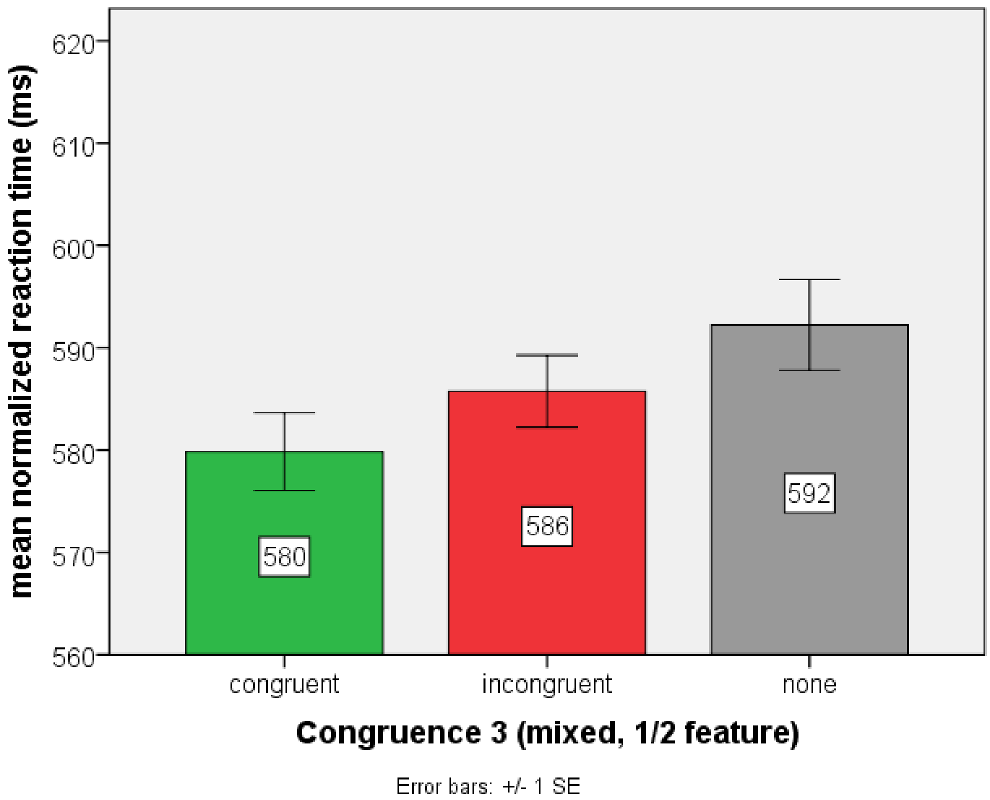

Figure 3.17: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English visual LDT

Figure 3.18 displays the mixed congruence (3) view of the auditory data from experiment 6. It shows the same pattern as the German auditory data in experiment 2: clear facilitation for nouns presented with congruent determiners in comparison to the no-determiner condition, and latencies for congruent determiner-noun combinations were considerably shorter than for incongruent ones. There was also a slight facilitation caused by incongruent determiners. Apart from the slight facilitation effect, the distribution of lexical decision times is in line with the hypotheses for congruence 3.

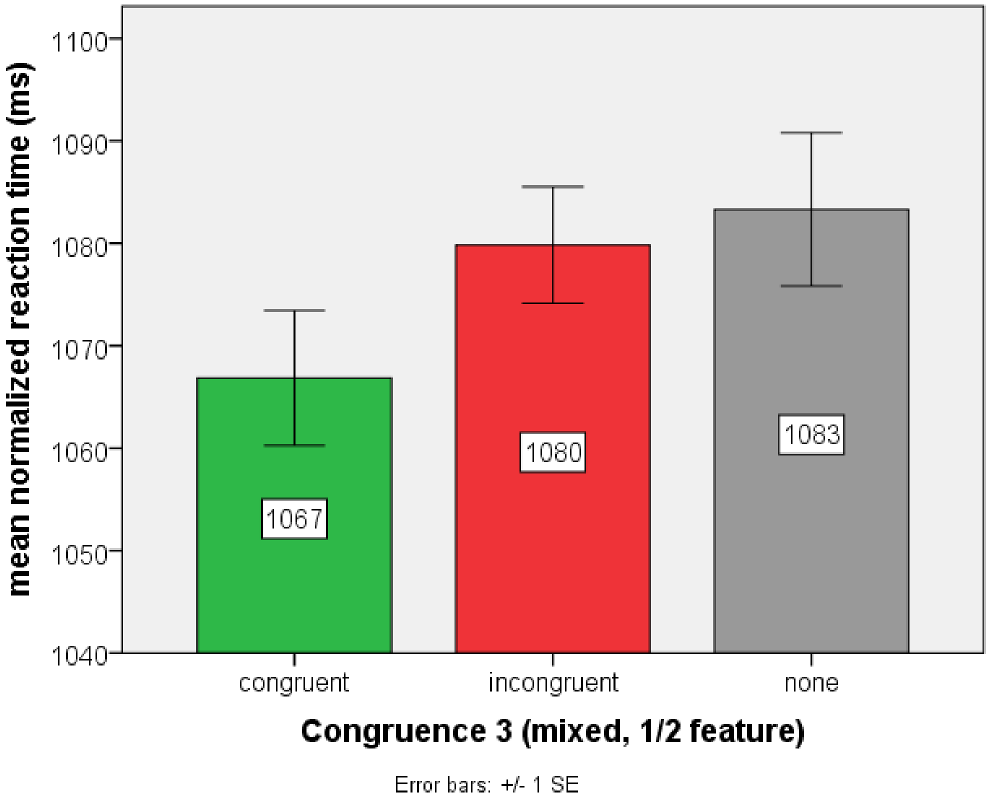

Figure 3.18: Lexical decision latencies for nouns used with congruent, incongruent and no determiner in English auditory LDT

In order to test, whether the observed differences could be validated by statistical analysis, a repeated measures ANOVA was conducted with the factors Congruence 3 {incongruent, congruent, none} and Modality {visual, auditory}. The ANOVA was conducted including the factor Modality, in order to check for a possible interaction of the factor Congruence 3 with the previously mentioned factor Modality (see Section 2.3.3. However, although the bar charts in figures 3.17 and 3.18 suggest a modality difference, the results yielded no significant interaction, $F(2, 190) = 1.25$, $p = .288$. As results for the factor Modality[44] are similar to those reported in Section 2.6.3 and are of no importance here, only the results for the factor

[44] Significant main effect of Modality, $F(1, 95) = 1195.89$, $p = 000$, $r = .96$.

Congruence 3 are reported here, analogous to the procedure for experiments 1-3.

Maulchy`s test of sphericity was significant for the factor Congruence 3, thus indicated that the assumption of sphericity had been violated for the main effect of Congruence 3, $\chi^2(2) = 6.60$, $p = .037$, thus the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .94$) was used to correct the degrees of freedom for the main effect of Congruence 3. The results of the repeated measures ANOVA reveal a significant main effect of Congruence 3, $F(1.87, 177.94) = 4.55$, $p = .014$, $r = .22$. Planned contrasts (simple (first)) compared congruent determiner-noun combinations and no-determiner cases with incongruent combinations, and revealed that nouns presented with a preceding congruent determiner yielded faster responses than incongruent determiner-noun combinations, $F(1, 95) = 4.77$, $p = .031$, $r = .22$. No significant difference was found between incongruent and no-determiner cases, $F(1, 95) = 085$, $p = .360$. To complement these results, a selective post hoc comparison of congruent and no-determiner cases showed significantly faster responses for congruent determiner-noun combinations compared to the neutral baseline ($p = .003$).

3.1.3 Compact Overview: Congruence 1-3

		Experiment	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 8	Experiment 5	Experiment 6
		Task	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision	Lexical Decision
		Language	German	German	German	German	German	English	English
		Modality	visual	auditory	visual	visual	auditory	visual	auditory
Overall Congruence (1)	significant effect of congruence 1		yes	yes	yes	yes	yes	yes	
	congruent vs. incongruent	planned contrasts	=	<	=	> (!)	<	<	
	incongruent vs. none	planned contrasts	<	=	<	<	=	=	
	congruent vs. none	post hoc	<	<	<	=	= (trend for <)	<	
Congruence 2	significant effect of congruence 2		yes	yes	yes	yes	no	no	yes
	fully congruent vs. fully incongruent	planned contrasts	<	<	=	= (trend for > (!))			<
	partly vs. fully incongruent	planned contrasts	=	<	=	>			=
	fully incongruent vs. none	planned contrasts	<	=	<	<			=
	fully congruent vs. partly incongruent	post hoc	= (trend for <)	<	=	=			<
	fully congruent vs. none	post hoc	<	<	<	=			<
	partly incongruent vs. none	post hoc	<	=	<	=			=
Congruence 3	significant effect of congruence 3		yes	yes	yes	no	yes	yes	
	congruent vs. incongruent	planned contrasts	=	<	=		<	<	
	incongruent vs. none	planned contrasts	<	=	<		=	=	
	congruent vs. none	post hoc	<	<	<		= (trend for <)	<	

Table 3.5: Overview of results for congruence 1-3 for experiments 1-6 & 8

<	a < b	a vs. b	a faster than b
<	a < b, c	a vs. b, c	a faster than b and a faster than c
>	a > b	a vs. b	a slower than b
=	=	a vs. b	no significant difference between a and b
			expected results
(!)			(very) unexpected results

Table 3.6: Legend for overview table 3.5

3.1.4 Summary and Intermediate Discussion

Section 3.1 addressed the notion of congruence from an empirical point of view in order to test, which of the three congruence models, presented in section 3.1.1, can be supported by the experimental data. All three congruence analyses of the data show comparable results concerning significance and specification of the congruence effects within the experiments: the presence or lack of effects in single experiments generally mirrors the pattern found in the previous analyses of the respective experiments.

Significant congruence 1, 2, and 3 effects in the expected form are only visible in the results of German auditory lexical decision experiments as well as for English (overall and auditory LDT). Comparing the analyses of the different definitions of *congruence* (cf. overview in section 3.1.3), none of the three variants is clearly preferred or rejected by the results. However, the auditory experiments (experiment 6 and 8 only partly) showed an effect of congruence (2) in the expected graded pattern. Hence, this more fine grained congruence variant might be better suited to represent congruence and in turn to explain the distribution of the auditory data, yet, not the visual data.

3.2 Co-occurrence Frequencies – An Explanation for Congruence Effects?

A possible concern is, that the concept type congruence effects (found in experiments 2, 6, and 8) might simply reflect a pure frequency (of co-occurrence) effect, thus that the facilitation is a mere effect of a high co-occurrence frequency of the respective congruent determiner-noun combinations. Although Horn and Kimm (2014) as well as Brenner et al. (2014) have shown that the proportion of congruent uses of nouns in German texts is high, their analyses do include a number of linguistic constructions, other than the determiners used here, that belong to the same determiner types[45]. Thus not only combinations like *sein Apfel*/*his apple* are counted as possessive, but of course all kinds of combinations involving possessor information, e.g. other possessive pronouns, Genitive, etc.

The same holds for all other determiner types. Thus it is quite unlikely that the co-occurrence frequencies of the specific combinations, that were used in the experiments reported here, caused a frequency effect that is reflected in the reaction time data. Furthermore, in the research lines referenced above there has also been reported a relatively high proportion of incongruent uses. This chapter examines whether there is any relation between the experimental data and the frequency of occurrence of the used determiner-noun combinations, and seeks to reject the frequency-explanation for the conceptual congruence effect.

3.2.1 Correlating Co-occurrence Frequencies with Reaction Times

For every experimental stimulus, noun the frequencies of co-occurrence with the three determiners (*ein/e* for indefinite, *der/die/das* for definite and *sein/e* for possessive – thus co-occurrence of the exact combinations used in the respective experiments) were extracted from the above mentioned German corpus (that is part of the Leipzig Corpus Collection)[46]. For example, for the word *apple* three co-occurrence values were extracted, one for each of the combinations *ein Apfel*/*an apple*, *der Apfel*/*the apple,*

[45] What I call *determiner type* is called *mode of determination* in the papers referenced here.

