The representation of nouns in the mental lexicon: Evidence from brain-impaired and normal speakers

Nora Fieder

A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

ARC Centre of Excellence in Cognition and its Disorders (CCD)

Department of Cognitive Science

Macquarie University, Sydney, Australia

October 2013

Declaration

This is to certify that this thesis is all of my own work and all of my own writing. No part of this thesis has been submitted for a higher degree to any other institution or university. All of the work reported in this thesis was undertaken during the time I was enrolled as a PhD student at Macquarie University and all of the studies reported in this thesis were conducted within the ARC Centre of Excellence in Cognition and its Disorders (CCD), Department of Cognitive Science, Macquarie University, under the supervision of my principle supervisor Lyndsey Nickels and my associate supervisors Britta Biedermann and Wendy Best. Ethics approvals for this project were obtained from Macquarie University (HE30OCT2009-D00147).

Two manuscripts (Paper 2 & 3) have been submitted for publication.

Fieder, N., Nickels, L., Biedermann, B. & Best, W. (submitted). From 'much butter' to 'many butter': An investigation of mass and count processing in aphasia.

Fieder, N., Nickels, L. & Biedermann, B. (submitted). Garlic and Ginger are not like Apples and Oranges. Effects of Mass/Count Information on the Production of Noun Phrases in English.

Signed:

Nora Fieder

9th October, 2013

Acknowledgements

I would like to thank my supervisor and mentor Lyndsey Nickels who did not only support me professionally but also emotionally and who helped me to overcome the challenge of continuing my work and starting a family. I am equally grateful to my associate supervisor Britta Biedermann for her open-mindedness, her kindness, her advice and her friendship. I would also like to thank my supervisor Wendy Best for her professional, clear and generous guidance. Thank you for your encouragement, for being always approachable and for making our meetings so enjoyable and cheerful. A big thank you for Lesley for her helpful advice and support throughout my PhD.

I would like to express my gratitude to all of the people who participated in this research, especially for their enthusiasm, patience and friendliness.

Special thanks to my wonderful partner David and my beautiful daughter Emilia who provide me with a lot of joy and laughter and who remind me daily of what is important in live.

My deepest thanks to my family, especially my mother who supported fully my decision of moving to Australia for my PhD and who took practical and emotional care of Emilia, David and me in the last two months of my PhD.

Lastly I want to thank my friends Eva, Huachen, Nicholas, Regine, Shu and Thushara who make every day at CCD enjoyable and fun.

Table of Contents

General Abstract

This thesis investigates the lexical representation of mass (e.g., rice, milk) and count nouns (e.g., chair, cat) in language production. The research presented focuses on how mass/count (countability) information is processed at the lexical-syntactic and conceptual-semantic levels.

Chapter 1 reviews and discusses previous research with language unimpaired and impaired speakers and its theoretical implications for the representation of countability information in language production and comprehension. Results support the assumption that nouns have lexical-syntactic specification for countability. Chapter 2 investigates processing of mass and count nouns and their determiners during noun phrase production with language unimpaired speakers in two picture-word interference experiments. Results showed countability congruency effects which indicate that mass/count information is represented at the level of lexical-syntax and that mass/count specific determiners compete for selection. Chapter 3 and 4 present single case studies (one in Chapter 3 and two in Chapter 4) which examine possible selective impairments of mass noun lexical-syntax in three aphasic individuals with grammatical impairment. These investigations provide further evidence for the lexical-syntactic representation of mass/count information. A series of mass/count specific tasks was used to systematically investigate countability processing in language production and comprehension. Two of the individuals, RAP (Chapter 3) and DEH (Chapter 4), were found to suffer from a lexical-syntactic impairment which affected processing of mass noun grammar and led to frequent substitutions of mass noun determiners by count noun determiners. The third case study describes (Chapter 4) the individual GEC, whose conceptual-

semantic impairment affected naming of mass nouns. Results of the case studies not only provide further evidence that nouns and determiners are specified for countability at the level of lexical-syntax but also reveal that this lexical-syntactic information can be influenced by conceptual-semantic information which is activated by visual properties of the stimuli.

The research presented in this thesis provides evidence that nouns are lexical-syntactically specified for mass and count and that activation of this information is required for the selection of countablity congruent determiners. Results show further that activation of mass and count nouns and their determiners can be influenced by conceptual-semantic information.

Chapter 1

Introduction

This thesis aims to inform and extend theories of language processing, focusing in particular on how lexical-syntactic information is represented and processed in language production. The studies presented in this thesis focus on the representation of countability information. Countability is defined as a grammatical and semantic characteristic which divides nouns into mass (e.g., milk, rice) and count (e.g., chair, cat) (Cheng, 1973; Gillon, Kehayia & Taler, 1999; Grandy, 1973; Middleton, 2008; Semenza, Mondini & Cappelletti, 1997; Taler & Jarema, 2007; Wisniewski, Lamb & Middleton, 2003). Unlike mass nouns, count nouns can grammatically be pluralised (e.g., chairs, cats versus *milks, *rices), combined with numerals (e.g., one chair, three cats versus *one milk, *three cats) and quantifiers that denumerate (e.g., many chairs, few cats versus *many milk, *few rice). In terms of conceptual-semantic distinctions, count nouns mostly represent individual entities with clear boundaries while mass nouns often represent substances and aggregates without clear boundaries. The empirical investigation of countability provides an opportunity to learn about lexical-syntactic processing during language production.

What happens during language production and how do we empirically investigate it? Language production is a complex sequence of mental processes, starting from an intention or concept and resulting in the production of written or spoken language. During this process, a speaker activates semantic concepts which represent the meaning of the intended message, selects matching word forms and accesses the words' lexical-syntactic information which specifies the grammatical & semantic relationship between words within a sentence. Research in psycholinguistics and cognitive neuropsychology has led to many different theories of language production (e.g., Levelt, Roelofs & Meyer, 1999; Caramazza, 1997; Dell, Schwartz, Martin, Saffran & Gagnon, 1997). All of these theories have at least two levels in common: a semantic level which stores the meaning of a word, and a word form level which stores the phonological/orthographic form of a word (e.g., Butterworth, 1989; Caramazza, 1997; Dell, 1986; Garrett, 1975, 1980; Levelt, 1989; Roelofs, 1992). Much research has concentrated on investigating the representation of words at these two levels predominantly using behavioural data from language unimpaired speakers (Caramazza, Costa, Miozzo & Bi, 2001; Glaser & Düngelhoff, 1984; Jescheniak & Levelt, 1994; Lupker, 1982; Schriefers, Meyer & Levelt, 1990; Shatzmann & Schiller, 2004) and impaired speakers with aphasia (Butterworth, Howard & McLoughlin, 1984; Caramazza & Hillis, 1990; Coughlan, Warrington, 1981; Hillis, Rapp, Romani & Caramazza, 1990; Howard & Orchard-Lisle, 1984; Howard, 1995; Huff, Mack, Mahlmann & Greenberg, 1988; Kay & Ellis, 1987; Warrington, 1975).

In comparison to research on semantic and word form information, only a few and more recent studies (e.g., Alario & Caramazza, 2002; Biedermann, Lorenz, Beyersmann & Nickels (in press); Schiller & Caramazza, 2002, 2003; Schriefers, 1993; Vigliocco, Vinson, Martin & Garrett, 1999) and theories (Levelt et al., Caramazza, 1997) have addressed the representation of lexical-syntactic information, such as number, grammatical gender and particularly countability. Consequently, comparably little is known about lexical-syntactic representations. This relative lack of empirical studies and therefore knowledge about lexical-syntax motivated the research in this thesis. The four studies of this thesis use different psycholinguistic and neuropsychological approaches in order to most effectively enhance knowledge about lexical-syntactic representation and processing (Nickels, 2001).

In the sections of this introduction that follow, we briefly outline two theories[1] of language production which have implemented a level of lexical-syntax. Further, we introduce different methods used to investigate word form production including lexical-syntactic processing. Finally, we give an overview of the aims and methods on which the research in this thesis is based.

Levelt, Roelofs & Meyer's (1999) theory of language production

Levelt et al.'s (1999) theory is one of the few theories of language production which describes in detail the representation of lexical-syntactic information. Within this theory, nouns are represented at three different lexical levels: the level of lexical concepts (conceptual-semantic level), the lemma (lexical-syntactic) level, and (phonological) word form level. Information processing at and between levels occurs exclusively via excitatory, unidirectional links. Activation can only be sent to the next level if processing has been completed at the previous level (so called serial processing). Word production starts with the access of a word's meaning in the form of a holistic concept at the conceptual-semantic level (e.g., the German noun concept: ELEFANT (elephant)). Each concept is represented by an empty lemma node at the lexical-syntactic level which provides access to the word's lexical-syntactic information. For example, the lemma node 'elefant' (elephant) is linked to its lexical-syntactic attributes, such as grammatical gender ([masculine]) and word category ([noun]). The lexical-syntactic attributes are further connected with lexical-syntactic congruent

[1] Another prominent theory of spoken word production, the Interactive Activation theory of Dell, Schwartz, Martin, Saffran & Gagnon (1997) has not been included here, as precise assumptions about the representation and processing of lexical-syntactic attributes are not currently implemented.

determiner lemma nodes, such as ‘der$_{masculine}$’ (the) and ‘ein $_{masculine}$’ (a). According to Levelt et al., lexical-syntactic attributes and determiner lemma nodes receive activation from the noun lemma node. The most highly activated noun and determiner lemma nodes are selected and subsequently send activation to their corresponding word forms at the (phonological) word form level. Consequently, in most of cases only one word form receives activation from the selected lemma node. Finally, selected word forms are phonetically and articulatory encoded at post-lexical levels in order to be converted into speech. Figure 1 shows how a noun like ‘Elefant’ (elephant) is represented at the different lexical and post-lexical levels within Levelt et al.’s (1999) theory. While Levelt et al. (1999) do not explicitly address modalities other than spoken word production, they do state that the lemma level is modality neutral (Levelt et al., 1999, p.7), consequently, in the figure, we have indicated the relationship with auditory and written comprehension, and written word production.