[46] The corpus extraction was conducted by Dr. Katina Bontcheva from project INF *Service Project for Information Infrastructure* within the Collaborative Research Center 991 @Heinrich-Heine-University Düsseldorf (http://www.sfb991.uni-duesseldorf.de/en)

sein Apfel/*his apple*. For every noun and the three determiners the co-occurrence's percentage of the respective combination was calculated through division by the word's total occurrence in the corpus. This served to compute a relative quantity of co-ocurrence rather than an absolute percentage, which could hardly be compared between nouns due to the general variance in their respective lexical frequency.

From the experimental data of the German experiments 1, 2, 8 and the English experiments 5 and 6, the mean reaction times for every noun were calculated/ aggregated by determiner type (excluding the no-determiner cases) in separate datasets for every experiment. The co-occurrence percentage values for each noun were added to the datasets of every experiment in order to compute a bivariate Pearson correlation for every concept type. The correlation was computed separately for every concept type over all noun items within the concept types. An example for the steps in the selection process shall clarify, which values were correlated. Firstly, the data set of experiment 1 was chosen. Secondly, sortal nouns were selected within this dataset. Thirdly, the mean reaction time for sortal nouns presented with indefinite determination (e.g. *ein Apfel*/ *an apple*) in the experiments was correlated with the respective percentage of co-occurrence value for the same combination. For every concept type, three correlations were computed, one for each of the three relevant determiner types, indefinite, definite, and possessive. In order to compensate for the multiple comparisons, a significance level of $p < .004$ (.05 divided by the number of correlations) was assumed.

This procedure (to compute the correlation separately for every concept type instead of across all concept types) was chosen in order to exclude the concept type effect, which would automatically lead to highly correlated data if one would compute the correlation across all concept types. However, within the four concept types, nouns' lexical frequencies vary just as do the frequencies across the concept types. Thus, if we were to find a significant correlation within the concept types it stands to reason, that the correlation can be generalized across concept types. And reversely, if there is no significant correlation within the groups it is very unlikely that there is a significant correlation across the groups that can explain the concept type congruence effect as being a mere frequency effect.

In order to state that the reported concept type congruence effect can be explained by mere frequency effects, a negative correlation would be expected, i.e. faster (decreasing) reaction times being liked to increasing co-occurrence frequencies. The results in the following subsections are reported by experiment, first for the German experiments 1, 2 and 8, and then for the English experiments 5 and 6. The tables contain the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive. For each determiner the given values represent the results of the correlation of the respective determiner's mean reaction time (for the use with nouns of a specific concept type) on the one hand, and the same determiner's co-occurrence percentage (with nouns of a specific concept type) on the other hand.

3.2.1.1 Experiment 1 – German Visual Lexical Decision Experiment

Table 3.7 contains the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive for experiment 1. None of the correlations is significant at $p < .004$.

	indefinite		**definite**		**possessive**	
	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)
sortal nouns	$r = -.105$	$p = .661$	$r = .002$	$p = .995$	$r = -.288$	$p = .218$
individual nouns	$r = -.277$	$p = .252$	$r = .043$	$p = .863$	$r = .087$	$p = .722$
relational nouns	$r = .249$	$p = .303$	$r = -.334$	$p = .162$	$r = .034$	$p = .890$
functional nouns	$r = -.136$	$p = .567$	$r = .140$	$p = .555$	$r = .154$	$p = .517$

Table 3.7: Results of the correlation of mean reaction times and co-occurrence data for German visual LDT (experiment1)

Figures 3.19 and 3.20 show the respective scatterplots for the correlated variables in order to illustrate the distribution of reaction times and co-occurrence percentages for nouns used with the three determiner types. The figures show that the lexical decision times are diffusely scattered across the graphs, however, the distribution does not show any dependence on the co-occurrence percentage.

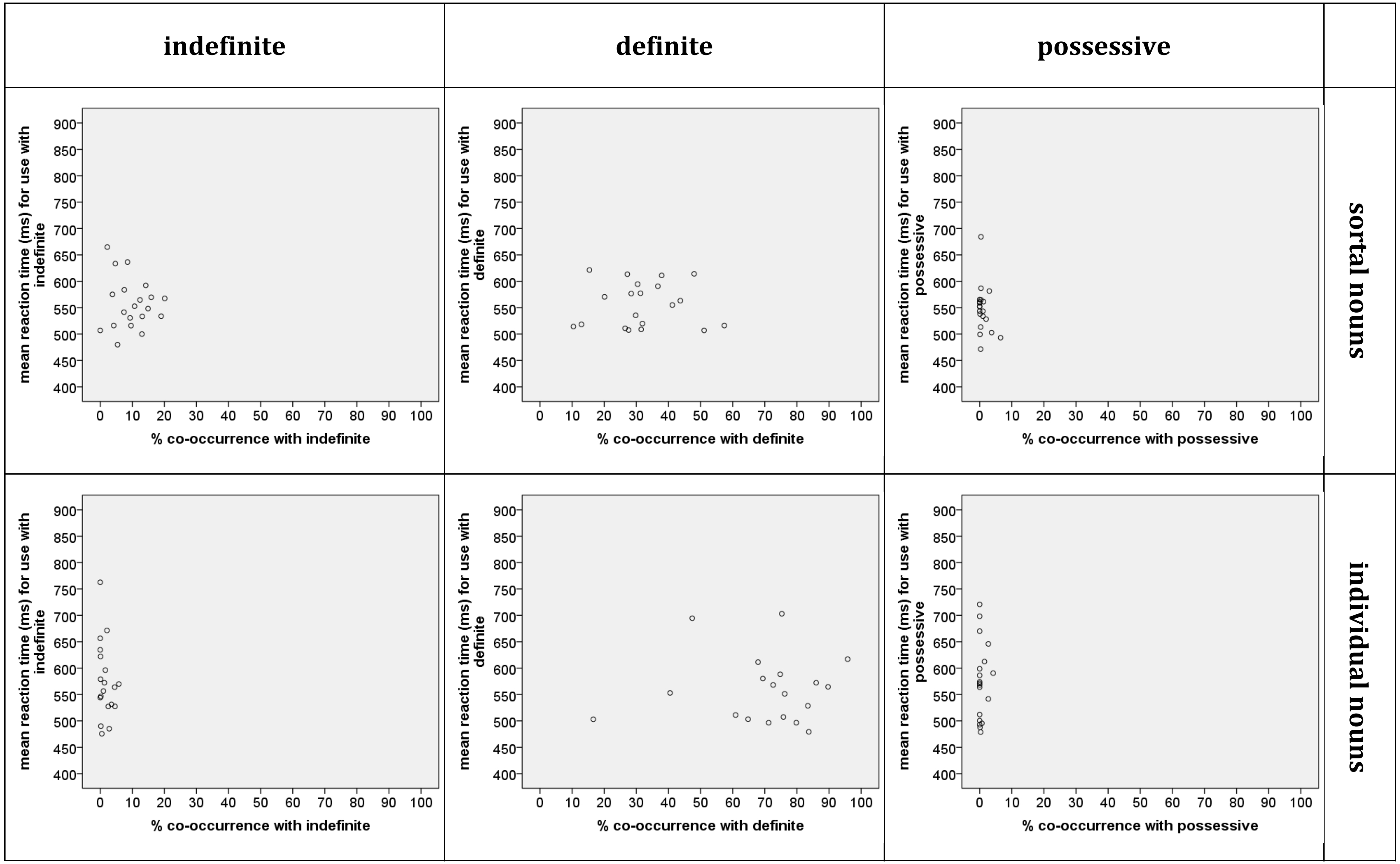

Figure 3.19: Scatterplots for the correlation of mean reaction times and co-occurrence data for German visual lexical decision, experiment 1 (sortal and individual nouns)

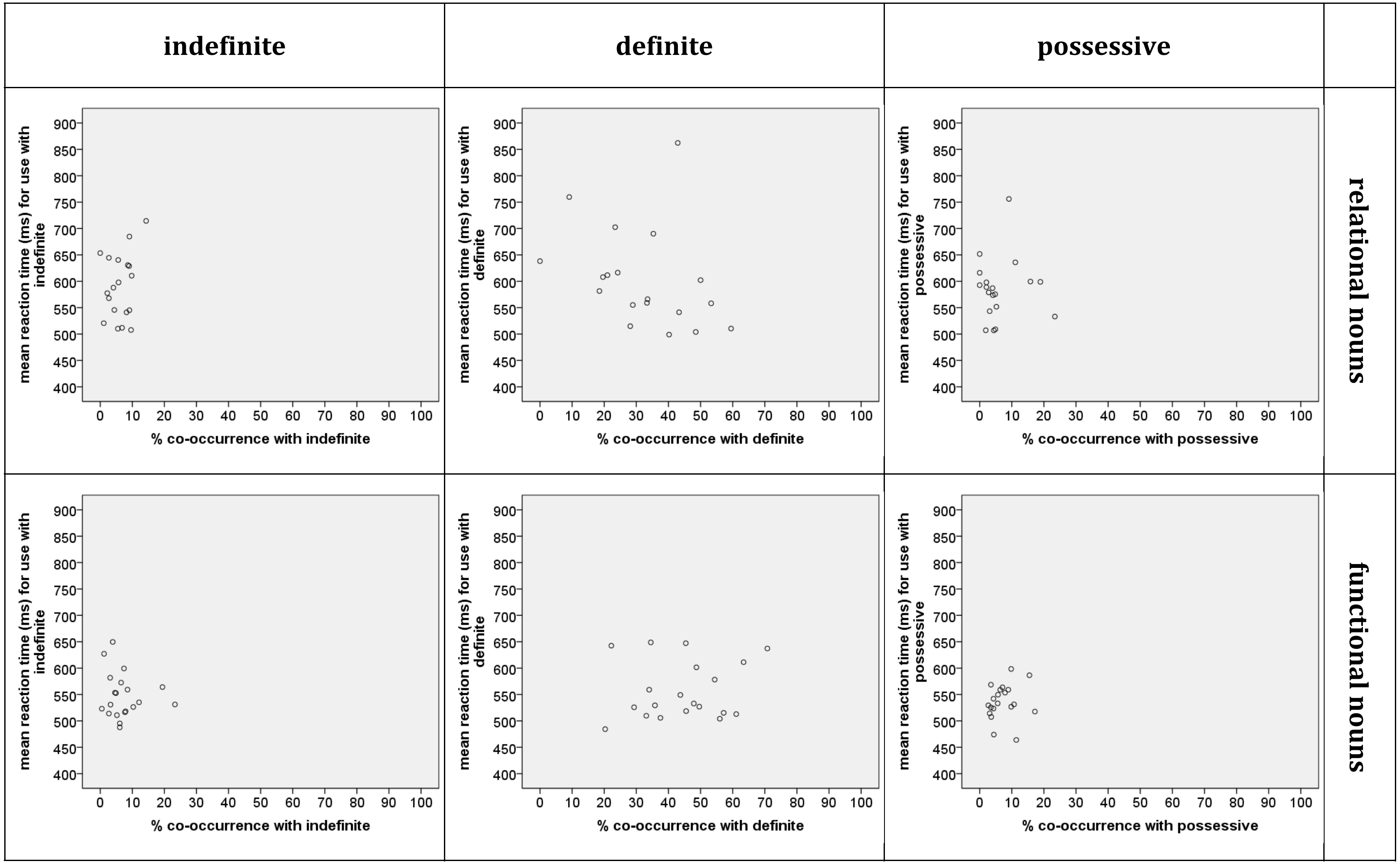

Figure 3.20: Scatterplots for the correlation of mean reaction times and co-occurrence data for German visual lexical decision, experiment 1 (relational and functional nouns)

3.2.1.2 Experiment 2 – German Auditory Lexical Decision Experiment

Table 3.8 contains the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive for experiment 2. None of the correlations is significant at $p < .004$.

	indefinite		definite		possessive	
	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)
sortal nouns	r = -.092	p = .701	r = .224	p = .343	r = -.381	p = .098
individual nouns	r = -.471	p = .042	r = .361	p = .129	r = .048	p = .844
relational nouns	r = .045	p = .851	r = -.348	p = .133	r = .314	p = .178
functional nouns	r = .168	p = .480	r = -.151	p = .525	r = .209	p = .377

Table 3.8: Results of the correlation of mean reaction times and co-occurrence data for German auditory LDT (experiment 2)

Figures 3.21 and 3.22 show the respective scatterplots for the correlated variables in order to illustrate the distribution of reaction times and co-occurrence percentages for nouns used with the three determiner types. The figures show that the lexical decision times are scattered across the graphs, however, the distribution does not show any dependence on the co-occurrence percentage.

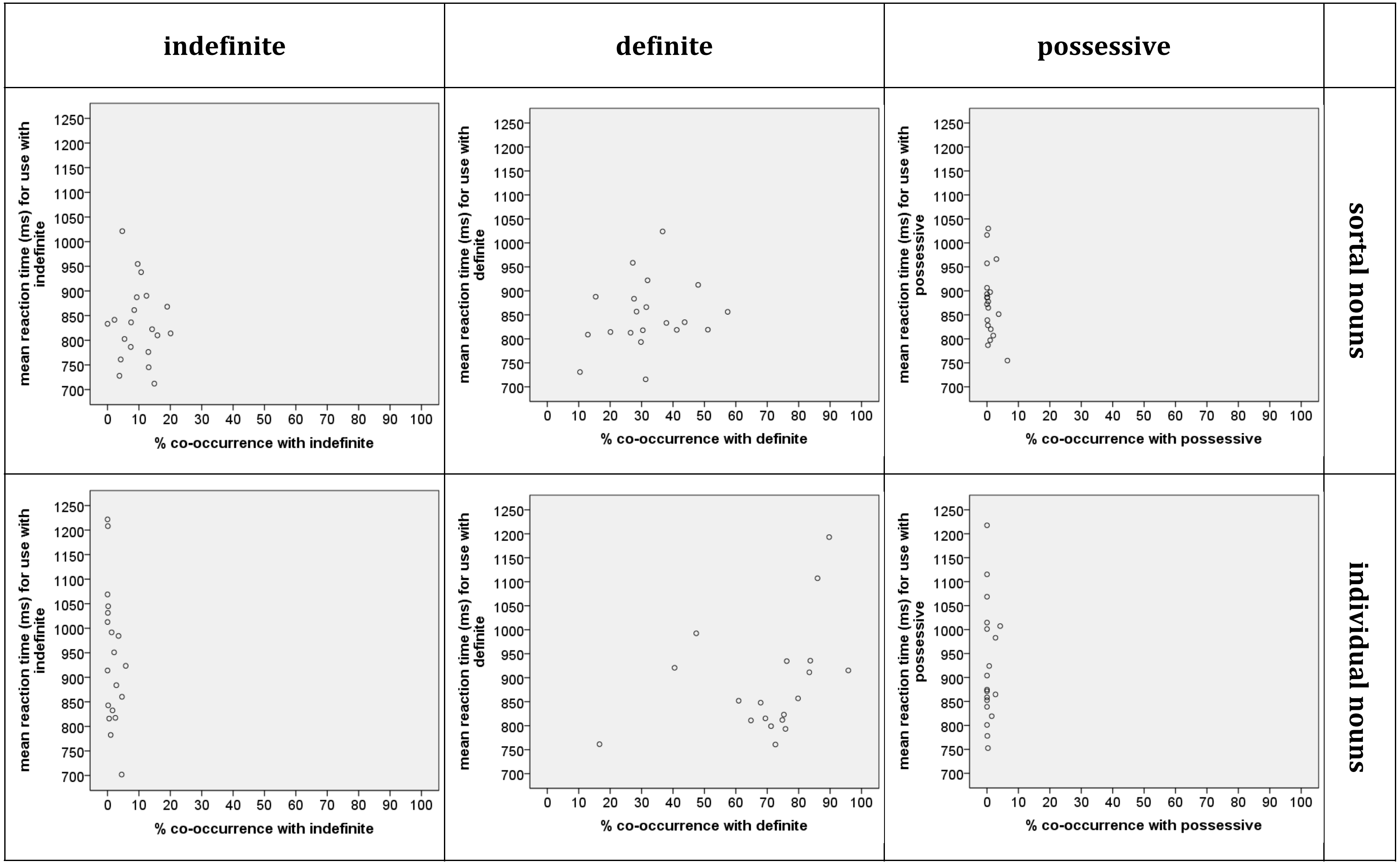

Figure 3.21: Scatterplots for the correlation of mean reaction times and co-occurrence data for German auditory lexical decision, experiment 2 (sortal and individual nouns)

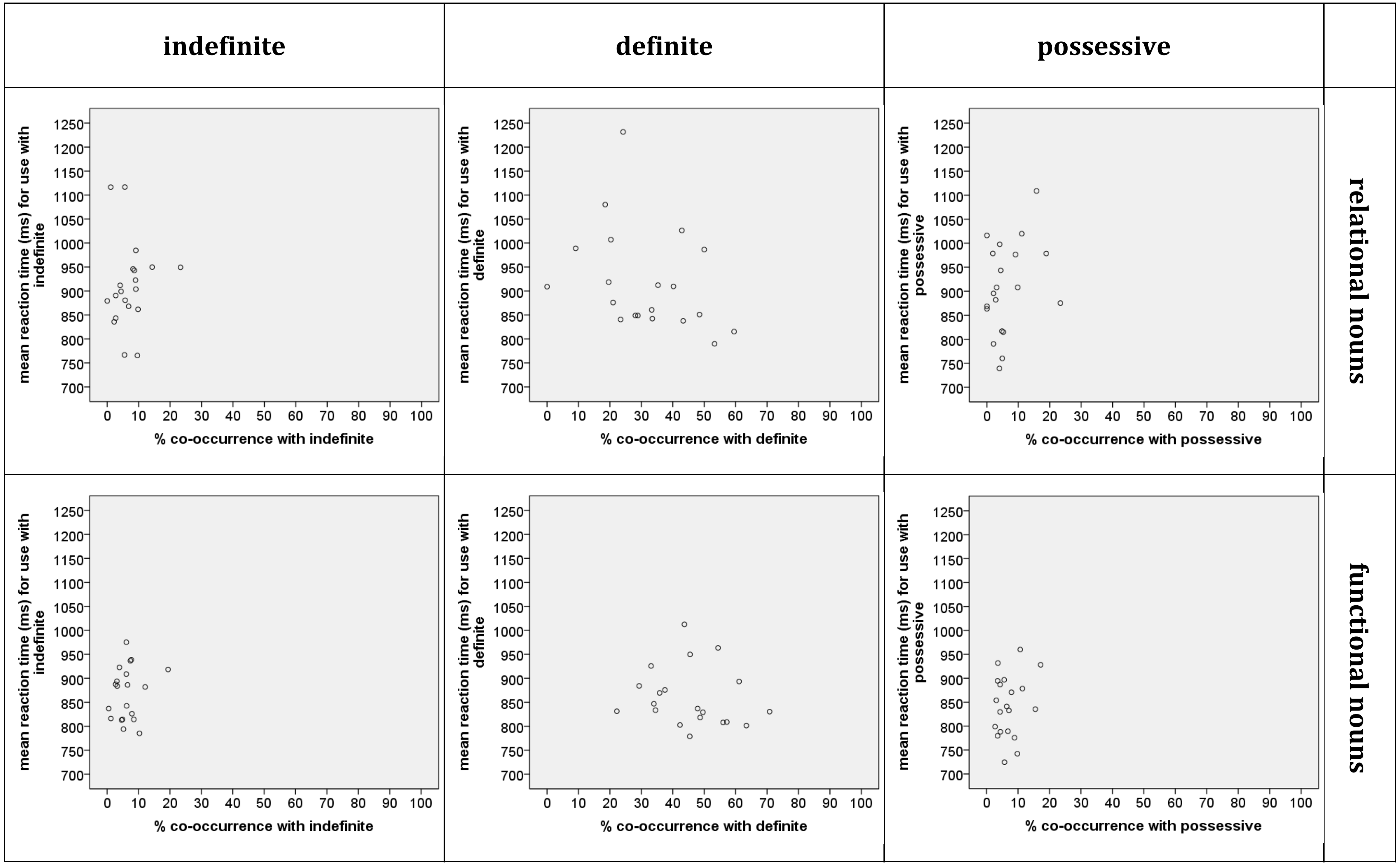

Figure 3.22: Scatterplots for the correlation of mean reaction times and co-occurrence data for German auditory lexical decision, experiment 2 (relational and functional nouns)

3.2.1.3 Experiment 8 – German Auditory Lexical Decision Experiment

Table 3.9 contains the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive for experiment 8. None of the correlations is significant at $p < .004$.

	indefinite		**definite**		**possessive**	
	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)
sortal nouns	r = -.048	p = .837	r = .196	p = .396	r = -.371	p = .098
individual nouns	r = .218	p = .342	r = .383	p = .087	r = -.054	p = .815
relational nouns	r = -.196	p = .396	r = .137	p = .554	r = .048	p = .836
functional nouns	r = .254	p = .266	r = -.284	p = .213	r = -.356	p = .113

Table 3.9: Results of the correlation of mean reaction times and co-occurrence data for German auditory LDT (experiment 8)

Figures 3.23 and 3.24 show the respective scatterplots for the correlated variables in order to illustrate the distribution of reaction times and co-occurrence percentages for nouns used with the three determiner types. The figures show that the lexical decision times are scattered across the graphs, however, the distribution does not show any dependence on the co-occurrence percentage.

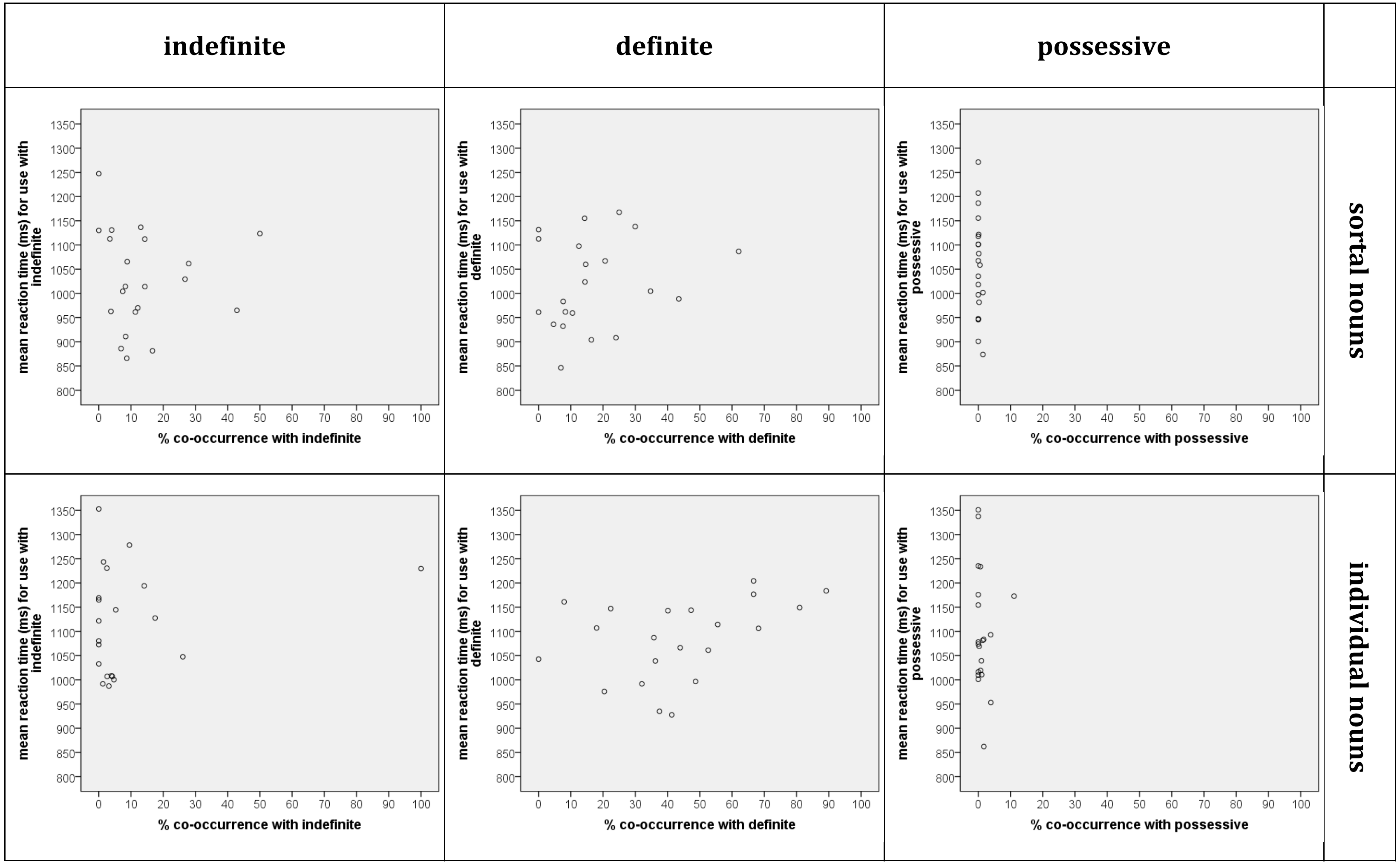

Figure 3.23: Scatterplots for the correlation of mean reaction times and co-occurrence data for German auditory lexical decision, experiment 8 (sortal and individual nouns)