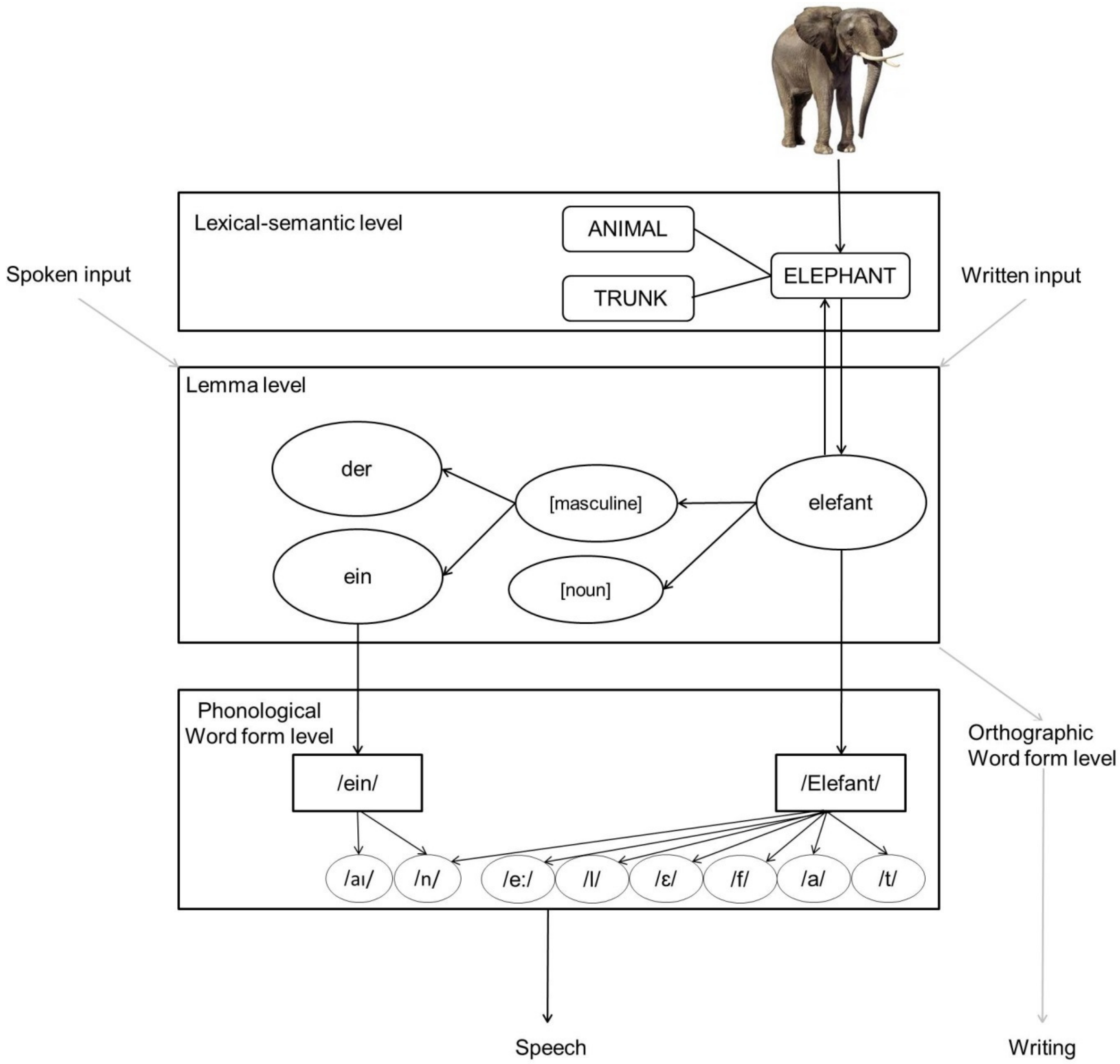

Figure 1. Illustration of the representation of the noun 'Elefant' (elephant) and the determiners 'der' (the) and 'ein' (a) (adapted from Levelt et al. (1999)).

Caramazza & Miozzo's Independent network model (Caramazza, 1997; Caramazza & Miozzo, 1997, 1998)

Consistent with Levelt et al.'s (1999) theory, the independent network model is composed of a lexical-semantic level, a syntactic level and a phonological word form level. The different levels are connected via unidirectional links but unlike in Levelt et al.'s theory activation can cascade down to the next level before processing is complete at the prior level. In the independent network model, word meaning and form are represented decomposed in the form of semantic features at the semantic level and P- lexemes. Compared to Levelt et al.'s theory, language production components in the independent network model are accessed in a different sequence. The syntactic level does not mediate between the semantic and the word form level. Instead, the semantic level accesses the word form level directly, while representations at the syntactic level are only fully accessed via the phonological/orthographic word form level. Exceptions are syntactic representations with semantic content, such as number (e.g., [singular], [plural]), which can be accessed and preactivated, but not selected, by semantics. Within each level, representations are organised in networks consisting of subnetworks. For example, the syntactic level has a subnetwork consisting of the different grammatical gender nodes (e.g., [masculine], [feminine], [neuter]) and another subnetwork with word category nodes (e.g., [noun], [verb], [adjective]). Representations within a subnetwork are competitors and therefore connected through inhibitory links.

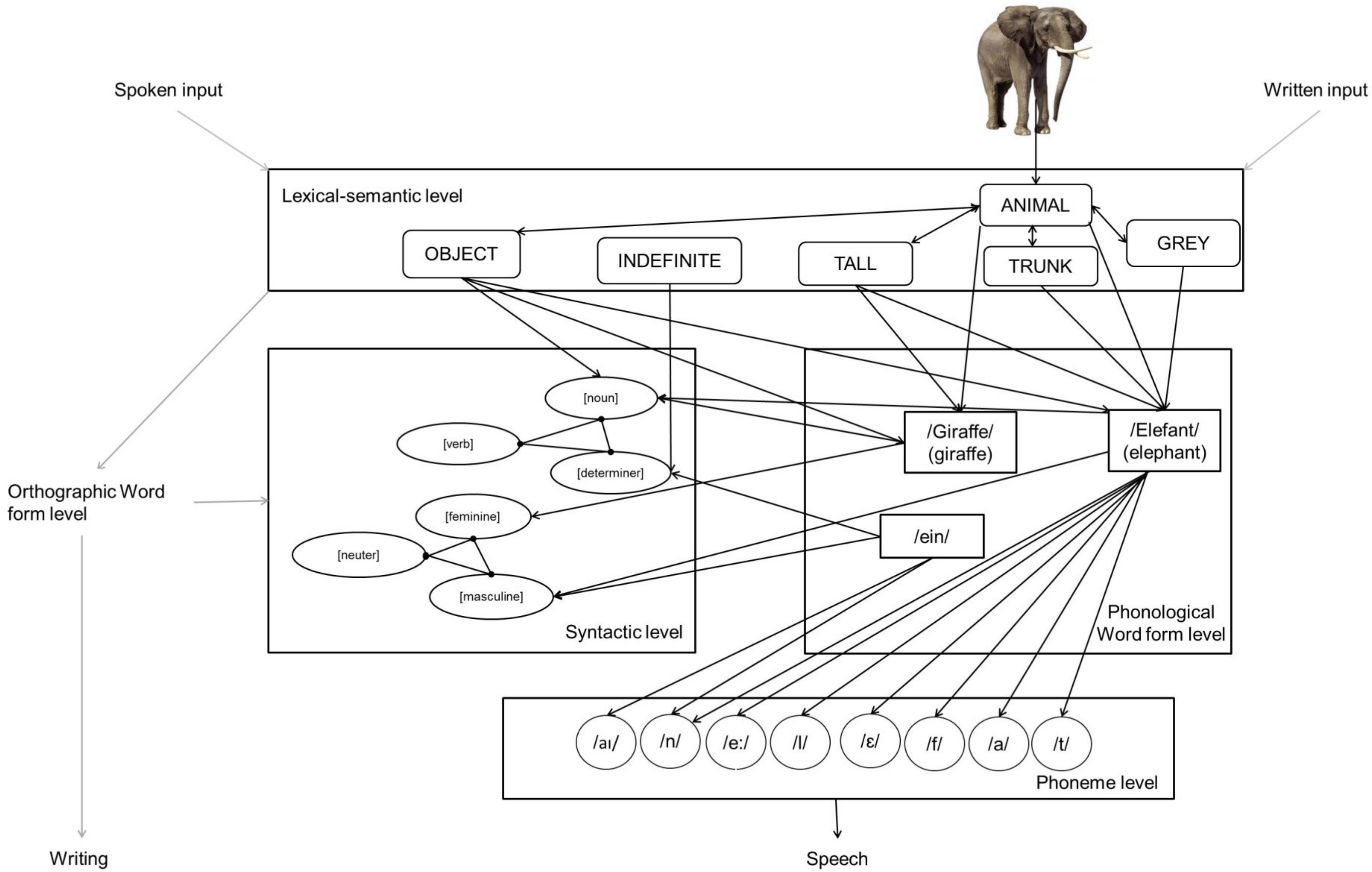

Figure 2. Illustration of the representation of the noun ‘Elefant’ (elephant) and the determiners ‘ein’ (a) according to the Independent Network Model (adapted from Caramazza & Miozzo, 1997).

In summary, the major difference between the two language production theories outlined above lies in the representation of lexical-syntactic information. Levelt et al.'s theory assumes lexical-syntactic selection prior to phonological/orthographic word form activation whereas in the Independent Network model lexical-syntax is only fully activated after phonological/orthographic word form access. However, even though lexical-syntactic representations are implemented in both theories, neither theory has explicitly addressed the representation of countability.

In the following section, we outline different empirical methods for investigating language production. Research in language production is based on a wide range of experimental techniques, such as, primed and unprimed picture naming, reading and repetition, Tip of the Tongue States and Tongue Twisters. However, in this Introduction, we will exclusively focus on the methods which have been used to study lexical-syntactic information.

Empirical Methods

Speech Errors

From early on, research in language production has extensively examined naturally occurring and elicited speech errors (Boomer & Laver, 1968; Fay & Cuttler, 1977; Fromkin, 1973; Garrett, 1988; Shattuck-Hufnagel & Klatt, 1979, 1980). Fromkin (1973) noted that the collection and analysis of speech errors provides important insights into the organisation of our language system. Certain types of speech errors, such as syntactic errors, occur relatively rarely in spontaneous speech (see Schriefers & Jescheniak, 1999; Bock, 1991; van den Broecke & Goldstein, 1980). For this reason, data from error corpora, which are typically collected in diary studies over a long period of time, are commonly used to investigate natural occurring speech errors. For example, Berg (1992) created a German data base of more than 6,000 slips of the tongue by monitoring the language of people in everyday life for over 4 years. These slips of the tongue could then be used for the analysis of different factors on error occurrence. For example, lexical-syntactic factors included whether target word and intruded (substituting) word shared the same word category, and whether they were gender congruent or not. Similar investigations of the effects of grammatical gender on natural occurring speech errors were performed in Spanish by Del Viso, Igoa and Garcia-Albea (1987). Both studies found effects of lexical-syntactic identity, where the majority of target and intruded words shared the same gender and word category (lexical-syntactically congruent).

An alternative approach is the investigation of experimentally elicited speech errors (see Schriefers & Jescheniak, 1999). One of the paradigms used to elicit speech errors are sentence completion tasks, where participants are typically presented with a preamble sentence containing two nouns which may or may not share the same lexical-syntactic information (e.g., grammatical gender). For example, in Dutch, which has neuter and common gender, the preamble sentence could be ‘Kijk, daar ligt de aardappel$_{\text{common}}$ bij het badpak$_{\text{neuter'}}$ (‘Look, there’s a potato$_{\text{common}}$ lying next to a swimsuit$_{\text{neuter}}$’) (Meyer & Bock, 1999). This is followed by a word which refers semantically to one of the nouns, such as the adjective ‘gaar’ (‘cooked’).The participant’s task is to continue the sentence including this word by producing a lexical-syntactically marked unit which refers grammatically to the appropriate noun in the preamble. For example, using the demonstrative pronoun ‘die$_{\text{common}}$’ to agree with ‘aardappel$_{\text{common}}$’ rather than the pronoun ‘dat$_{\text{neuter}}$’ as in the sentence ‘Kijk, daar ligt de **aardappel**$_{\text{common}}$ bij het badpak$_{\text{neuter,}}$ **die**$_{\text{common}}$ is gaar’ (‘Look, there’s a potato$_{\text{common}}$ lying next to a swimsuit$_{\text{neuter}}$ that$_{\text{common}}$ is cooked.’). Research studies which used this paradigm to investigate grammatical gender found that participants produced more gender errors on the critical unit when the nouns in the preamble sentence differed in their grammatical gender (lexical-syntactically incongruent) (Meyer & Bock, 1999; Vigliocco & Franck, 1999), than when they shared grammatical gender.

Tip of the Tongue States

During a Tip of the Tongue (TOT) state a speaker experiences the feeling of knowing a word which he/she is searching for without being able to retrieve its full word form. Speakers in a TOT state can often retrieve the word’s meaning and sometimes even fractions of its phonological information (e.g., the initial phoneme or the number of syllables).,The TOT phenomenon has been used to investigate the availability of a word’s lexical-syntactic information independent of its word form. A number of studies (Biedermann, Ruh, Nickels & Coltheart, 2008; Miozzo & Caramazza, 1997a, Caramazza & Miozzo, 1997; Vigliocco, Antonini & Garrett, 1997; Vigliocco, Vinson, Martin & Garrett, 1999) induced TOT states in participants by presenting them with pictures or definitions of relatively low-frequency nouns (e.g. plankton, gondola, biceps). When a participant was in a TOT state, in other words they could not name the picture/word momentarily despite knowing it, the investigator would ask questions about its phonological word form (e.g., first and last phoneme, number of syllables) and its lexical-syntactic attributes (e.g., grammatical gender, countability). Afterwards participants were presented with the target word and questioned whether it was the word they intended to produce (positive TOT state) or not (negative TOT state). TOT studies in Italian (Gonzalez & Miralles, 1997; Vigliocco et al., 1997), Spanish (Miozzo & Caramazza, 1997a, Caramazza & Miozzo, 1997), English (Vigliocco et al., 1999; Biederman et al., 2008) and in German (Biedermann et al., 2008) revealed that speakers in a positive TOT state have access to a word's lexical-syntactic information independent of word form retrieval.