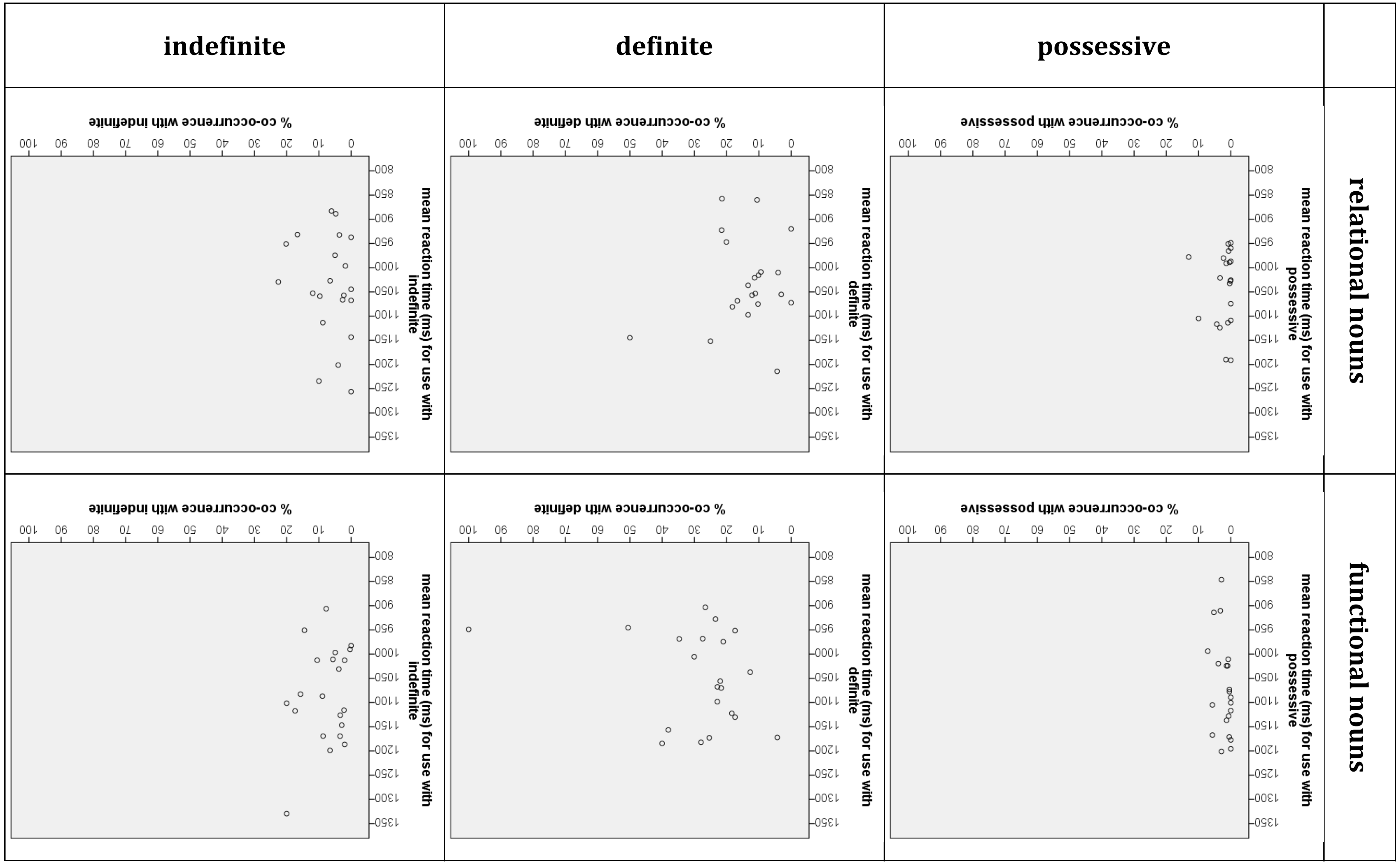

Figure 3.24: Scatterplots for the correlation of mean reaction times and co-occurrence data for German auditory lexical decision, experiment 8 (relational and functional nouns)

3.2.1.4 Experiment 5 – English Visual Lexical Decision Experiment

Table 3.10 contains the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive for experiment 5. None of the correlations is significant at $p < .004$.

	indefinite		**definite**		**possessive**	
	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)
sortal nouns	r = .385	p = .094	r = .166	p = .485	r = -.159	p = .502
individual nouns	r = -.163	p = .492	r = .618	p = .004	r = -.276	p = .239
relational nouns	r = -.092	p = .700	r = .226	p = .339	r = -.203	p = .390
functional nouns	r = .122	p = .610	r = .139	p = .560	r = .049	p = .837

Table 3.10: Results of the correlation of mean reaction times and co-occurrence data for English visual LDT (experiment 5)

Figures 3.25 and 3.26 show the respective scatterplots for the correlated variables in order to illustrate the distribution of reaction times and co-occurrence percentages for nouns used with the three determiner types. The figures show that the lexical decision times are scattered across the graphs, however, the distribution does not show any dependence on the co-occurrence percentage.

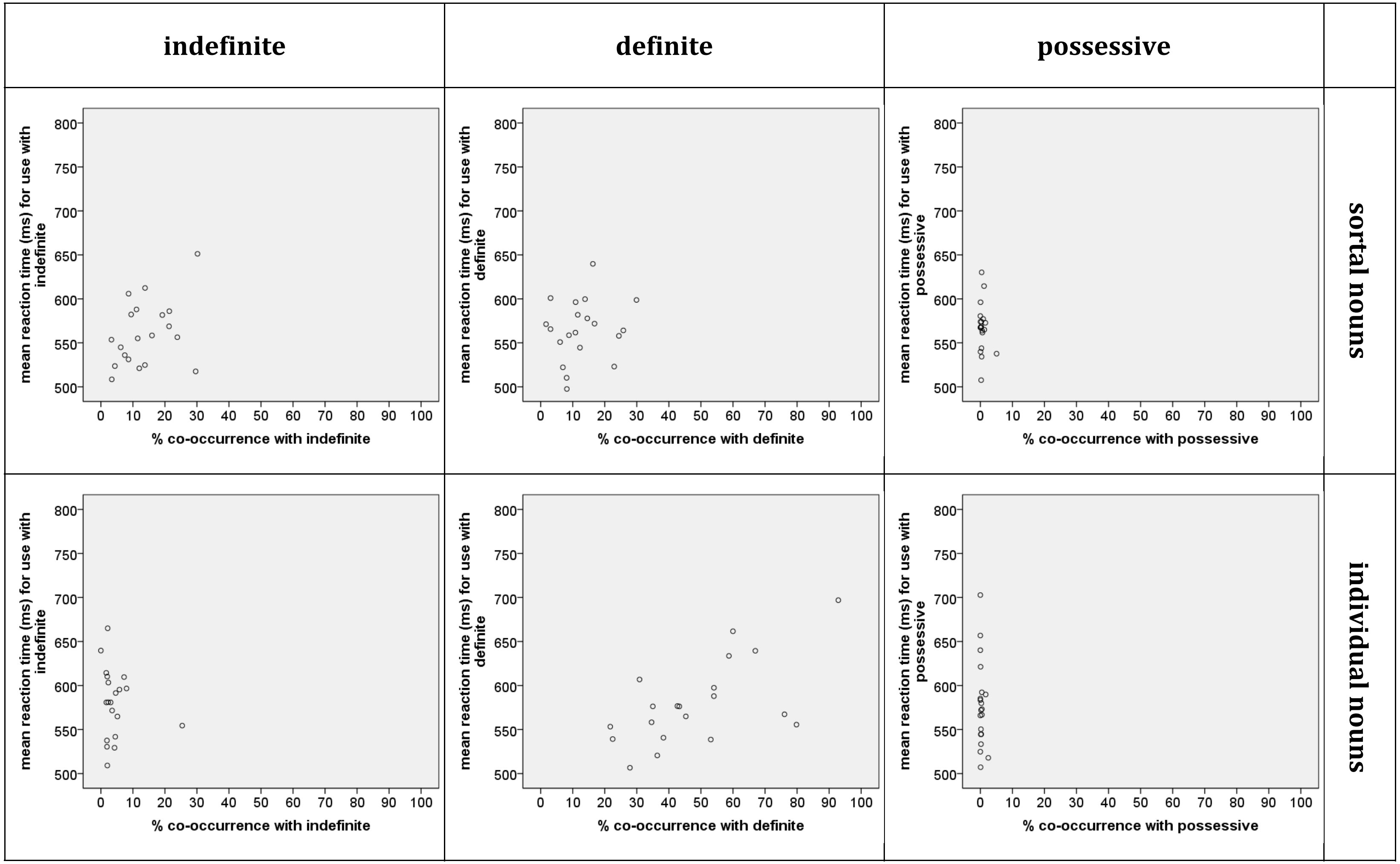

Figure 3.25: Scatterplots for the correlation of mean reaction times and co-occurrence data for English visual lexical decision, experiment 5 (sortal and individual nouns)

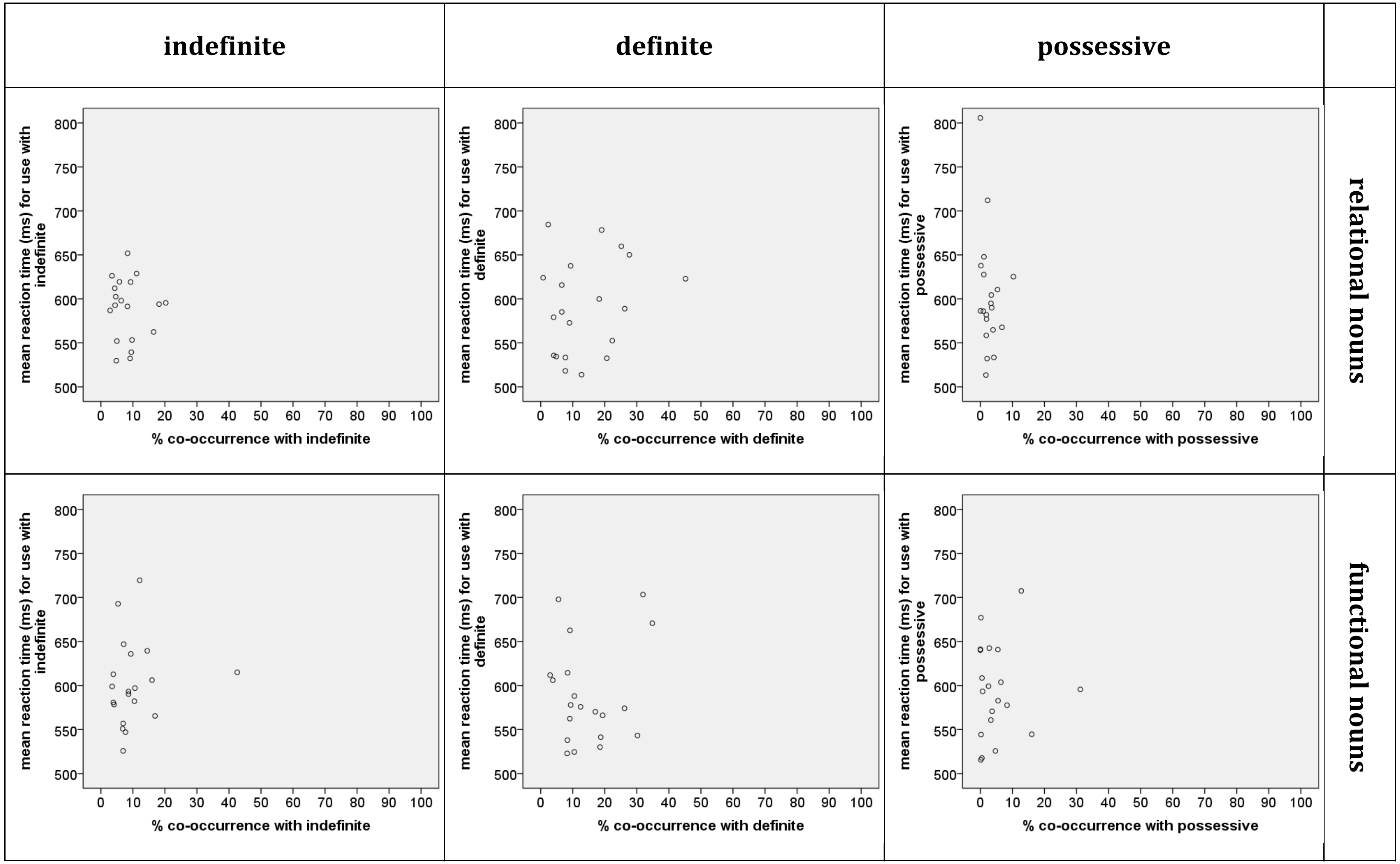

Figure 3.26: Scatterplots for the correlation of mean reaction times and co-occurrence data for English visual lexical decision, experiment 5 (relational and functional nouns)

3.2.1.5 Experiment 6 – English Auditory Lexical Decision Experiment

Table 3.11 contains the Pearson correlation coefficient and significance value for the three determiners indefinite, definite, and possessive for experiment 6. None of the correlations is significant at $p < .004$.

	indefinite		**definite**		**possessive**	
	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)	Pearson correlation coefficient	Significance (2-tailed)
sortal nouns	r = .409	p = .073	r = .169	p = .477	r = .442	p = .051
individual nouns	r = -.006	p = .981	r = .196	p = .407	r = -.187	p = .429
relational nouns	r = -.185	p = .435	r = .159	p = .502	r = -.407	p = .075
functional nouns	r = .453	p = .045	r = .242	p = .304	r = -.436	p = .054

Table 3.11: Results of the correlation of mean reaction times and co-occurrence data for English auditory LDT (experiment 6)

Figures 3.27 and 3.28 show the respective scatterplots for the correlated variables in order to illustrate the distribution of reaction times and co-occurrence percentages for nouns used with the three determiner types. The figures show that the lexical decision times are scattered across the graphs, however, the distribution does not show any dependence on the co-occurrence percentage.

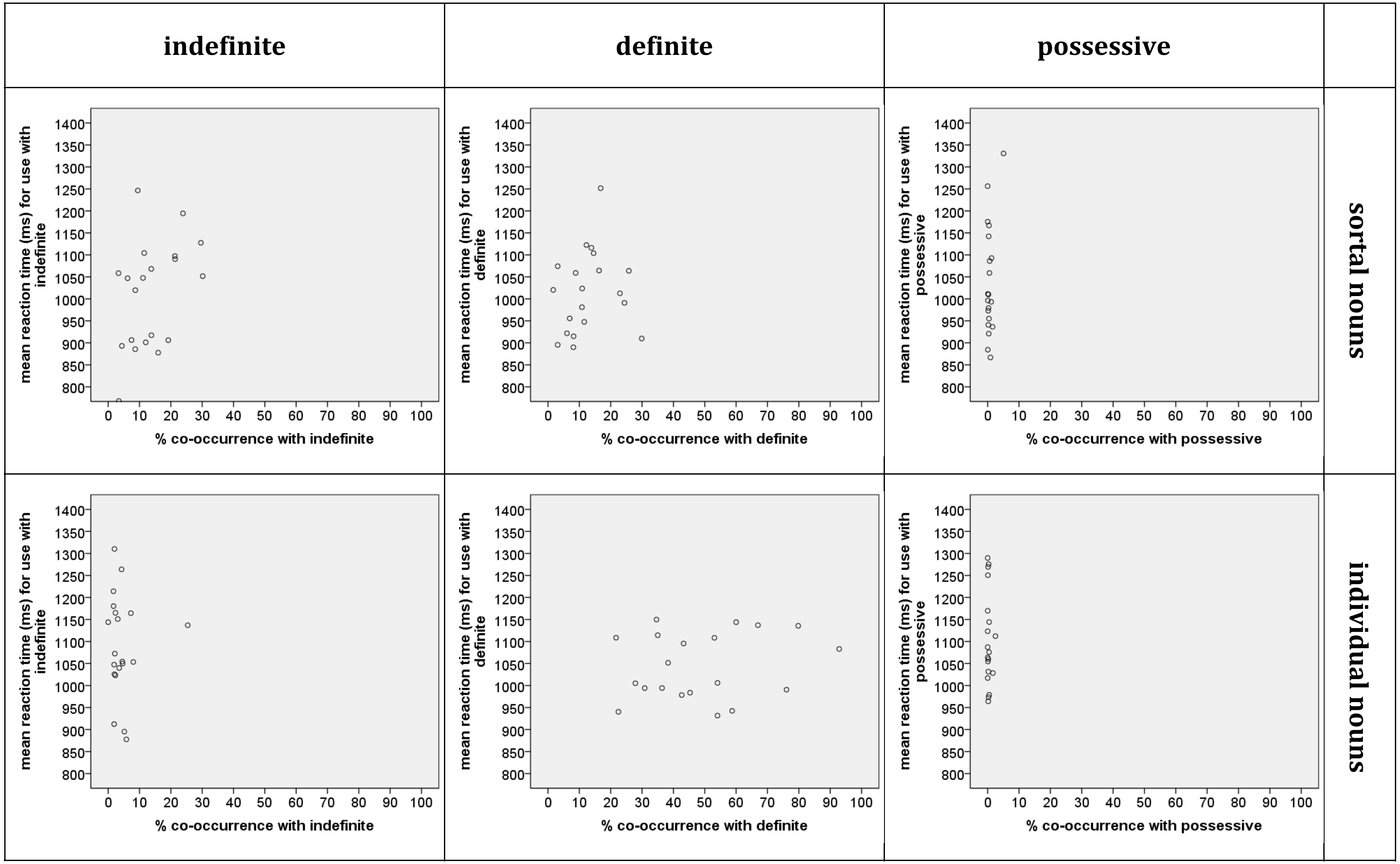

Figure 3.27: Scatterplots for the correlation of mean reaction times and co-occurrence data for English auditory lexical decision, experiment 6 (sortal and individual nouns)

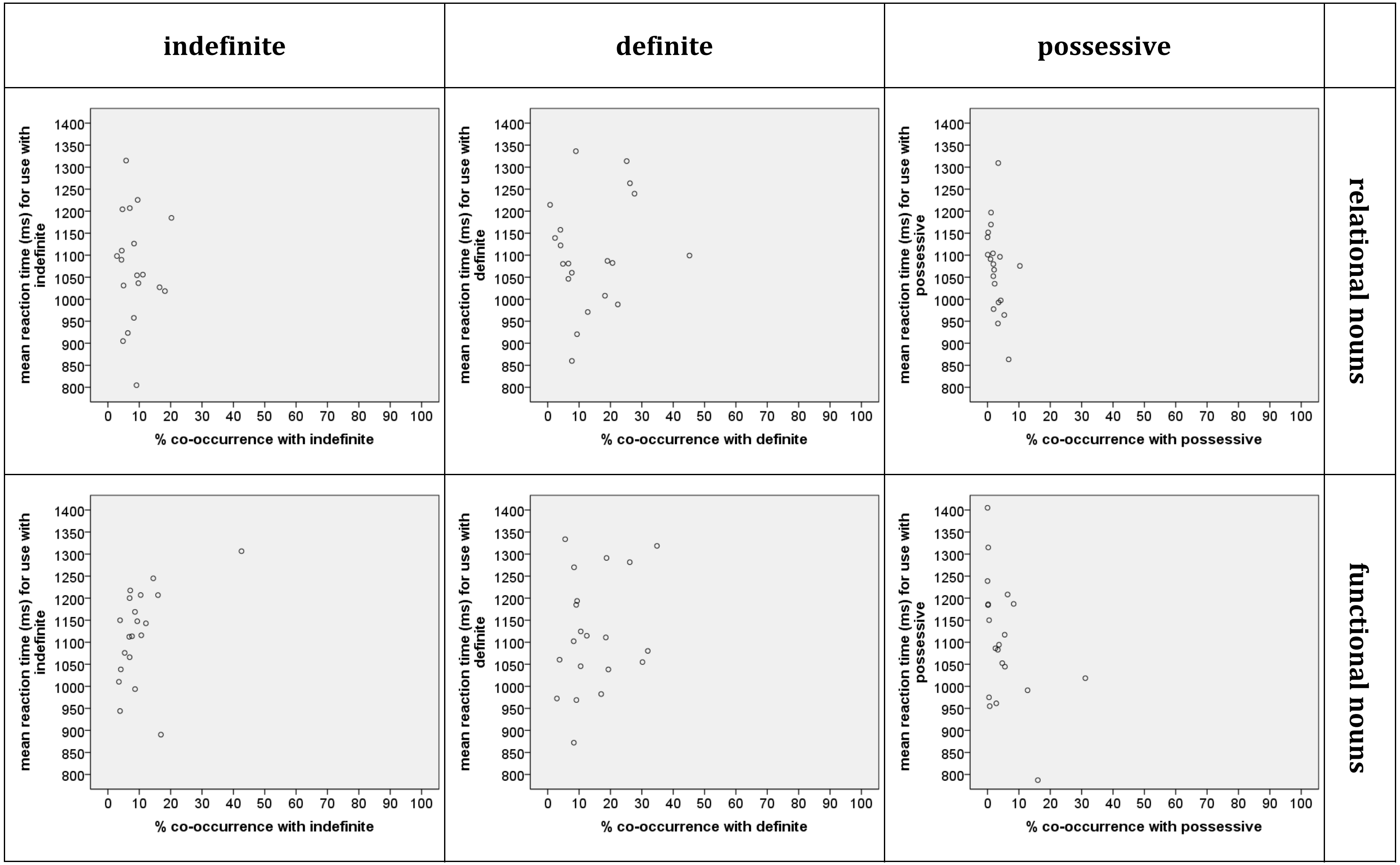

Figure 3.28: Scatterplots for the correlation of mean reaction times and co-occurrence data for English auditory lexical decision, experiment 6 (relational and functional nouns)

3.2.2 Summary and Intermediate Discussion

This section analyzed a possible correlation between the reaction time data obtained in German and English experiments, which in the auditory versions showed a concept type congruence effect, and frequency data of the co-occurrence of the experimental determiner and noun stimuli, which was extracted from corpus data. The correlation analyses showed that none of the correlations of mean reaction time and co-occurrence frequency for determiner-noun combinations has been significant.