Picture-Word Interference Paradigm

Picture-word interference tasks have become one of the most commonly used empirical paradigms to investigate lexical-syntactic information (e.g., Alario, Matos & Segui, 2004; Costa, Mahon, Savova & Caramazza, 2003; La Heij, Mak, Sander & Willeboordse, 1998; Schiller & Caramazza, 2002; Schriefers, 1993; Schriefers, Jescheniak & Hantsch, 2002; Schriefers & Teruel, 2000; Spalek & Schriefers, 2005; van Berkum, 1997). In this approach, participants are presented with a picture and asked to name the displayed object(s) with a bare noun (e.g., German noun: Schlange$_{\text{feminine}}$ (snake)) or noun phrase (e.g., determiner plus noun; determiner plus adjective plus noun: die$_{\text{feminine}}$ Schlange$_{\text{feminine}}$ (the snake)). Additionally, participants see or hear a distractor word (e.g., Maske$_{\text{feminine}}$ (mask) or Mond$_{\text{masculine}}$ (moon)) which they are asked to ignore. Picture naming latencies have been found to vary depending on the relationship between target and distractor word. For example, longer naming latencies have been found for semantically related target-distractor pairs and shorter naming latencies for phonologically related target-distractor pairs compared to unrelated target-distractor pairs (e.g., Schriefers et al., 1990). Picture-word interference studies which have investigated lexical-syntactic information (e.g., grammatical gender, declensional class) have found a lexical-syntactic congruency effect with shorter naming latencies for target-distractor pairs which were lexical-syntactically congruent (e.g., target noun: $\text{Schlange}_{\text{feminine}}$ (snake), distractor noun: $\text{Maske}_{\text{feminine}}$ (mask)) compared to lexical-syntactically incongruent pairs (e.g., target noun: $\text{Schlange}_{\text{feminine}}$ (snake), distractor noun: $\text{Mond}_{\text{masculine}}$ (moon)) (e.g., in Czech: Bordag & Pechmann, 2008, 2009; in German & Dutch: Janssen & Caramazza, 2003; Schiller & Caramazza, 2003, 2006; Schriefers, 1993; Schriefers, Jescheniak & Hantsch, 2002, 2005). Longer picture naming latencies for lexical-syntactically incongruent target-distractor pairs were taken as evidence for a competitive selection process between the different lexical-syntactic attributes activated by the target picture and distractor word (see Paper 2 for further discussion).

Cognitive Neuropsychological approach

The cognitive neuropsychological approach investigates language representations and their functional relationships by studying individuals or case series of individuals with language impairments, such as, aphasia. The language performance of the language impaired individual(s) is either compared with a language unimpaired group or alternatively with a language impaired individual(s) showing a contrasting pattern of performance. There are a number of neuropsychological studies which have investigated the representation of lexical-syntactic information, such as grammatical gender (e.g., Biran & Friedmann, 2011; Seyboth, Blanken, Ehmann, Schwartz & Bormann, 2011), number (e.g., Biedermann, Nickels & Beyersmann, 2009; Biedermann, Lorenz, Beyersmann & Nickels, 2012; Biedermann, Beyersmann, Mason & Nickels, 2013; Luzzatti, Mondini & Semenza, 2001) and countability (e.g., Garrad, Carrol, Vinson & Vigliocco, 2004; Herbert & Best, 2010; Semenza, Mondini & Cappelletti, 1997; Semenza, Mondini & Marinelli, 2000; Vigliocco, Vinson, Martin & Garrett, 1999). The investigation of language specific information, such as lexical-syntax, requires careful testing of critical stimuli which carry the lexical-syntactic information at the different levels of the language system. Common tasks used to test lexical-syntactic processing are grammaticality judgements of noun phrases/sentences and picture naming with nouns or noun phrases. A number of single case studies have reported dissociations between lexical-syntactic representations and their related processes. For example, Seyboth et al. (2011) reported the case of E.M., a woman with aphasia who showed a lexical-syntactic impairment affecting only masculine gender while sparing feminine and neuter gender. From neuropsychological studies, inferences can be made regarding representation of language specific information in the normal, unimpaired language system. For example, Seyboth et al. (2011) concluded from the selective lexical-syntactic impairment, that grammatical gender is represented in the form of central nodes, one for each type, which are connected to gender congruent nouns and determiners.

In summary, lexical-syntactic processing has been investigated using a number of different empirical paradigms. Two of the discussed paradigms, the picture-word interference task and the neuropsychological approach are used in this thesis to find evidence for the lexical-syntactic representation of countability which is still relatively under-researched (see Paper 1 for a review).

Preview

The four papers which are presented in this thesis aim to investigate the representation and processing of lexical-syntactic countability information. To do so, mass and count nouns and their semantic and syntactic differences are introduced and findings on countability from previous studies are reviewed and discussed in detail. Subsequently, findings from a series of psycholinguistic and neuropsychological studies are used to evaluate and extend current language theories particularly Levelt et al.'s (1999) theory of language production on the representation of countability information. The Independent Network Model (Caramazza, 1997; Caramazza & Miozzo, 1997, 1998) is not referred to until the final chapter. The research presented in this thesis builds on findings and theoretical implications of studies which investigated other lexical-syntactic attributes, such as grammatical gender and number.

Paper One is a literature review which summarised and critically evaluated empirical evidence for the lexical-syntactic representation of countability information from studies of language production and comprehension with language unimpaired and impaired speakers. Theoretical implications of the results are discussed in an extended version of Levelt et al.'s (1999) theory using existing accounts about the representation of countability or related lexical-syntactic attributes (e.g., grammatical gender). The discussion focuses on lexical-syntactic markedness of mass and count nouns, as markedness is a major difference between the different countability accounts. The question is raised of whether only mass nouns (Taler & Jarema, 2006), only count nouns (Barner & Snedeker, 2005, 2006), or alternatively both mass and count nouns (in analogy to grammatical gender In Levelt et al.'s theory, 1999) are lexical-syntactically specified for countability.

The focus of the remaining papers shifts from the representation of mass and count nouns in terms of lexical-syntactic markedness to how lexical-syntactic countability information is processed. **Paper Two** investigates processing of mass and count nouns and their determiners in two experiments using the picture-word interference paradigm. Experiment 1 aims to investigate whether countability information is processed in a similar way to grammatical gender, as a fixed intrinsic lexical-syntactic attribute which is activated via the noun's lemma, or alternatively in a similar way to number as a variable extrinsic lexical-syntactic attribute which is set through semantics. Experiment 1 further looks at effects of number congruency in the context of mass and count nouns. Experiment 2 extends the findings of Experiment 1 by investigating whether the selection process of lexical-syntactic attributes ([mass] versus [count]) or of their determiners (e.g., $\text{much}_{\text{mass}}$ vs. $\text{many}_{\text{count}}$) is competitive in nature.

Papers Three and **Four** use a cognitive neuropsychological approach to investigate processing and impairment of countability information at the lexical-syntactic and conceptual-semantic levels. The papers report a series of single case studies of aphasic individuals with different countability specific impairments. A series of mass/count specific tasks was developed to look at the nature of countability information and its selection in language comprehension and production. **Paper Three** reports an aphasic individual, RAP with a lexical-syntactic impairment affecting mass noun determiners. **Paper Four** contains two single case studies of aphasic individuals, DEH and GEC with different countability specific impairments. DEH shows a lexical-syntactic deficit similar to that of RAP, while GEC's impairment affects the production of bare mass nouns.

The four papers in this thesis address two major issues. The literature review focusses predominantly on the representation of countability information in the form of lexical-syntactic markedness. While the three empirical studies investigate how countability information is processed. Both of these issues are discussed in the light of the empirical evidence from Papers Two, Three and Four in the Discussion.

References

Alario, F.-X., Matos, R.E. & Segui, J. (2004). Gender congruency effects in picture naming. *Acta Psychologica,* 117, 185-204.

Alario, F.-X. & Caramazza, A. (2002). The production of determiners: evidence from French. *Cognition*, 82, 179-223.

Barner, D. & Snedeker, J. (2005). Quantity judgements and individuation: evidence that mass nouns count. *Cognition*, 97, 41-66.

Barner, D. & Snedeker, J. (2006). Children's Early Understanding of Mass-Count Syntax: Individuation, Lexical Content, and the Number Asymmetry Hypothesis. *Language Learning And Development*, 2(3), 163-194.

Berg, T. (1992). Prelexical and postlexical features in language production. *Applied Psycholinguistic*s, 13, 199-235.

Biedermann, B., Beyersmann, E., Mason, C. & Nickels, L. (2013). Does plural dominance play a role in spoken picture naming? A comparison of unimpaired and impaired speakers. *Journal of Neurolinguistics*, 26, 712-736.

Biedermann, B., Lorenz, A., Beyersmann, E. & Nickels, L. (2012). The influence of plural dominance in aphasic word production. *Aphasiology*, 26(8), 985-1004.

Biedermann, B., Nickels, L.A. & Beyersmann, E. (2009). Organisation of 'number' information in the lexicon: Insights from aphasic plural errors. In Otsu, Y.

(Ed.), *The Proceedings of the 10th Tokyo Conference on Psycholinguistics* (pp. 27-42). Japan: Hituzi Syobo Publishing.

Biedermann, B., Ruh, N., Nickels, L. & Coltheart, M. (2008). Information Retrieval in Tip of the Tongue States: New Data and Methodological Advances. *Journal of Psycholinguistic Research*, 37, 171-198.

Biran, M. & Friedmann, N. (2012). The representation of lexical-syntactic information: Evidence from syntactic and lexical retrieval impairments in aphasia, *Cortex*, 48(9), 1103-1127.

Boomer, D.S. & Laver, J.D.M. (1968). Slips of the Tongue. *International Journal of Language and Communication Disorders*, 3(1), 2-12.

Bock, J.K. (1991). A sketchbook of production problems. *Journal of Psycholinguistic Research*, 20, 141-160.

Bordag, D. & Pechmann, T. (2008). Grammatical Gender in Speech Production: Evidence from Czech. *Journal of Psycholinguistic Research*, 37, 69-85.

Bordag, D. & Pechmann, T. (2009). Externality, Internality, and (In)Dispensability of Grammatical Features in Speech Production: Evidence from Czech Declension and Conjugation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(2), 446-465.

Butterworth, B. (1989). Lexical access in speech production. In Marslen-Wilson, W. (Ed). *Lexical representation and process*. (pp. 108-135). Cambridge, MA, US: The MIT Press

Butterworth, B, Howard, D. & McLoughlin, P. (1984). The semantic deficit in aphasia: the relationship between semantic errors in auditory comprehension and picture naming. *Neuropsychologia*, 22(4), 409-426.

Caramazza, A. (1997). How many levels of processing are there in lexical access?. *Cognitive neuropsychology*, *14*(1), 177-208.

Caramazza, A., Costa, A., Miozzo, M. & Bi, Y. (2001). The specific-word frequency effect: implications for the representation of homophones in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 1430-1450.

Caramazza, A. & Hillis, A. E. (1990). Where do semantic errors come from? *Cortex*, 26, 95-122.