Furthermore, the scatterplots showed that mostly a definite determiner in combination with all noun types has a high co-occurrence frequency, whereas the co-occurrence frequency value for the possessive determiner and any noun is at almost zero. This aspect is especially informative for the case of functional and relational nouns, which – foremost in the auditory experiments – showed the strongest facilitation with the possessive determiner. Hence, a frequency effect cannot be the cause for this facilitation. In summary, this analysis indicates that the concept type congruence effect cannot be explained by a mere frequency (of co-occurrence) effect.

4. Final Summary, Discussion and Outlook

The present dissertation investigated the core assumptions of the Theory of Concept Types and Determination by Löbner (1985, 1998, 2011) from a psycholinguistic perspective. In order to create a solid theoretical basis for this endeavor (chapter 1), section 1.1 broke down the core aspects and assumptions of the CTD (section 1.1.1) and provided a broader theoretical context to this theory (1.1.2). Additionally, section 1.2 presented psycholinguistic background by considering theories and empirical research concerning word recognition (section 1.2.1). A focus on the investigation of gender information was chosen as it is assumed to provide a good example of how conceptual type information could function in language comprehension. A summary of the implementation of behavioral methods into CTD research (section 1.2.2) was complemented by a discussion of hypotheses and predictions (section 2.1) for the experimental work.

A series of behavioral experiments (reported in sections 2.2-2.6) examined the influence of contextually provided conceptual type information on noun recognition. Combinations of determiners and nouns were chosen and presented to participants in German and English lexical decision experiments, as well as in a German phoneme monitoring experiment. Nouns of the four concept types were preceded by determiners of different types that provided congruent, incongruent or neutral type information.

Finally, section 3.1 discussed the notion of *congruence* in three variations and provided statistical analyses in the attempt to empirically decide between the three possibilities. Section 3.2 correlated reaction time data obtained in the lexical decision experiments with co-occurrence frequency data that was extracted from corpora with the aim to reject a pure frequency explanation of the CT-congruence effect.

As mentioned before, the experiments conducted within this dissertation project sought to provide empirical support for the CTD. The experimental results in chapter 2 partly support the CTD. The two core CTD assumptions of interest were the question of nouns' lexical specification of conceptual type information (i.e. underlying concept type), on the one hand, and the question of concept type shifting operations as additional processes in noun recognition, on the other hand (cf. section 1.1.1). Thus, in order to claim that the experiments provide empirical evidence for the CTD's core assumptions, the experimental data were expected to show differential processing costs for the four different concept types in dependence of their use with different determiner types. More specifically, this means that a concept type congruence effect was expected to be visible in the sense that congruent determination causes faster noun recognition than incongruent determination and should yield a facilitation compared to a neutral baseline. Furthermore, the experiments were expected to yield slower noun recognition caused by incongruent determination compared to a no-determiner baseline, which would support the idea of concept type shifts (cf. section 2.1).

A reliable concept type congruence effect – for German as well as for English – could only be obtained in the auditory modality (experiments 2, 6, and 8). Furthermore, the nature of the effect differed from the pattern predicted by the CTD. Before going into detail about the results and implications of the auditory experiments, the results of the visual experiments shall be discussed.

The German visual lexical decision results (experiments 1 and 3) did not show a concept type congruence effect with the expected facilitation for congruent determiner-noun combinations and/or inhibition for incongruent determiner-noun combinations, and thus cannot be counted as evidence for the CTD. However, the results suggest that any given determiner facilitates noun recognition compared to a neutral baseline, i.e. that there must be some sort of information carried by a preceding determiner that facilitate(s) noun recognition.

A possible cause for the facilitating effect of determiners in general might be the influence of gender information that (even conceptually incongruent) German determiners carry and that has been previously shown to facilitate noun recognition (cf. Bölte and Connine, 2004, as well as other references given in section 1.2.). In English, a language that lacks gender marking, this advantage for nouns used with any determiner compared to the baseline was non-significant but measurable in visual lexical decision (cf. experiment 5, section 2.2.4). This allows the conclusion that grammatical gender marking does influence German nouns, which was already suggested by the gender effect found in experiment 4 (and by Bölte and Connine, 2004).

What do the visual results yield concerning the hypotheses that were pointed out in section 2.1? The visual lexical decision results do not provide evidence for the type shift assumption of the CTD (thus rejects hypothesis 1), as there was no inhibition on incongruent determiner-noun combinations. Hypothesis 2b assumes that all four concept types are lexically stored and ranked according to frequency of occurrence, and the results of the visual lexical decision experiments, i.e. the facilitating effect of any determiner, might be interpreted as empirical support for this assumption. Arguing with the assumptions of hypothesis 2b, any given conceptual type information facilitates noun recognition because all four concept types are lexically stored and available. Any conceptual type information, which a given determiner provides, triggers the lexical representation and in consequence facilitates noun processing at a lexical or post-lexical level.

Furthermore, although the results do not explicitly indicate the "ranked-by-frequency" aspect of hypothesis 2b, the results allow the modification of this aspect: ranking of different concept types might be subject to individual variation and thus might blur the expected advantage of congruent determiner noun pairs. However, the assumption that for every noun that a person learns all four concept types are lexically specified, before any frequency data provides a ranking, is an assumption that is neither economic nor plausible. Hypothesis 2a, the weaker version of hypothesis 2b, offers a more economic and therefore plausible account for the visual data, if the type shift component is rejected. Hypothesis 3 is ruled out due to the presence of a facilitation effect caused by any determiner.

As mentioned above, the auditory lexical decision experiments in English and German showed a clear concept type congruence effect. Overall, this effect is facilitating in nature, as there were faster responses for congruent conditions compared to incongruent and neutral conditions. The results of the German auditory lexical decision experiment (2) provide the clearest (and most detailed) support for the CTD. As shown and discussed in section 2.2.2, the reaction time data showed facilitation effects for almost all expected congruent determiner type and concept type combinations.

An important finding of auditory experiments was the lack of inhibition for incongruent conditions, which bears important consequences for the CTD. The assumption of concept type shifts being additional processes during noun processing cannot be supported by the experimental data. However, the CTD assumption, that there are certain congruent vs. incongruent determiner types for certain concept types, accounts for the facilitation effect of congruent determiner-noun pairs. Furthermore, the observed facilitation of noun recognition caused by conceptually congruent determiners supports the more general assumption, as well as previous findings that claim that contextual information – be it conceptual type information or grammatical gender, both show similar effects – influences noun recognition (cf. section 1.2).

Although the auditory results do not support the idea of concept type shifts (or at least not in the form of additional processes which are assumed by the CTD), the assumption of different types of concepts and their lexical representation – possibly by a representation of the referential properties, uniqueness and relationality – can be supported with these data. In order to examine the extent to which the data support this claim, let us recall the hypotheses about lexical representation of concept types that were differentiated in section 2.1. Hypothesis 3 denied any lexical specification of conceptual type information. With the obtained results of auditory lexical decision experiments it can be argued that the presence of a concept type congruence effect in the auditory lexical decision experiments rejects hypothesis 3.

Between the different hypotheses, that assumed underlying concept type/s of some sort, hypothesis 2b, which assumed that all concept types are lexically stored and ordered by lexical frequency of occurrence, seems to hold the scepter, as only facilitating effects of congruent determiner-noun combinations were obtained in the experiments, but no inhibitory effect that would support hypothesis 1 or 2a. In contrast to the conclusions derived from the visual data, the auditory data also support the "ranked-by-frequency" part of the hypothesis, as there was a clear difference between congruent (=highest ranking) and incongruent (=lower/lowest ranking) determiner-noun combinations.

Although the assumption of type shifts is not supported by the experimental data, the finding, that determiners facilitate noun types with different intensity depending on their congruence, suggests that conceptual information is lexically stored. Concerning the classification of concepts into the four distinct types, that are assumed by the CTD, the results of German and English visual and auditory lexical decision experiments show differential patterns. Across all German experiments, sortal and functional nouns were recognized faster than individual and relational nouns, while relational nouns had the tendency to be the slowest of them all, and sortal nouns the fastest. As speculated in the intermediate discussion of experiment 1 (cf. section 2.2.1.3), from these results it is possible to infer that sortal and functional nouns, on the one hand, and individual and relational nouns, on the other hand, might form two noun classes. This distinction, however, is not supported by any theoretical position mentioned in section 1.1.

The alternative/historical outline of noun class approaches (cf. section 1.1.2) showed that the distinction of sortal (or non-relational) and relational nouns has a long tradition, and that this distinction is rooted in inherent differences between nouns that do or do not carry inherent relationships. The presupposition of this generally assumed distinction of (sortal) non-relational nouns versus relational nouns allows us to interpret the experimental results, which show a significant reaction time difference between sortal and functional versus individual and relational nouns, in two steps. Firstly, a distinction between sortal and functional nouns versus individual and relational nouns could be inferred. Secondly, the results implicitly suggest a further distinction of sortal versus functional and individual versus relational nouns.

However, these speculations can only be sustained, if the results show the same pattern across experiments and across languages. This was not the case, which has been comparatively discussed in the intermediate discussion of the English experiments. Adding to this issue, the data of experiment 8 were selectively examined with respect to a concept type effect and showed yet another pattern, namely SC = RC < FC < IC (reminder: German experiments 1-4 yielded SC = FC < IC = RC; English experiments 5-6 yielded SC < IC = RC < FC). This further supports the idea that the choice of words within the concept types might have caused these varying concept type effects.

As pointed out in the introductory section, Löbner's assumption of functional nouns as a separate concept type is at odds with Partee and Borschev's (2012) claim that functional nouns are merely "an accidental subclass of the relational nouns" (ibid.: 445, cf. section 1.1.2). Experiment 2 suggests that both features, uniqueness and relationality, are accountable for the concept type congruence effect, not only relationality[47], and hence favors a distinction between relational and functional nouns, as assumed by Löbner.

After it had been established that auditory lexical decision experiments yielded a concept type congruence effect, the question of the locus of such an effect was addressed. In order to find an answer to this question, the German phoneme monitoring experiment (7) was conducted. The results first of all showed the expected similarity effect, and thus replicated the findings of Connine et al. (1997) and Bölte and Connine (2004). The presence of the similarity effect ensured that the experiment actually activated lexical processing. There was no interaction of an overall congruence ef-

[47] I thank Peter Indefrey for a lively discussion on this topic and this insight.

fect with the similarity effect, and there was no difference between congruent and incongruent determiner-noun combinations.

However, the phoneme monitoring results showed a facilitating effect of any determiner compared to the neutral baseline (similar to the results from visual lexical decision experiments). From this we can infer that there must be some contextual information provided by the determiners that influences noun processing at a lexical level, although it is probably neither conceptual information (as there was a slight facilitation by any determiner but no congruence effect in German phoneme monitoring, cf. experiment 7) nor grammatical gender information (as Bölte and Connine, 2004, did not find a gender effect in German phoneme monitoring). In order to gain a clearer view on this aspect, an English phoneme monitoring experiment might yield informative results.

Adding to these findings, the excursus in chapter 3 completed the investigation of the CTD. The results of the comparison of different definitions of congruence (section 3.1) yielded rather diffuse evidence for CTD assumptions. The experimental data can be interpreted in favor of congruence 2, however, only experiment 2 significantly showed a graded effect as predicted by the assumption of congruence 2. Complementarily the correlation data (3.2) showed that the congruence effect is not caused by frequency of co-occurrence of the specific determiner-noun pairs that were used in the German and English experiments presented here, but that it is a true effect of the influence of conceptual type information on noun recognition.

The bottom line of all experiments is that – although the idea of concept type shifts as additional processes in noun recognition cannot be supported – conceptual type information does influence noun and noun phrase processing, depending on the congruence with its concept type (cf. lexical decision experiments). However, it does not restrain the activation or selection of competing candidates (neither by eliminating lexical competitors nor by reducing lexical activation in the first place), which indicates a post-lexical rather than lexical locus of the concept type congruence effect (cf. phoneme monitoring). As the results of the lexical decision experiments did not show any inhibitory effect, we might infer that conceptual information acts at the earlier post-lexical built up processing stage, rather than at the later stage of post-lexical reanalysis.

Last but not least, a few remarks concerning further investigation of the CTD shall bring this final discussion to a round figure. The present dissertation project used behavioral methods to investigate the cognitive reality of the CTD in language comprehension. A continuation with experiments in the production domain would surely complement these findings. For future research of the CTD, auditory experiments might be the better choice for investigating the conceptual information – at least in the behavioral domain. Furthermore an investigation by means of electrophysiological and neurocognitive methods, such as ERP and fMRI could shed further light into concept types and the influence of determiner types similar to the neurocognitive paradigms used in the research of grammatical gender or syntactic priming (cf. for example Haagort and Brown, 1999; Davidson and Indefrey, 2009; Fitzpatrick and Indefrey, 2010).

Epilogue (or the Moral of This Story)

In a series of empirical studies using lexical decision and phoneme monitoring this line of research addressed the nature and locus of a possible concept type congruence effect, as predicted by the CTD. A facilitating effect of congruent determiner-noun combinations could be shown in German and English auditory lexical decision, but not in the visual versions. The absence of the congruence effect in phoneme monitoring showed a post-lexical locus, not interfering with lexical activation or selection processes. Due to its facilitating nature, it can be assumed to reflect earlier post-lexical build-up of noun phrases, rather than later post-lexical checking mechanisms.

An important concluding note is that the experiments reported in this dissertation were conducted in a laboratory environment – as are most experimental investigations in our field. The used linguistic entities were rather unnatural simulations of natural language, considering that one does not regularly hear or read standalone utterances like *his mother*, *the pope* or *a stone*. Therefore conclusions about the cognitive reality of conceptual entities do not necessarily follow from the results presented here, or at least such conclusions need to be treated with great care before claiming that they are true statements about cognition.

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Appendix

I. German Lexical Decision Noun Stimuli (experiments 1-4)

SORTAL	INDIVIDUAL
Apfel	*Antike*
Baum	*Äquator*
Blume	*Astronomie*
Buch	*Bibel*
Dokument	*Erde*
Ereignis	*Himmel*
Flasche	*Internet*
Fotograf	*Luft*
Frucht	*Meer*
Gerücht	*Natur*
Linie	*Nordpol*
Mensch	*Papst*
Moment	*Polizei*
Person	*Schweiz*
Stern	*Sonne*
Tier	*Umwelt*
Tiger	*Vergangenheit*
Wolke	*Welt*
Wunder	*Wetter*
Zigarette	*Winter*
RELATIONAL	**FUNCTIONAL**
Arm	*Alter*
Abteilung	*Anteil*
Aufgabe	*Beruf*
Auge	*Besitz*
Befehl	*Chef*
Erfahrung	*Existenz*
Fach	*Geburt*
Fuss	*Gesicht*
Idee	*Gewicht*
Imitation	*Heimat*
Kamerad	*Herz*
Kollege	*Körper*
Kreation	*Meinung*
Kunde	*Mutter*
Marotte	*Name*
Merkmal	*Schicksal*
Seite	*Seele*
Uroma	*Stimme*
Vorfahre	*Vater*
Vorliebe	*Verhalten*

II. English Lexical Decision Noun Stimuli (experiments 5 & 6)

SORTAL	**INDIVIDUAL**
animal	*air*
apple	*apocalypse*
bakery	*bible*
bird	*darkness*
bottle	*earth*
cigarette	*environment*
cloud	*equator*
flower	*horizon*
horse	*internet*
hour	*moon*
miracle	*past*
person	*pope*
photographer	*public*
sentence	*sea*
shelf	*sky*
star	*sun*
step	*weather*
theatre	*wind*
tiger	*winter*
tree	*world*
RELATIONAL	**FUNCTIONAL**
ancestor	*age*
arm	*centre*
assistant	*content*
claim	*debut*
corner	*home*
customer	*husband*
decision	*identity*
department	*mother*
desire	*origin*
duty	*position*
ear	*profession*
employee	*pulse*
foot	*radius*
image	*scent*
opinion	*shape*
page	*soul*
phase	*summit*
quirk	*tongue*
side	*torso*
victim	*weight*

III. German Phoneme Monitoring Noun Stimuli (experiment 7)

	Word	Minimal Pseudo	Maximal Pseudo
SORTAL	*Akrobat*	*Äkrobat*	*Ükrobat*
	Diamant	*Biamant*	*Miamant*
	Dokument	*Bokument*	*Mokument*
	Elefant	*Ilefant*	*Ulefant*
	Experiment	*Axperiment*	*Uxperiment*
	Konsonant	*Ponsonant*	*Sonsonant*
	Anorak	*Änorak*	*Ünorak*
	Apotheke	*Äpotheke*	*Upotheke*
	Bibliothek	*Dibliothek*	*Sibliothek*
	Republik	*Lepublik*	*Gepublik*
	Albatros	*Älbatros*	*Ölbatros*
	Ananas	*Änanas*	*Unanas*
	Ereignis	*Areignis*	*Oreignis*
	Erlebnis	*Örlebnis*	*Ürlebnis*
	Gefängnis	*Defängnis*	*Lefängnis*
	Harlekin	*Farlekin*	*Karlekin*
	Telefon	*Pelefon*	*Relefon*
	Kartoffel	*Tartoffel*	*Fartoffel*
	Krokodil	*Trokodil*	*Brokodil*
	Musical	*Nusical*	*Tusical*
	Orakel	*Urakel*	*Irakel*
RELATIONAL	**Word**	**Minimal Pseudo**	**Maximal Pseudo**
	Absolvent	*Äbsolvent*	*Übsolvent*
	Angebot	*Ängebot*	*Üngebot*
	Angewohnheit	*Ängewohnheit*	*Üngewohnheit*
	Eigenschaft	*Ägenschaft*	*Ugenschaft*
	Fähigkeit	*Wähigkeit*	*Gähigkeit*
	Finalist	*Winalist*	*Minalist*
	Kandidat	*Pandidat*	*Wandidat*
	Marotte	*Narotte*	*Larotte*
	Opponent	*Upponent*	*Ipponent*
	Gedanke	*Dedanke*	*Redanke*
	Bedürfnis	*Gedürfnis*	*Redürfnis*
	Erkenntnis	*Arkenntnis*	*Urkenntnis*
	Ebene	*Öbene*	*Ubene*
	Imitation	*Emitation*	*Omitation*
	Kollegin	*Pollegin*	*Mollegin*
	Kommilitone	*Tommilitone*	*Rommilitone*
	Kreation	*Treation*	*Breation*
	Kusine	*Tusine*	*Fusine*
	Portion	*Kortion*	*Sortion*
	Kapitel	*Tapitel*	*Rapitel*
	Tentakel	*Pentakel*	*Mentakel*

	Word	Minimal Pseudo	Maximal Pseudo
INDIVIDUAL	**Word**	**Minimal Pseudo**	**Maximal Pseudo**
	Ewigkeit	*Iwigkeit*	*Owigkeit*
	Gegenwart	*Degenwart*	*Pegenwart*
	Horizont	*Forizont*	*Borizont*
	Orient	*Urient*	*Irient*
	Vergangenheit	*Wergangenheit*	*Nergangenheit*
	Wirklichkeit	*Sirklichkeit*	*Kirklichkeit*
	Zölibat	*Tschölibat*	*Pölibat*
	Antike	*Äntike*	*Üntike*
	Genetik	*Denetik*	*Lenetik*
	Mathematik	*Nathematik*	*Tathematik*
	Pazifik	*Tazifik*	*Gazifik*
	Poetik	*Toetik*	*Noetik*
	Politik	*Bolitik*	*Jolitik*
	Antarktis	*Äntarktis*	*Untarktis*
	Apokalypse	*Äpokalypse*	*Opokalypse*
	Paradies	*Baradies*	*Garadies*
	Evolution	*Ivolution*	*Uvolution*
	Gravitation	*Dravitation*	*Fravitation*
	Medizin	*Bedizin*	*Kedizin*
	Reformation	*Leformation*	*Teformation*
	Karneval	*Tarneval*	*Marneval*
FUNCTIONAL	**Word**	**Minimal Pseudo**	**Maximal Pseudo**
	Belegschaft	*Delegschaft*	*Kelegschaft*
	Favorit	*Wavorit*	*Lavorit*
	Fundament	*Wundament*	*Kundament*
	Parlament	*Karlament*	*Sarlament*
	Präsident	*Kräsident*	*Dräsident*
	Grammatik	*Brammatik*	*Frammatik*
	Adresse	*Ädresse*	*Üdresse*
	Gedächtnis	*Kedächtnis*	*Medächtnis*
	Nukleus	*Mukleus*	*Kukleus*
	Radius	*Ladius*	*Madius*
	Uterus	*Oterus*	*Eterus*
	Gewissen	*Dewissen*	*Rewissen*
	Kapitän	*Tapitän*	*Sapitän*
	Position	*Tosition*	*Rosition*
	Redaktion	*Ledaktion*	*Medaktion*
	Volumen	*Folumen*	*Kolumen*
	Arsenal	*Ärsenal*	*Ursenal*
	Domizil	*Bomizil*	*Schomizil*
	Gegenteil	*Degenteil*	*Schegenteil*
	Kapital	*Papital*	*Mapital*
	Potential	*Totential*	*Motential*

IV. German Lexical Decision Noun Stimuli (experiment 8)

SORTAL	**INDIVIDUAL**
Akrobat	*Ewigkeit*
Diamant	*Gegenwart*
Dokument	*Horizont*
Elefant	*Orient*
Experiment	*Vergangenheit*
Konsonant	*Wirklichkeit*
Anorak	*Zölibat*
Apotheke	*Antike*
Bibliothek	*Genetik*
Republik	*Mathematik*
Albatros	*Pazifik*
Ananas	*Poetik*
Ereignis	*Politik*
Erlebnis	*Antarktis*
Gefängnis	*Apokalypse*
Harlekin	*Paradies*
Telefon	*Evolution*
Kartoffel	*Gravitation*
Krokodil	*Medizin*
Musical	*Reformation*
Orakel	*Karneval*
RELATIONAL	**FUNCTIONAL**
Absolvent	*Belegschaft*
Angebot	*Favorit*
Angewohnheit	*Fundament*
Eigenschaft	*Parlament*
Fähigkeit	*Präsident*
Finalist	*Grammatik*
Kandidat	*Adresse*
Marotte	*Gedächtnis*
Opponent	*Nukleus*
Gedanke	*Radius*
Bedürfnis	*Uterus*
Erkenntnis	*Gewissen*
Ebene	*Kapitän*
Imitation	*Position*
Kollegin	*Redaktion*
Kommilitone	*Volumen*
Kreation	*Arsenal*
Kusine	*Domizil*
Portion	*Gegenteil*
Kapitel	*Kapital*
Tentakel	*Potential*