Caramazza, A. & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the 'tip-of-the tongue' phenomenon. *Cognition*, 64, 309-364.

Caramazza, A. & Miozzo, M. (1998). More is not always better: a response to Roelofs, Meyer, & Levelt. Cognition, 69, 231-241.

Cheng, C. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Costa, A., Mahon, B., Savova, V. & Caramazza, A. (2003). Level of categorisation effect: A novel effect in the picture-word interference paradigm. *Language and Cognitive Processes,* 18(2), 205-233.

Coughlan, A. K. & Warrington, E. K. (1981). The impairment of verbal semantic memory: a single case study. *Journal of Neurology, Neurosurgery and Psychiatry*, 44, 1079-1083.

Dell, G.S. (1986). A spreading-activation model of retrieval in sentence production. Psychological Review, 93, 283-321.

Dell, G.S., Schwartz, M.F., Martin, N., Saffran, E.M. & Gagnon, D.A. (1997). Lexical Access in Aphasic and Nonaphasic Speakers. Psychological Review, 104(4), 801-838.

Del Viso, S., Igoa, J.M. & Garcia-Albea, J.H. (1987). *Corpus of spontaneous slips of the tongue in Spanish*. Unpublished materials.

Fay, D., & Cutler, A. (1977). Malapropisms and the Structure of the Mental Lexicon. *Linguistic Inquiry*, 8(3), 505-520.

Fromkin, V.A. (1973). *Speech errors as linguistic evidence*. The Hague: Mouton de Gruyter.

Garrard, P., Carroll, E., Vinson, D. & Vigliocco, G. (2004). Dissociation of Lexical Syntax and Semantics: Evidence from Focal Cortical Degeneration. *Neurocase,*10(5), 353-362.

Garrett, M.F. (1975). The analysis of sentence production. In G. Bower (ed.). *The psychology of learning and motivation: Advances in research and theory.* Vol. 9. New York: Academic press.

Garrett, M.F. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.). *Language production. Vol. 1: Speech and talk.* London: Academic Press.

Garrett, M.F. (1988). Processes in language production. In F.J. New meyer (ed.). *The Cambridge survey of linguistics. Vol. 3: Biological and psychological aspects of language*. Cambridge, MA: Harvard University Press.

Gillon, B.S., Kehayia, E. & Taler, V. (1999). The mass/count distinction: Evidence from online psycholinguistic performance. *Brain and Language*, *68*, 205-211.

Glaser, W. R. & Düngelhoff, F.-J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance*, 10, 640–654.

Gonzalez, J., & Miralles, J.L. (1997). *La informacion sintatica esta disponible durante un estado de punto de la lengua* [Syntactic information is available in a tip-of-the-tongue state]. University Jaume I of Castellon (Spain).

Grandy, R.G. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex*, 46(3), 329-342.

Hillis, A. E., Rapp, B., Romani, C. & Caramazza, A. (1990). Selective impairments of semantics in lexical processing. *Cognitive Neuropsychology*, 7, 191-243.

Howard, D. (1995). Lexical anomia: or the case of the missing lexical entries. *The Quarterly Journal of Experimental Psychology*, 48a(41), 999-1023.

Howard, D. & Orchard-Lisle, V. (1984). On the origin of semantic errors in naming: evidence form the case of a global aphasic. *Cognitive Neuropsychology*, 1(2), 163-190.

Huff, J. F., Mack, L., Mahlmann, J. & Greenberg, S. (1988). A comparison of lexical-semantic impairments in left hemisphere stroke and Alzheimer's disease. *Brain and Language,* 34, 262-278.

Jacobsen, T. (1999). Effects of Grammatical Gender on Picture and Word Naming: Evidence from German. Journal of Psycholinguistic Research, 28(5), 499-514.

Janssen, N. & Caramazza, A. (2003). The selection of closed-class words in noun phrase production: The case of Dutch determiners. *Journal of Memory and Language*, 48, 635-652.

Jescheniak, J.D. (1999). Gender priming in picture naming: Modality and baseline effects. Journal of Psycholinguistic Research, 28(6), 729-737.

Jescheniak, J.D. & Levelt, W.J.M. (1994). Word Frequency Effects in Speech Production: Retrieval of Syntactic Information and of Phonological Form. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(4), 824-843.

Kay, J. & Ellis, A. (1987). A cognitive neuropsychological case study of anomia. Implications for psychological models of word retrieval. *Brain*, 110, 613-629.

La Heij, W., Mak, P., Sander, J. & Willeboordse, E. (1998). The gender-congruency effect in picture-word tasks. *Psychological Research*, 61, 209-219.

Levelt, W.J.M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences*, *22*, 1-75.

Lupker, S. J. (1982). The role of phonetic and orthographic similarity in picture–word interference. *Canadian Journal of Psychology*, 36, 349–367.

Luzzatti, C., Mondini, S. & Semenza, C. (2001). Lexical representation and processing of morphologically complex words: Evidence from the reading performance of an Italian agrammatic patient. *Brain and Language*, *79,* 345–359.

Meyer, A.S. & Bock, J.K. (1999).Representation and processes in the production of pronouns: Some perspectives from Dutch. *Journal of Memory and Language*, 41, 281-301.

Middleton, E.L. (2008). Mass Matters. *Dissertation Abstracts International*, 70(02), (UMI No. 3347451).

Miozzo, M. & Caramazza, A. (1997a). The retrieval of lexical-syntactic features in tip-of-the-tongue states. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 23, 1-14.

Nickels, L. (2001). Spoken word production. In B. Rapp (Ed.). *A Handbook of Cognitive Neuropsychology* (pp. 291-320). New York: Psychology Press.

Roelofs, A. (1992a). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, 42, 107-142.

Schiller, N. O. & Caramazza, A. (2002). The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German. *Brain and Language,* 81, 342-357.

Schiller, N. O. & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. *Journal of Memory and Language,* 48, 169-194.

Schiller, N. O., & Caramazza, A. (2006). Grammatical gender selection and the representation of morphemes: The production of Dutch diminutives. *Language and Cognitive Processes,* 21(7-8), 945-973.

Schriefers, H. (1993). Syntactic Processes in the Production of Noun Phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19(4), 841-850.

Schriefers, H. & Jescheniak, J.D. (1999). Representation and Processing of Grammatical Gender in Language Production: A Review. *Journal of Psycholinguistic Research*, *28*(6), 575-600.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2002). Determiner Selection in Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 28(5), 941-950.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2005). Selection of Gender-Marked Morphemes in Speech Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 31(1), 159-168.

Schriefers, H., Meyer, A.S. & Levelt, W.J.M. (1990). Exploring the Time Course of Lexical Access in Langugae Production: Picture-Word Interference Studies. *Journal of Memory and Language,* 29, 86-102.

Schriefers, H. & Teruel, E. (2000). Grammatical Gender in Noun Phrase Production: The Gender Interference Effect in German. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 26(6), 1368-1377.

Semenza, C., Mondini, S. & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Semenza, C., Mondini, S. & Marinelli, K. (2000). Count and Mass Nouns: Semantics and Syntax in Aphasia and Alzheimer`s disease. *Brain and Language, 74*, 395-431.

Seyboth, M., Blanken, G., Ehmann, D., Schwarz, F. & Bormann, T. (2011). Selective impairment of masculine gender processing: Evidence from a German aphasic. *Cognitive Neuropsychology*, 28(8), 564-588.

Shattuck-Hufnagel, S. & Klatt, D.H. (1979). The limited use of distinctive features and markedness in speech production: evidence from speech error data. *Journal of Verbal Learning and Verbal Behavior*, 18(1), 41-55.

Shattuck-Hufnagel, S. & Klatt, D.H. (1980). How single phoneme error data rule out two models of error generation. In V. A. Fromkin (Ed.). *Errors in* *linguistic performance: slips of the tongue, ear, pen and hand* (pp. 35–46). New York: Academic Press.

Shatzmann, K.B. & Schiller, N.O. (2004). The word frequency effect in picture naming: contrasting two hypothesis using homonym pictures. *Brain and Language*, 90, 160-169.

Spalek, K. & Schriefers, H.J. (2005). Dominance affects determiner selection in language production. *Journal of Memory and Language,* 52, 103-119.

Taler, V. & Jarema, G. (2006). On-Line lexical processing in AD and MCI: An early measure of cognitive impairment? *Journal of Neurolinguistics, 19*, 38-55.

Taler, V. & Jarema, G. (2007). Lexical access in younger and older adults: The case of the mass/count distinction. *Canadian Journal of Experimental Psychology*, *61*, 21-34.

Van den Broecke, M.P.R. & Goldstein, L (1980). Consonant features in speech errors. In V.A. Fromkin (Ed.). *Errors in linguistic performance: slips of the tongue, ear, pen and hand*. New York: Academic Press.

Van Berkum, J. J. A. (1997). Syntactic processes in speech production: the retrieval of grammatical gender. *Cognition,* 64, 115-152.

Vigliocco, G., Antonini, T. & Garrett, M.F. (1997). Grammatical gender is on the tip of Italian tongues. *Psychological Science*, 8, 314-317.

Vigliocco, G. & Franck, J. (1999). When sex and syntax go hand in hand: Gender agreement in language production. *Journal of memory and Language*, 40, 455-478.

Vigliocco, G., Vinson, D.P., Martin, R.C. & Garrett, M.F. (1999). Is “Count” and “Mass” Information Available When the Noun Is Not? An Investigation of Tip of the Tongue States and Anomia. *Journal of Memory and Language,* 40, 534-558.

Warrington, E. K. (1975). The selective impairment of semantic memory. *Quarterly Journal of Psychology*, 27, 635-657.

Wisniewski, E.J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and cognitive processes*, 18(5/6), 583-624.

Chapter 2

Representation and processing of mass and count nouns: A review.

Nora Fieder, Lyndsey Nickels & Britta Biedermann

ARC Centre of Excellence for Cognition and its Disorders (CCD)

Department of Cognitive Science

Macquarie University, Sydney, Australia

Abstract

Comprehension and/or production of noun phrases and sentences requires the selection of lexical-syntactic attributes of nouns. These lexical-syntactic attributes include grammatical gender (masculine/feminine/neuter), number (singular/plural) and countability (mass/count). While there has been considerable discussion regarding gender and number, relatively little attention has focused on countability. Therefore, this article reviews empirical evidence for lexical-syntactic specification of nouns for countability. This includes evidence from studies of language production and comprehension with normal speakers and case studies which assess impairments of mass/count nouns in people with acquired brain damage. Current theories of language processing are reviewed and found to be lacking specification regarding countability. Consequently, the theoretical implications of the empirical studies are discussed in the context of frameworks derived from these accounts of language production (Levelt, 1989; Levelt, Roelofs & Meyer, 1999) and comprehension (Taler & Jarema, 2006). The review concludes that there is emprical support for specification of nouns for countability at a lexical-syntactic level.

> "Many of the things you can count don't count. Many of the things you can't count really count." (Albert Einstein,14.03.1879-18.04.1955)

What is the difference between *rice* and *lentils*, *garlic* and *onions* or *asparagus* and *salsifies*[2]? Rice and lentils are small, similar looking entities which appear in bigger clusters and often are used as a side dish. Garlic and onions belong to the same plant genus *Allium*. Both grow underground and the bulb of the plant is used for cooking due to its spicy flavour. Asparagus and salsifies are also both similar looking vegetables and salsifies are even colloquially referred to as *poor man's asparagus*. All in all, these entities seem to have much in common regarding their origin, appearance and use. Why then, do we say: "There is an onion." but "There is some garlic.", "There are a few lentils left." but "There is a little rice left." or "There are too many salsifies." but "There is too much asparagus."? Why is it that onion, lentil and salsifies are count nouns, and garlic, rice and asparagus mass nouns? In other words, why and how do we grammatically distinguish these nouns for countability as English speakers?

Nouns have a variety of lexical-syntactic attributes. These include grammatical gender (e.g., feminine, masculine), number (i.e., singular, plural) and countability (i.e., mass, count). In language production, these attributes determine the form of adjacent constituents in a phrase or a sentence, such as determiners. For example, in German, the definite determiner 'der$_{\text{masculine}}$' (the) is required for singular nouns of masculine gender and 'die $_{\text{feminine}}$' for singular nouns of feminine

[2] Salsify is a plant in the genus Tragopogon. Salsify can grow to 60 cm height. Its stem is unbranched and the leaves are grasslike. The colour of the flower can be purple, yellow or bronze. The roots and shoots of salsify can be eaten raw or cooked. The taste is described as being sweet and similar to oysters. Very popular in France and Italy it is used as an accompaniment to meats and in soufflés and is a very popular snack in Belgium served as a fritter with beer. It is less widely known in the UK and Australia.

gender. For example in the phrases ‘der$_{\text{masculine}}$ Hund$_{\text{masculine, singular}}$’ (the dog) for a singular noun of masculine gender, ‘die$_{\text{plural}}$ Hunde$_{\text{masculine, plural}}$’ (the dogs) for a plural noun of masculine gender; similarly, in English while either ‘a’ or ‘the’ is acceptable for a count noun only ‘the’ can be used for a mass noun. Therefore to produce grammatical sentences or to fully understand a sentence, information regarding countability needs to be activated and retrieved from the mental lexicon.

There has been a relatively large amount of attention in the literature on some lexical-syntactic attributes, including number (e.g, Baayen, Burani & Schreuder, 1996; Baayen, Dijkstra & Schreuder, 1997; Sonnenstuhl & Huth, 2002; Schiller & Caramazza, 2002) and grammatical gender (Badecker, Miozzo & Zanuttini, 1995; Jacobsen, 1999; Jescheniak, 1999; La Heij, Mak, Sander & Willeboordse, 1998; Schriefers, 1993; van Berkum, 1997). However, countability is an equally valid lexical-syntactic attribute which is distinguished in many languages, but yet has received far less attention. We will therefore review the current literature on countability, both experimental and theoretical.

We will first introduce the fundamental semantic and syntactic characteristics of mass and count nouns in order to understand their linguistic differentiation. Subsequently, three theories will be presented which have explicitly discussed the representation of mass and count nouns (Barner & Snedeker, 2005, 2006; Levelt, 1989; Levelt, Roelofs & Meyer, 1999; Taler & Jarema, 2006). We then go on to review experimental studies which have investigated the representation and processing of mass and count nouns. We first focus on investigations of language processing in adults without language impairment, comprising studies on the availability of grammatical information in the Tip-of-the-Tongue state (ToT), visual lexical decision, semantic categorisation and grammatical judgement. Subsequently, we review case studies which assess impairments of mass nouns and processing of mass and count nouns in people with language impairment as a result of stroke and progressive neurological disorders (e.g., Alzheimer's disease, semantic dementia). Finally, we bring the disparate literatures together and draw some conclusions from the research to date.

Characteristics of Count Nouns and Mass Nouns

Many languages differentiate between count nouns (e.g. chair, dog) and mass nouns (e.g., honey, gold). Mass and count nouns have been argued to differ semantically, syntactically and morphologically. However, there is still disagreement regarding whether the mass/count categorisation can be attributed to differences in semantics (e.g., Armon-Lotem, Crain & Varlokosta, 2004; Jackendoff, 1991) or whether it reflects a syntactic distinction (e.g., Garrard, Carroll, Vinson & Vigliocco, 2004; Shapiro, Zurif, Carey & Grossman, 1989; Vigliocco, Vinson, Martin & Garrett, 1999) or both (Warrington & Crutch, 2005). A similar debate is ongoing for the acquisition of conceptual-semantic and lexical-syntactic knowledge about mass and count nouns. Quine (1960) proposed that it is mass and count syntax which provides a means by which children can acquire conceptual-semantic knowledge of physical objects, such as individuation and quantification (syntactic bootstrapping). In contrast, Macnamara (1972, 1982) assumed, however, that it is conceptual-semantic knowledge in the form of prelinguistically acquired categories such as 'object' and 'substance' which leads to the acquisition of the syntactic categories mass and count (semantic bootstrapping) (see also Barner & Snedeker, 2005).

Count nouns and mass nouns differ in ways which can inform ideas about their representation at different levels of language processing. On the one hand, the two classes of nouns have been suggested to differ in their semantic and/or conceptual characteristics (Armon-Lotem, Crain & Varlokosta, 2004; Wisniewski, Lamb & Middleton, 2003). A count noun which applies to an object does not apply to any of its parts (e.g. table applies to a single table but not to its legs). In other words, count nouns are indivisible or atomic, and therefore can be sorted and counted. In contrast, many mass nouns apply to their parts (e.g. the term 'water' can apply to an obtainable portion of water like a puddle). They are non-atomic and often represent substances (e.g., water, honey) or aggregates[3] (e.g., rice, confetti) without defined boundaries. Thus, a combination of two samples of a mass noun like, for instance, water plus water would result in one larger sample of water. As this makes it impossible to count or sort mass nouns, they are mostly measured (e.g., one litre of water, two teaspoons of honey). Count nouns on the other hand have clear and accessible boundaries. The sum of two chairs would not lead to one bigger chair. However, the distinction between count and mass nouns is not always conceptual-semantically transparent. Some nouns refer to distinct objects (e.g., broccoli, bread) but are still categorized as mass nouns. Similarly, count nouns can also represent small, homogeneous entities and therefore refer to aggregates (e.g., lentils, peas, pearls) just like mass nouns. In some cases, there are even nouns which refer to the same entities but belong to a different noun category (e.g., pebbles vs. gravel, garments vs. clothing). A conceptual-semantic distinction underlying countability becomes even harder to maintain when abstract nouns are considered (e.g., abstract count nouns: future,

[3] Middleton, Wisniewski, Trindel and Imai (2004, p. 372) defined aggregates as "collections of relatively small, homogeneous entities" (e.g., rice, gravel, confetti, sand).

dream, idea vs. abstract mass nouns: appetite, irony, evidence) or in reference to superordinate categories (e.g., countable superordinate categories: vegetable, animal vs. non-countable superordinate categories: clothing, furniture) (Middleton, Wiesniewski, Trindel & Imai, 2004).

The lack of conceptual-semantic transparency between mass and count categories is also reflected in cross-linguistic differences regarding categorization. For example, some nouns which are mass nouns in English, are countable in other languages such as ‘bread’ and ‘soup’ which are count nouns in German (Brot, Suppe) and ‘spinach’ and ‘spaghetti’ which are count nouns in Italian (spinaci, spaghetti). Hence, the categorization of some nouns as count or mass is language-specific. Indeed, some languages do not even have this distinction. For instance, in Japanese all nouns are neutral regarding countability (Iwasaki, Vinson & Vigliocco, 2010).

The distinction between mass and count nouns can also depend on the context. The same noun (e.g., coffee, tea) which is conceptual-semantically classified as a mass noun can often be used in another context as a count noun (e.g., Three coffees, please.) by deleting the unit of measurement (e.g. ‘cups of’) from the surface structure. Furthermore, the same noun can be used sometimes with either mass or count syntax without any deletion in the surface structure (e.g., I’ll go buy a cake (count). vs. I want cake (mass) for dessert.). Taler and Jarema (2007) referred to this group of nouns as dual nouns.

From this brief overview of the conceptual-semantic differences between mass and count nouns, it is clear that the distinction between the categories is not clear-cut. Hence, the categorization of nouns into mass and count cannot be based completely on their conceptual-semantic characteristics. Indeed, the hypothesis of a conceptual-semantic distinction has sometimes even been described as being arbitrary or idiosyncratic (Bloomfield, 1933; Gillon, Kehayia & Taler, 1999; Semenza, Mondini & Cappelletti, 1997). Nevertheless, Wisniewski et al. (2003) suggested that the syntax of mass and count nouns is systematically related to the conceptual distinction in the mind of speakers. The interpretation of an aspect of reality (conceptualization) as an individual or non-individuated entity[4] by a person or group of people determines the use of count or mass syntax. Within this *cognitive individuation hypothesis* it is assumed that how people perceive and interact with entities influences their categorization of nouns into mass or count. Wierzbicka (1988) believed that one of the important factors is the ease with which several elements of an entity can be distinguished. This assumption was supported by Middleton et al. (2004) who demonstrated that participants judged count noun aggregates (e.g., toothpicks, nuts, olives) as being easier to perceptually distinguish than mass noun aggregates (e.g., coal, popcorn, hair). Another important factor was considered to be the frequency with which people interact with individual elements or with multiple elements of aggregates. Regarding this hypothesis, Middleton et al. (2004) provided evidence that people interact more often with individual (one or a few) elements of count noun aggregates. However, people tend to interact more often with multiple (many) elements of mass noun aggregates. In other words, Middleton et al. proposed that the syntactic distinction is based not just on the semantics of those items (Langacker, 1987; Bates & MacWhinney, 1982) but also on the way people conceptualize these entities as being distinguishable and individual in their usage.

[4] Middleton et al. (2004) describe 'non-individuated entity' as a term which is more abstract than the term substance and comprises more kinds of mass entities. Hence, in addition to substances it refers also to cognitive events (e.g., anger), physical events (e.g., sleep) and sounds (e.g., thunder).

Iwasaki et al. (2010) found further support for this theory by analysing substitution errors in the Japanese language. As noted above, Japanese speakers do not possess the grammatical distinction between mass and count nouns. However, the speakers were still found to be sensitive to conceptual distinctions related to English mass and count nouns. This was shown by the fact that the majority of Japanese substitution errors shared the English mass/count status of the target word (e.g., target word: beer; substitution error: wine). Further support for a conceptual-semantic distinction between objects and substances has been found in several studies involving acquisition of novel names in children and adults (Imai & Gentner, 1997; Soja, Carey & Spelke, 1991).

In sum, it appears that there is a broad conceptual-semantic difference between mass and count nouns, which is to some extent reflected in the syntactic distinction. However, it has also been shown that conceptual-semantic and syntactic characteristics do not always correspond, hence, entities which can be counted and are easy to perceptually distinguish are not always count nouns (e.g., mass nouns: broccoli, asparagus) and substances or aggregates are not necessarily mass nouns (e.g., peas, lentils) (Vigliocco, Lauer, Damian & Levelt, 2002).

The contrast between mass and count nouns is also manifested in morphological and syntactic structures. Evidence for a primarily lexical-syntactic rather than a semantic mass/count distinction comes from an electrophysiological (EEG) study (Steinhauer, Pancheva, Newman, Gennari & Ullman, 2001) which found a grammatically related frontal negativity effect during reading of grammatical and semantically plausible sentences with mass/count nouns. The grammatical mass/count effect was unrelated to posterior semantic effects (N400) which were found in semantically implausible sentences. One major difference between mass and count nouns is evident from the category name ‘countability’: count nouns can be counted and therefore combined with numerals (e.g., two chairs, twenty books), while mass nouns cannot. Countability also implies that count nouns can be pluralised, which is mostly marked morphologically (e.g., chair vs. chairs). The count/mass status of a noun can also determine the form of a noun phrase. Count nouns can take an indefinite determiner (e.g., a chair) and singular and plural specific quantifiers that denumerate (e.g., another, each, many, few). Whereas mass nouns can only take definite determiners (e.g., the milk vs. *a milk) and quantifiers that do not denumerate (e.g., much milk vs. *many milk). Mass nouns can generally not be counted and hence are not combined with a numeral nor morphologically marked for plural (e.g., *two rice, milks) (Gillon, Kehayia & Taler, 1999; Semenza, Mondini & Cappelletti, 1997; Taler & Jarema, 2007; Wisniewski et al., 2003). Finally, the count/mass status of the subject in a sentence can determine the verb form. In order to form subject/verb agreement, in some languages (e.g., German, French) the verb has to be conjugated for plural or third person morphology depending on whether the subject is a plural count or a mass noun (e.g., Der Reis koch**t**. (The rice cooks.) vs. Die Kartoffeln koch**en**. (The potatoes cook.)).