V. Item Analyses (experiments 1-8)

	df	F	p	r
Experiment 1: German Visual Lexical Decision				
Determiner Type and Concept Type				
Determiner Type	3, 225	4.47	.005	.24
indefinite vs. none	1 75	9.52	.003	.34
definite vs. none	1, 75	6.02	.017	.27
possessive vs. none	1, 75	10.46	.002	.35
indefinite vs. definite (post-hoc, Bonferroni corrected)			1.000	
definite vs. possessive (post-hoc, Bonferroni corrected)			1.000	
Concept Type (between items)	3, 75	4.12	.009	.38
individual vs. sortal			.206	
relational vs. sortal			.005	
functional vs. sortal			.801	
individual vs. relational (post-hoc, Bonferroni corrected)			.642	
relational vs. functional (post-hoc, Bonferroni corrected)			.014	
Determiner Type × Concept Type	9, 225	.61	.787	---
Congruence 1 & 3				
Overall Congruence (1)	2, 156	7.66	.001	.30
congruent vs. incongruent	1, 78	1.42	.238	---
none vs. incongruent	1, 78	6.31	.014	.27
congruent vs. none (post-hoc)			.000	
Congruence 3	2, 156	9.11	.000	.32
congruent vs. incongruent	1, 78	1.38	.244	---
none vs. incongruent	1, 78	8.42	.005	.31
congruent vs. none (post-hoc)			.000	
Determiner Type and Uniqueness				
Determiner Type	2, 154	5.13	.007	.25
indefinite vs. none	1, 77	9.75	.003	.34
definite vs. none	1, 77	6.30	.014	.28
indefinite vs. definite (post-hoc, Bonferroni corrected)			.933	
Uniqueness (between items)	1, 77	.01	.942	---
Determiner Type × Uniqueness	2, 154	.43	.649	---
Determiner Type and Relationality				
Determiner Type	1, 77	10.84	.002	.35
Relationality (between items)	1, 77	.02	.892	---
Determiner Type × Relationality	1, 77	.14	.712	---

	df	F	p	r
Experiment 2: German Auditory Lexical Decision				
Determiner Type and Concept Type				
Determiner Type	3, 228	5.16	.002	.25
indefinite vs. none	1, 76	3.07	.084	---
definite vs. none	1, 76	11.76	.001	.37
possessive vs. none	1, 76	8.43	.005	.32
indefinite vs. definite (post-hoc, Bonferroni corrected)			.188	
definite vs. possessive (post-hoc, Bonferroni corrected)			1.000	
Concept Type (between items)	3, 76	3.27	.026	.34
individual vs. sortal			.019	
relational vs. sortal			.020	
functional vs. sortal			.708	
individual vs. relational (post-hoc, Bonferroni corrected)			1.000	
relational vs. functional (post-hoc, Bonferroni corrected)			.291	
Determiner Type × Concept Type	9, 228	4.68	.000	.40
Determiner Type for sortal nouns (across items)	3, 57	3.97	.012	.42
indefinite vs. none	1, 19	6.93	.016	.52
definite vs. none	1, 19	3.58	.074	---
possessive vs. none	1, 19	.000	.999	---
indefinite vs. definite (post-hoc, Bonferroni corrected)			1.000	
definite vs. possessive (post-hoc, Bonferroni corrected)			.201	
Determiner Type for individual nouns (across items)	3, 57	6.96	.000	.52
indefinite vs. none	1, 19	.63	.439	---
definite vs. none	1, 19	13.53	.002	.65
possessive vs. none	1, 19	.00	.971	---
indefinite vs. definite (post-hoc, Bonferroni corrected)			.000	
definite vs. possessive (post-hoc, Bonferroni corrected)			.014	
Determiner Type for relational nouns (across items)	2.09, 39.63	2.10	.134	.32
indefinite vs. none	1, 19	7.23	.015	.52
definite vs. none	1, 19	.70	.415	---
possessive vs. none	1, 19	8.52	.009	.56
indefinite vs. definite (post-hoc, Bonferroni corrected)			1.000	
definite vs. possessive (post-hoc, Bonferroni corrected)			1.000	
Determiner Type for functional nouns (across items)	3, 57	5.76	.002	.48
indefinite vs. none	1, 19	.01	.908	---
definite vs. none	1, 19	.36	.557	---
possessive vs. none	1, 19	12.57	.002	.63
indefinite vs. definite (post-hoc, Bonferroni corrected)			1.000	
definite vs. possessive (post-hoc, Bonferroni corrected)			.065	

	df	F	p	r
Congruence 1 & 3				
Overall Congruence (1)	2, 158	18.25	.000	.43
congruent vs. incongruent	1, 79	24.81	.000	.49
none vs. incongruent	1, 79	.60	.440	---
congruent vs. none (post-hoc)			.000	
Congruence 3	2, 158	18.36	.000	.44
congruent vs. incongruent				
none vs. incongruent				
congruent vs. none (post-hoc)				
Determiner Type and Uniqueness				
Determiner Type	2, 156	6.71	.002	.28
indefinite vs. none	1, 78	3.24	.076	.020
definite vs. none	1, 78	11.28	.001	.36
indefinite vs. definite (post-hoc,)			.045	
Uniqueness (between items)	1, 78	.156	.694	---
Determiner Type × Uniqueness	2, 156	6.17	.003	.27
Determiner Type for non-unique nouns across items	2, 78	5.09	.008	.34
indefinite vs. none	1, 39	13.79	.001	.51
definite vs. none	1, 39	3.62	.064	---
indefinite vs. definite (post-hoc, Bonferroni corrected)			.358	
Determiner Type for unique nouns across items	2, 78	7.78	.001	.41
indefinite vs. none	1, 39	.52	.475	---
definite vs. none	1, 39	8.45	.006	.42
indefinite vs. definite (post-hoc, Bonferroni corrected)			.000	
Determiner Type and Relationality				
Determiner Type	1, 78	8.73	.004	.32
Relationality (between items)	1, 78	.56	.455	.08
Determiner Type × Relationality	1, 78	8.45	.005	.31

	df	F	p	r
Experiment 3: German Visual Lexical Decision				
Determiner Type and Concept Type				
Determiner Type	3, 225	6.93	.000	.29
indefinite vs. none	1, 75	4.20	.044	.23
definite vs. none	1, 75	19.43	.000	.45
possessive vs. none	1, 75	9.28	.003	.33
indefinite vs. definite (post-hoc, Bonferroni corrected)			.204	
definite vs. possessive (post-hoc, Bonferroni corrected)			.586	
Concept Type (between items)	3, 75	2.73	.050	.31
individual vs. sortal			.372	
relational vs. sortal			.043	
functional vs. sortal			.522	
individual vs. relational (post-hoc, Bonferroni corrected)			1.000	
relational vs. functional (post-hoc, Bonferroni corrected)			.052	
Determiner Type × Concept Type	9, 225	.99	.453	---
Congruence 1 & 3				
Overall Congruence (1)	2, 156	9.00	.000	.32
congruent vs. incongruent	1, 78	.78	.379	---
none vs. incongruent	1, 78	8.34	.005	.31
congruent vs. none (post-hoc)			.000	
Congruence 3	2, 156	9.04	.000	.32
congruent vs. incongruent	1, 78	1.22	.272	---
none vs. incongruent	1, 78	8.34	.005	.31
congruent vs. none (post-hoc)			.000	

	df	F	p	r
Experiment 4: German Visual Lexical Decision				
Determiner Type and Concept Type				
Interaction check **Determiner Type × Concept Type × Gender**	6, 150	.27	.952	---
Determiner Type	2.65, 198.78	.34	.771	---
Concept Type (between items)	3, 75	4.09	.010	.38
individual vs. sortal			.729	
relational vs. sortal			.015	
functional vs. sortal			.375	
individual vs. relational (post-hoc, Bonferroni corrected)			.206	
relational vs. functional (post-hoc, Bonferroni corrected)			.007	
Determiner Type × Concept Type	9, 225	1.02	.43	---
Congruence 1, 3, Gender				
Interaction check **Overall Congruence (1) × Gender**	1, 78	.06	.806	---
Overall Congruence (1)	1.74, 135.73	.32	.694	---
Gender Congruence	1.64, 127.85	5.46	.009	.26
correct vs. incorrect	1, 78	1.10	.297	---
none vs. incorrect	1, 78	12.51	.001	.37
correct vs. none (post-hoc)			.063	
Interaction check **Congruence 3 × Gender**	1, 78	.06	.806	---
Congruence 3	1, 78	.37	.544	---

	df	F	p	r
Experiment 5 & 6: English Visual & Auditory Lexical Decision				
Modality, Determiner Type and Concept Type				
Modality	1, 76	1736.60	.000	.98
Determiner Type	3, 228	2.05	.108	---
Modality × Determiner Type	3, 228	.88	.454	---
Concept Type (between items)	3, 76	3.10	.032	.33
individual vs. sortal			.160	
relational vs. sortal			.027	
functional vs. sortal			.055	
individual vs. relational (post-hoc, Bonferroni corrected)			1.000	
relational vs. functional (post-hoc, Bonferroni corrected)			1.000	
Modality × Concept Type	3, 76	1.08	.363	---
Determiner Type × Concept Type	9, 228	1.59	.120	---
Modality × Determiner Type × Concept Type	9, 228	2.22	.022	.28
Congruence1, 3, Modality				
Modality	1, 79	1809.67	.000	.98
Overall Congruence (1)	2, 158	3.98	.021	.22
congruent vs. incongruent	1, 79	1.73	.192	---
none vs. incongruent	1, 79	1.98	.163	---
congruent vs. none (post-hoc)			.003	
Modality × Overall Congruence (1)	2, 158	2.22	.112	---
Modality	1, 79	1760.31	.000	.98
Congruence 3	2, 158	3.26	.041	.20
congruent vs. incongruent	1, 79	.73	.395	---
none vs. incongruent	1, 79	2.60	.111	---
congruent vs. none (post-hoc)			.012	
Modality × Congruence 3	2, 158	1.67	.191	---

	df	F	p	r
Determiner Type and Uniqueness				
Modality	1, 78	1796.51	.000	.98
Determiner Type	2, 156	2.77	.065	---
Modality × Determiner Type	2, 156	.15	.862	---
Uniqueness (between items)	1, 78	.13	.720	---
Modality × Uniqueness	1, 78	.43	.513	---
Determiner Type × Uniqueness	2, 156	.20	.819	---
Modality × Determiner Type × Uniqueness	2, 156	.84	.433	---
Determiner Type and Relationality				
Modality	1, 78	1579.98	.000	.98
Determiner Type	1, 78	1.34	.250	---
Modality × Determiner Type	1, 78	1.16	.285	---
Relationality (between items)	1, 78	.17	.680	---
Modality × Relationality	1, 78	.74	.392	---
Determiner Type × Relationality	1, 78	3.49	.065	---
Modality × Determiner Type × Relationality	1, 78	.03	.865	---
Experiment 5: English Visual Lexical Decision				
Determiner Type and Concept Type				
Determiner Type	3, 228	2.28	.080	---
Concept Type (between items)	3, 76	2.57	.060	---
Determiner Type × Concept Type	9, 228	1.87	.057	---
Experiment 6: English Auditory Lexical Decision				
Determiner Type and Concept Type				
Determiner Type	3, 228	1.31	.272	---
Concept Type (between items)	3, 76	2.23	.091	---
Determiner Type × Concept Type	9, 228	1.87	.058	---

	df	F	p	r
Experiment 7: German Phoneme Monitoring				
Overall Congruence, Similarity				
Overall Congruence	2, 498	13.28	.000	.23
congruent vs. incongruent	1, 249	.01	.912	---
none vs. incongruent	1, 249	16.91	.000	.25
congruent vs. none (post-hoc)			.000	
Similarity (between items)	2, 249	49.34	.000	.53
minimal pseudoword vs. word			.000	
maximal pseudoword vs. word			.000	
Overall Congruence (1) × Similarity	4, 498	.23	.920	---
Experiment 8: German Auditory Lexical Decision				
Congruence 1 & 3				
Overall Congruence (1)	2, 166	5.01	.008	.24
congruent vs. incongruent	1, 83	6.23	.015	.27
none vs. incongruent	1, 83	.35	.554	---
congruent vs. none (post-hoc)			.005	
Congruence 3	2, 166	4.73	.010	.23
congruent vs. incongruent	1, 83	5.55	.021	.25
none vs. incongruent	1, 83	.40	.527	---
congruent vs. none (post-hoc)			.008	

Erklärung

Ich erkläre hiermit, dass ich die vorliegende Arbeit selbständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt und die aus fremden Quellen direkt oder indirekt übernommenen Gedanken als solche kenntlich gemacht habe, und dass die Arbeit bisher in gleicher oder ähnlicher Form keiner Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht wurde. Bereits veröffentlichte Teile sind in der Arbeit gekennzeichnet.

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Wissenschaftliche Publikationen

Brenner, D., Indefrey, P., Horn, C., Kimm, N. (2014). Evidence for four basic noun types from a corpus-linguistic and a psycholinguistic perspective. In: Gerland, D., Horn, C., Latrouite, A. & Ortmann, A. (eds.). *Meaning and Grammar of Nouns and Verbs.* Studies in Language and Cognition, 1. Düsseldorf: University Press, pp. 21-48.

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