English is one of the many languages which marks the countability of nouns morphologically, syntactically or both. Plural nouns are marked morphologically by the plural suffix *-s* which indicates clearly countability. Uninflected bare[5] nouns are

[5] The term ‘bare nouns’ is used in this paper to describe nouns which appear in isolation (e.g., water) instead of as part of a noun phrase with a determiner and/or adjective (e.g., the water, cold water).

ambiguous in terms of countability. For this reason the countability of nouns is marked syntactically within a noun phrase by a denumerator. Allan (1980) defined a denumerator as a quantifier which identifies one or more discrete entities and can be substituted for a natural number (e.g., one, two, no, all) within any noun phrase without changing the grammaticality of the noun phrase. The noun ‘chair’, for example, a count noun, can be combined with the denumerator ‘a’ in a phrase such as ‘a chair’. ‘A’ is a denumerator because it can be substituted for the number ‘one’ (one chair). The noun ‘honey’, however, is not countable, and cannot be combined with a denumerator (*a honey, *one honey). Allan considered mass nouns as morphologically and syntactically unmarked compared to count nouns due to the absence of denumerators or often of any determiner, in English.

In the next section, we will discuss in how far the different syntactic and morphological characteristics of mass and count nouns have been considered and explained in theories of language processing.

Representation of Countability in Psycholinguistic Theories of Language Comprehension and Production

If the distinction between mass and count nouns is primarily syntactic, then the question emerges whether, for nouns, countability information is stored as a lexical-syntactic attribute, such as [count] and/or [mass] or whether the mass/count status of a noun is computed on the basis of the noun’s semantic, morphological and phonological characteristics each time a noun is perceived or produced. There has been remarkably little attention paid in the literature to this question, with only three explicit discussions, namely Taler and Jarema (2006), Barner and Snedeker (2005, 2006) and Levelt (1989). We will discuss these in turn. However, as questions regarding the representation and processing of mass and count nouns are similar to those concerning grammatical gender (e.g., masculine, feminine; see Schriefers & Jescheniak, 1999), we will refer to theories that discuss representation of grammatical gender where relevant.

Taler and Jarema (2006) argue that mass nouns, count nouns and dual nouns (nouns that can be both mass and count) are represented differently in the mental lexicon. According to their theory, nouns possess a node [countability] ([C]; see Figure 1). Noun categories differ in the specification of the [C] node. For mass nouns, the [C] node is further specified as mass [M], while count nouns only possess a bare [C] node. The bare [C] node is seen as the minimal structure which is necessary for nouns to form a valid representation. This account diverges from that of Allan (1980) who regarded mass nouns as the basic unmarked form.

Taler and Jarema (2006) suggest further that dual nouns contrast with mass and count nouns by having no [C] node. To become valid, dual nouns require specification at the surface level, depending on the context, by means of a rule which Taler and Jarema (2006) named *countability by context* (CBC). Dual nouns can become specified by the determiner (e.g., a, much, many). Determiners also have countability nodes and the determiner is able to spread its countability node [C] to a dual noun representation. Dual nouns can be recognised as mass or count nouns through inheriting the countability attribute of the determiner (see Figure 2).

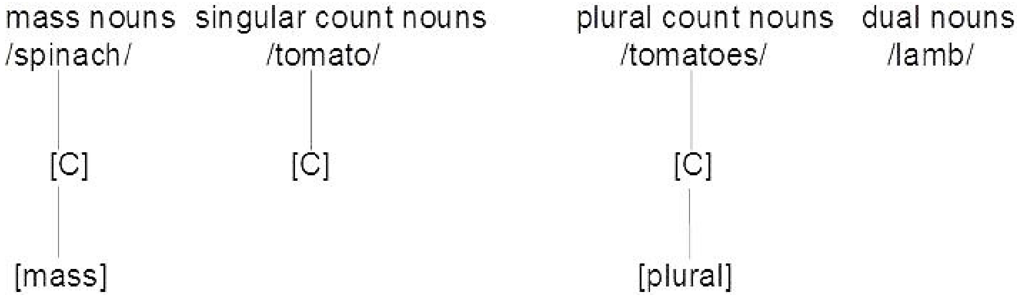

Figure 1. Lexical representation of mass, count and dual nouns adapted from Taler & Jarema (2006, Figure 4, page 49).

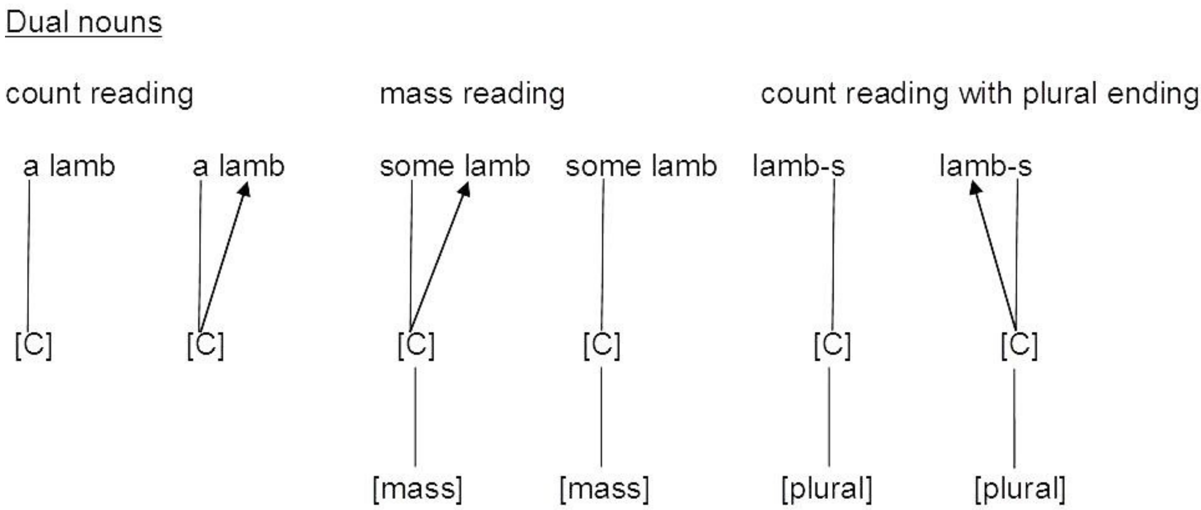

Figure 2. Application of the lexical rule ‘countability by context’ adapted from Taler & Jarema (2006, Figure 5, page, 50). Representation of the lexical-syntactic specification of dual nouns for countability by determiners or affixes during bare noun/noun phrase processing. The lexical-syntactic information [C] (count) or [mass] of the determiners ‘a’/‘some’ and the plural affix ‘–s’ spreads automatically to the dual noun ‘lamb’ (to be read from left-to-right). The application of the lexical rule on dual nouns in a grammatical context is regarded as an automatic and mandatory process (Taler & Jarema, 2006).

Barner and Snedeker (2005, 2006) proposed a theory which contrasts with that of Taler and Jarema. Although they also propose that mass and count nouns differ in a single lexical-syntactic attribute, for Barner and Snedeker, *count nouns* are specified for countability whereas mass nouns and dual nouns lack any lexical-syntactic specification. The count specification 'licences' count nouns to be conceptual-semantically specified as individuated (individual) entities. The lack of lexical-syntactic specification for mass and dual nouns leads to more flexibility and allows both noun groups to individuate depending on the syntactic context. For example, if a mass or dual noun is preceded by a determiner or quantifier which is specified lexical-syntactically for being count (e.g., a, many), the lexical-syntactic specification can lead to a count reading of dual nouns and to a conceptual-semantic interpretation of mass and dual nouns as individuated entities (e.g., a water, many ironies; see Figure 3).

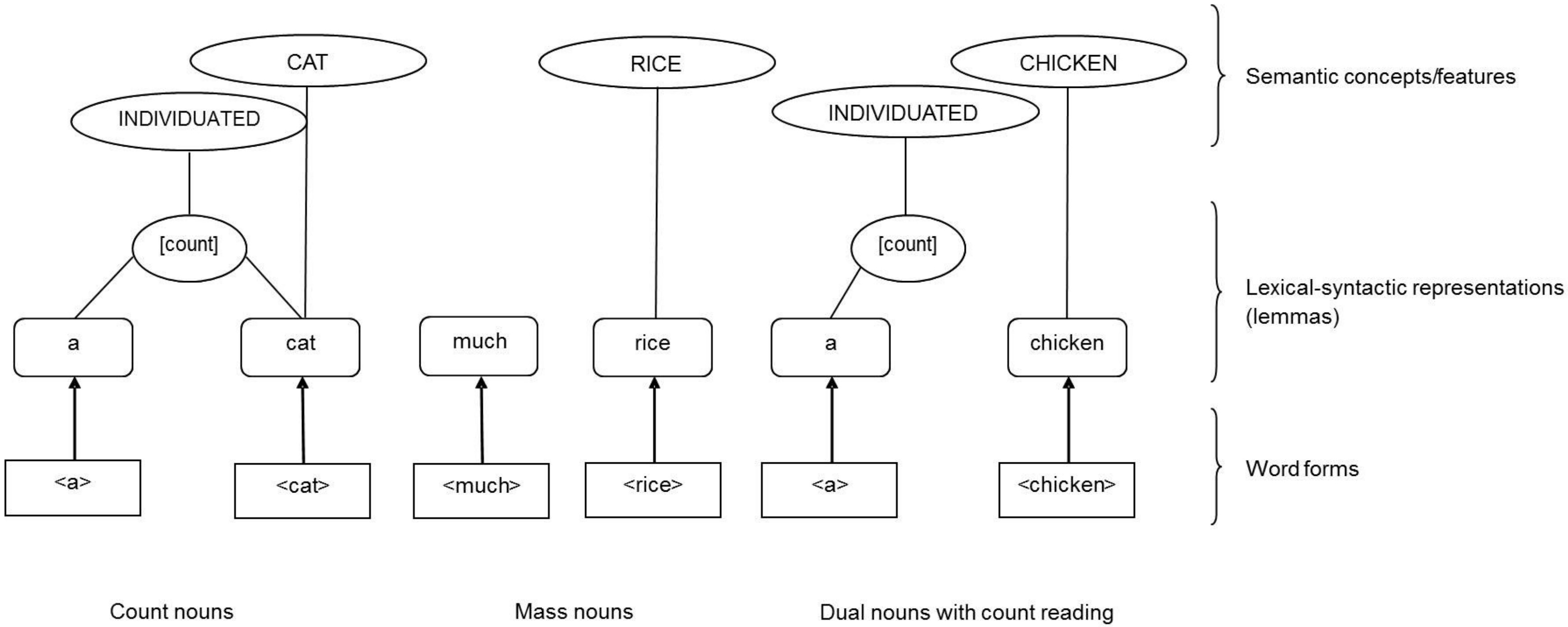

Figure 3. Lexical representation of count, mass and dual nouns with count reading adapted from Barner and Snedeker (2005, 2006). The mass-count distinction is based on the single lexical-syntactic attribute [+ individual]. Count nouns and their syntactic context (e.g., count noun determiners: a, many) activate the lexical-syntactic attribute [+ individual] which allows the semantic and/or conceptual specification for 'individuated'. To adapt Barner and Snedeker's theory to other theories (Levelt et al.1999; Taler & Jarema, 2006), we use the term [count] for the attribute [+ individual]. Mass nouns and dual nouns as well as their syntactic context (e.g., mass noun determiners: much) lack the lexical-syntactic attribute [count]. Being unspecified for countability and individuation, mass nouns and dual nouns can inherit the lexical-syntactic and semantic specification of the syntactic context (e.g., the count noun determiner 'a' assigns its [count] specification to the dual noun 'chicken' and leads to a count reading of and a semantic interpretation of 'chicken' as individuated entity).

While Taler and Jarema (2006) and Barner and Snedeker (2005, 2006) are among the few to have proposed potential theories of the representation of mass and count nouns, their accounts remain underspecified and are not embedded into a larger psycholinguistic theory. Hence, they are neither specified for how processing occurs (e.g., does every noun possess its own [mass] and/or [count] attribute or do all nouns share the same [mass] and/or [count] attribute node) nor at which level of processing the attribute nodes [mass] and/or [count] are represented. Therefore, we will first outline a more complete psycholinguistic theory (Levelt, Roelofs & Meyer, 1999) and then consider whether Taler and Jarema and Barner and Snedeker's accounts of countability could be integrated into such a theory. It is possible that such an integrated theory might be able to interpret results from experiments with mass and count nouns in language perception and production in a clearer and more transparent manner.

Levelt et al. (1999) developed an influential theory of spoken word production. Although this theory does not explicitly mention countability, it is one of the few theories which makes clear assumptions about the representation and processing of lexical-syntactic attributes. We will first introduce the general organisation and processing of the current version of this theory (Levelt et al., 1999). Following this, we will describe the lexical-syntactic representation of countability in Levelt's (1989) earlier version of this theory and employ this, together with the current assumption about the representation of grammatical gender (Levelt et al., 1999) to generate an expanded theory which includes the lexical-syntactic attribute countability. Finally, Levelt et al.'s (1999) theory of language production will be extended to incorporate processing of lexical-syntactic attributes in word comprehension.

Levelt et al.'s (1999) theory incorporates five levels of linguistic processing: a level of lexical concepts[6], a lexical-syntactic (lemma) level, a word form level, a phonetic level and an articulatory level. The production of a meaningful word implies the activation of a concept. Concepts and the relationships among them are represented in the form of nodes and the connections between the nodes. For example, the notion of *hammer* is represented by the node HAMMER and its meaning is represented by the network of links to other conceptual-semantic nodes, such as an *is-a* link to the node TOOL or a *function* link to NAIL (see Figure 4). Conceptual-semantic nodes are also linked to other semantically related nodes in the network which receive excitation through spreading activation, for example TOOL will activate SAW and SCREWDRIVER, which are semantically related to HAMMER but not directly linked. Each conceptual-semantic node is connected with one lemma node and spreads activation to it. The highest activated lemma is selected.

[6] Levelt et al. (1999) refer to this level as lexical-conceptual level. We prefer the term conceptual-semantic level (and semantic concepts) as it indicates more directly its function as semantic memory.

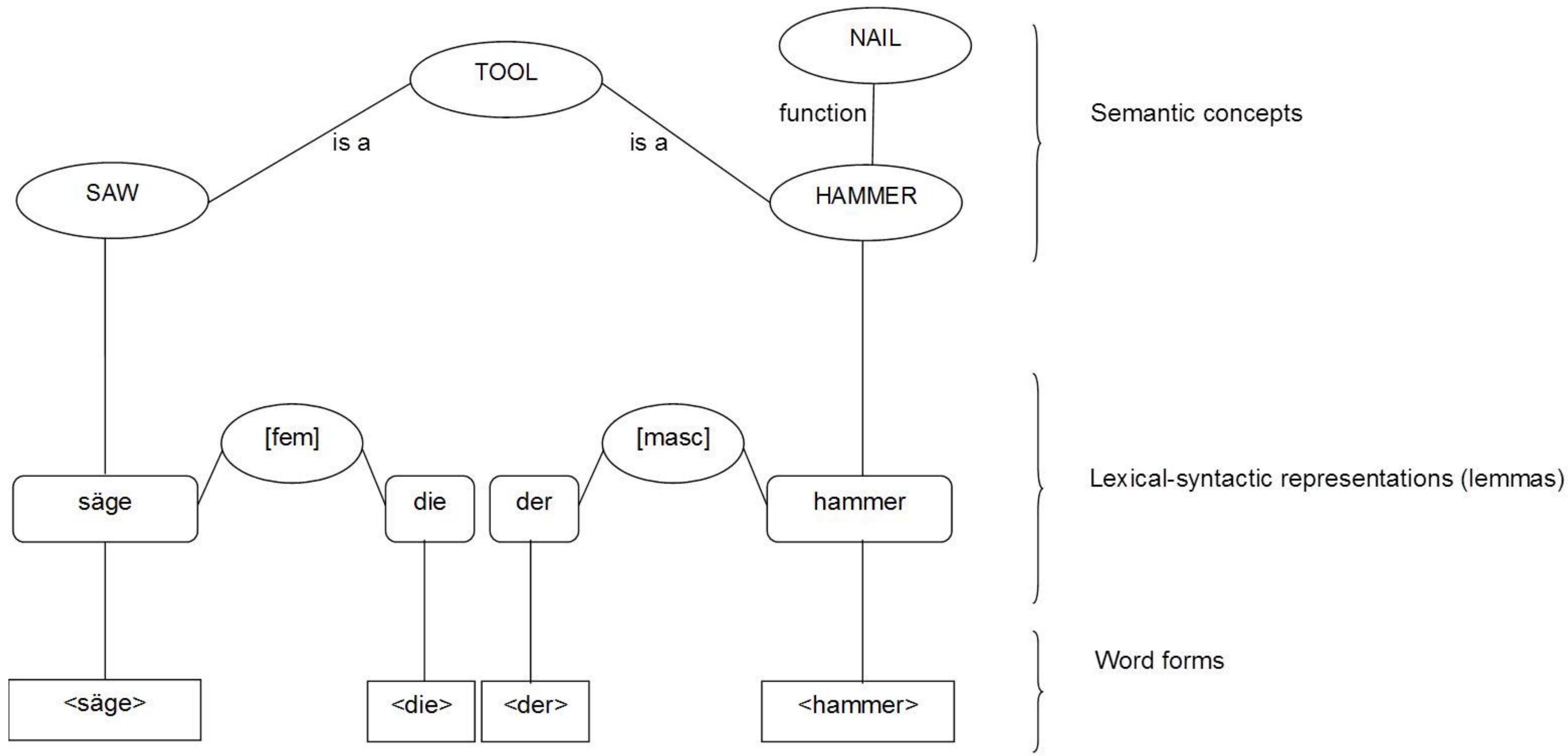

Figure 4. Illustration of the different representations of the German nouns 'Hammer' (hammer) and 'Säge' (saw) at each level in Levelt et al.'s (1999) theory. For the sake of clarity not all links are shown.

Lemma nodes are *empty nodes,* which mediate between conceptual-semantic, lexical-syntactic and phonological information. Each lemma node is linked to lexical-syntactic attributes. Levelt et al. (1999) distinguish between two kinds of lexical-syntactic attributes: lexical-syntactic properties and lexical-syntactic features. Lexical-syntactic properties are fixed intrinsic attributes of a lemma (e.g., grammatical gender[7]). Lexical-syntactic features are variable extrinsic attributes which are set depending on the context or intention of the speaker (e.g., number: singular vs. plural). For clarity from here on, we will use the more explicit terms: ‘fixed intrinsic lexical-syntactic properties’ to refer to lexical-syntactic properties, ‘variable extrinsic lexical-syntactic features’ to refer to lexical-syntactic features, We will use the term ‘lexical-syntactic attributes’ to refer to both features and properties. All lemmas with a given lexical-syntactic attribute are connected to the same abstract node which marks this attribute (e.g., there is a single node for the grammatical gender [masculine]) (Schriefers & Jescheniak, 1999). The lexical-syntactic nodes (e.g., [masculine],) are in turn connected to grammatically congruent lemma nodes, such as determiners and quantifiers (e.g., the German determiner ‘$\text{der}_{\text{masculine}}$’). Consequently, the selection of a lexical-syntactic attribute affects grammatical encoding: the selection of the correct determiner, the correct inflectional suffix for the adjective or quantifier, and the form of agreement within a phrase. For example, a selected fixed intrinsic lexical-syntactic property influences the agreement of constituents in a noun phrase. In German, the grammatical

[7] Even though grammatical gender is a grammatically derived and hence a fixed lexical-syntactic property, in some cases its selection can be influenced by conceptual-semantic information. For example, Schiller, Muente, Horemans & Jansma (2003) found that participants made faster gender decisions for words which have biological sex (e.g., die_{fem} Frau_{fem} – the woman) and are congruent regarding their grammatical and biological gender compared to words with no biological sex (e.g., der_{masc} $\text{Tisch}_{\text{masc}}$ – the table) (see also Nickels, Biedermann, Fieder & Schiller, submitted).

gender of a noun influences the choice of determiner (e.g. '**der**$_{\mathbf{masc}}$ neue Hammer$_{\mathbf{masc}}$' (the new hammer)). If a noun phrase does not contain a definite determiner, gender can be marked by the suffix of the adjective (e.g. 'neue**r**$_{\mathbf{masc}}$ Hammer$_{\mathbf{masc}}$' (new hammer) or 'ein$_{masc/neuter}$ neue**r**$_{\mathbf{masc}}$ Hammer$_{masc}$' (a new hammer)). Even though lexical-syntactic attributes are always activated when bare nouns, noun phrases or sentences are processed, they are only selected if they are grammatically required, such as for the selection of grammatically congruent determiners (see also Schriefers, Jescheniak & Hantsch, 2002).

Fixed intrinsic lexical-syntactic properties, such as grammatical gender are selected through activation from the noun lemma, which flows unidirectionally to the property node and further to grammatically congruent lemma nodes (e.g. determiners). In contrast, variable extrinsic lexical-syntactic features, such as number are predominantly, or even exclusively, activated and selected via semantic concepts/features in language production. For example, the lexical-syntactic feature [plural] is activated via the semantic concept/feature MULTIPLE. We will address below whether countability might be considered as a fixed intrinsic lexical-syntactic property.

The selection of a lemma is the first stage of lexicalization. It is followed by the retrieval of the appropriate word form at the word form level (see Figure 4). One of the fundamental assumptions of the theory is *seriality*: only the selected lemma is able to send activation to a single word form. Hence, no competition takes place at the word form level[8] (Levelt, 1993). Through activation of the word form node, three kinds of information become available: the morphological structure, the metrical shape (number of syllables and their stress) and the

[8] In rare cases two lemma nodes can be activated to an equal level leading to selection of both lemmas and activation of both their word forms (Roelofs, 1992a; Levelt et al., 1999).

segmental structure (phonemes). After the selection of the phonological word form, the phonemes are inserted in the metrical structure. Then the surface phonetic shape of the phonological representation is specified at the phonetic level. The way phonetic encoding is carried out depends on the frequency of the syllables of the target word. Gestural scores for articulatory movements for syllables of high frequency are retrieved from the syllabary. Gestural scores for low-frequency syllables are assembled. Finally, the articulation of the word is initiated and executed (Levelt et al., 1999).

How can countability be represented at the lexical-syntactic level within Levelt et al.'s (1999) theory? While Levelt et al. (1999) do not address this explicitly, Levelt (1989) described the differences between mass and count nouns briefly in his previous version of the theory. In addition, we can deduce further assumptions from the representation of other lexical-syntactic attributes, like grammatical gender, which Levelt et al. (1999) have explicitly addressed.

Unlike Taler et al. (2006) and Barner and Snedeker (2005, 2006), Levelt (1989) did not propose countability specific attributes, such as [mass] and/or [count] to distinguish between mass and count nouns. Instead, he postulated that the underlying difference lies in the number feature(s) to which a noun is connected. Count nouns, which can occur as singular and plural, are connected to the variable extrinsic lexical-syntactic features [singular] and [plural]. Mass nouns however, are linked to the single, and therefore fixed, lexical-syntactic attribute [singular][9] (see Figure 5).

[9] Although it is possible that the singular nodes for mass and count nouns are different nodes, this seems unlikely given the general assumption of Levelt et al.'s (1999) theory.

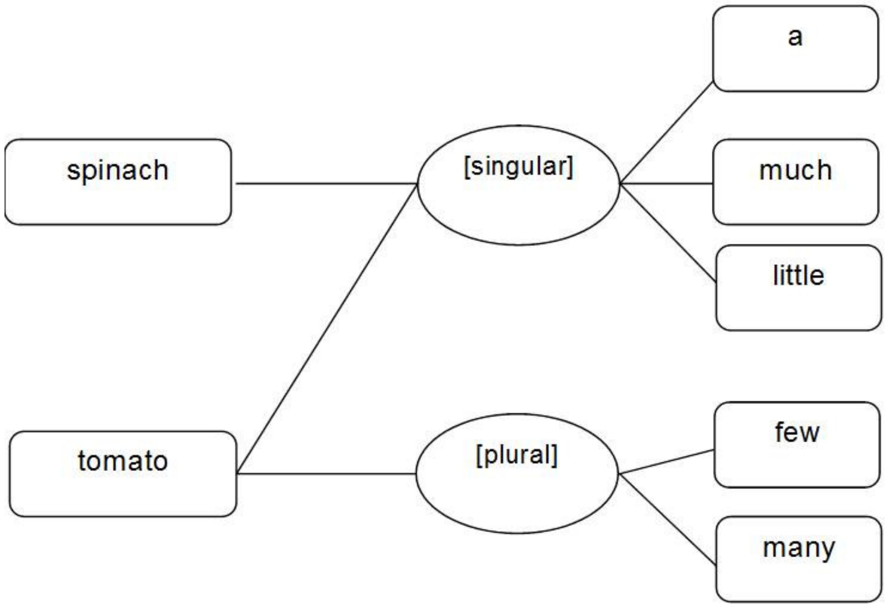

Figure 5. Representation of mass nouns (e.g.,spinach) and count nouns (e.g.,tomato) at the lexical-syntactic (lemma) level according to Levelt (1989).

However, Levelt did not consider that mass nouns can require different determiners and quantifiers to singular count nouns (e.g., much, little, some vs. a, one), a fact which cannot be explained by countability being represented via number attributes: both mass and count nouns would be connected to the same lexical-syntactic node [singular]. Although this lexical-syntactic node can be either fixed (for mass nouns) or variable (for count nouns), it cannot differ in the connections to the grammatically congruent determiner/quantifier lemma nodes. Consequently, the abstract node [singular] would be connected to determiner lemma nodes for singular count nouns (e.g., the, a) as well as with determiner lemma nodes for mass nouns (e.g., much, some, enough) which may also be associated with a plural meaning. Levelt's (1989) proposal of countability representation could theoretically lead to the selection of countability/number incongruent determiners for mass and singular count nouns (e.g., 'a' for mass nouns, 'much' for singular count nouns) and hence to the production of countability incongruent noun phrases and sentences (e.g., *a rice, *much car). This, however, is inconsistent with speech error data which shows that substitution errors of language unimpaired speakers are generally lexical-syntactically congruent with the target word (e.g., Berg 1992, Del Viso, Igoa & Garcia-Albea, 1987). In sum, Levelt's (1989) proposal for the lexical-syntactic specification of mass and count nouns seems to be insufficient. We propose therefore an account which is based on the representation of the fixed intrinsic lexical-syntactic property gender in the more recent version of this theory (Levelt et al. 1999).

The lack of conceptual-semantic transparency between mass and count nouns within and across languages makes it unlikely that countability is represented in the form of extrinsic variable lexical-syntactic features like number. Instead, it seems more plausible that nouns are specified for countability in the form of fixed intrinsic lexical-syntactic properties similar to grammatical gender (supported by data from Steinhauer et al.'s (2001) study). Assuming that nouns are specified through fixed intrinsic lexical-syntactic [mass] and/or [count] properties, three forms of representation are possible. Mass and count nouns could be equally well specified with count noun lemmas being linked to a [count] property node and mass noun lemmas being linked to an independent [mass] property node at the lexical-syntactic (lemma) level (similar to the assumption for the representation of grammatical gender, see Figure 6a). Another theory is that of Taler and Jarema (2006), discussed above. According to their theory both count nouns and mass nouns are linked to a countability property ([C]) which can be regarded as the unmarked or default property (see Figure 6b). Mass nouns are further specified through a mass property - a marked property (see also Mondini, Kehayia, Gillon, Arcara, & Jarema, 2009, below). Alternatively, as described earlier in Barner and Snedeker's (2005, 2006) theory the specification of countability for count nouns could be implemented in the form of a [count] property at the lexical-syntactic level. The [count] property could be linked to a semantic feature INDIVIDUATED at the conceptual-semantic level. Mass nouns and dual nouns would remain syntactically unspecified for countability and semantically unspecified for individuation (see Figure 6c).

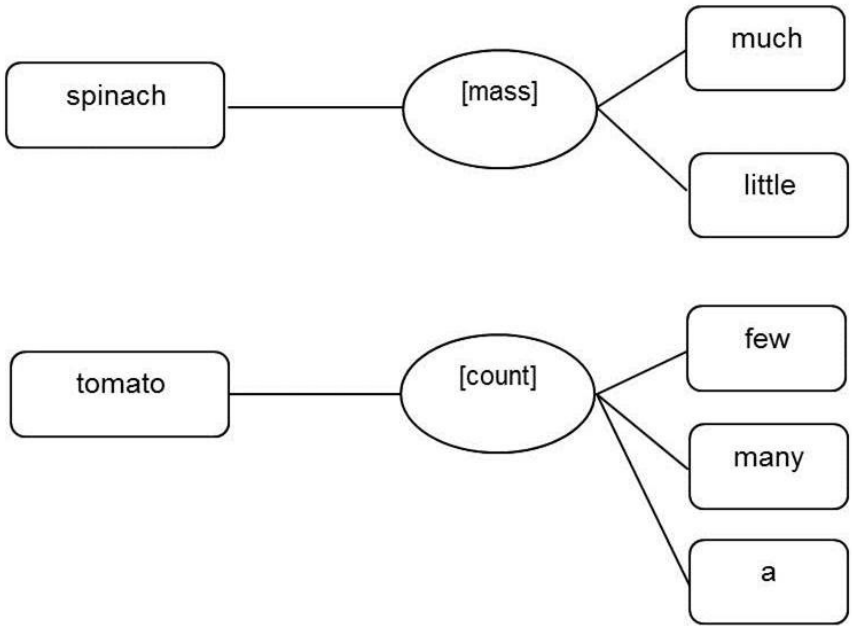

Figure 6a. Representation of mass nouns (e.g., spinach) and count nouns (e.g., tomato) at the lexical-syntactic (lemma) level derived from assumptions about the representation of the fixed intrinsic lexical-syntactic property gender in Jescheniak and Levelt (1994) and Levelt et al. (1999).

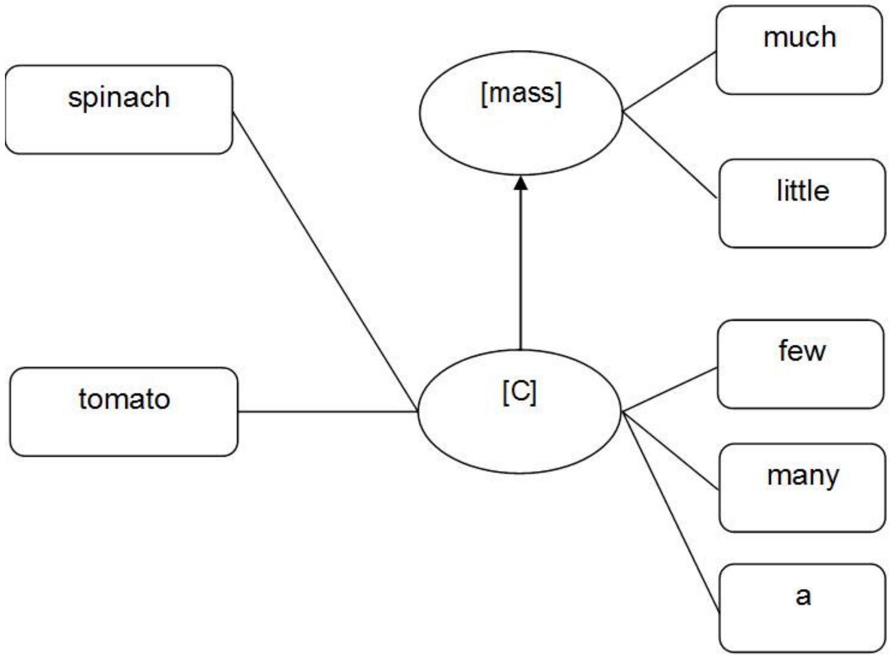

Figure 6b. Representation of mass nouns (e.g., spinach) and count nouns (e.g., tomato) at the lexical-syntactic (lemma) level derived from Taler and Jarema's assumption (2006).

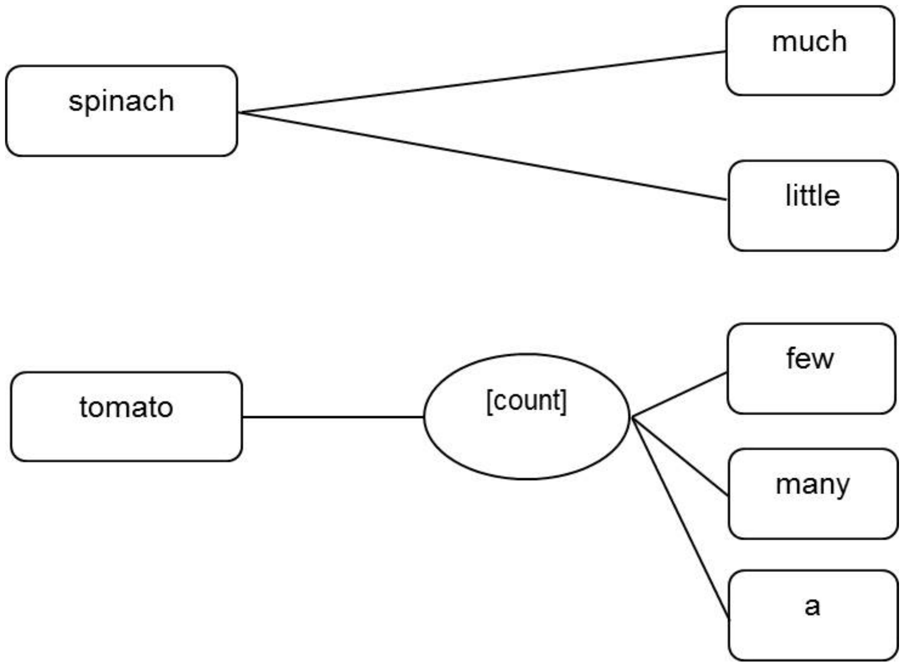

Figure 6c. Representation of mass nouns (e.g., spinach) and count nouns (e.g., tomato) at the lemma level derived from Barner and Snedeker's assumption (2005, 2006).

Like grammatical gender, the countability of a noun can be regarded as a fixed intrinsic lexical-syntactic property which means it is predetermined for each noun lemma and cannot be influenced by context. In all three accounts above, an activated and selected noun lemma would spread activation to its [mass]/[count] property. Like other fixed intrinsic lexical-syntactic properties in Levelt et al.'s (1999) theory, [mass]/[count] properties would only become selected if they are required for grammatical computation, for instance to select a countability congruent determiner/quantifier (e.g., 'much' for mass nouns vs. 'many' for count nouns, see Figure 7) but not for the production of bare nouns (see also Roelofs, 1992a, 1993; Schriefers & Jescheniak, 1999). However, Levelt et al. do not specify the precise mechanism by which a lemma 'knows' whether or not grammatical information should be selected dependent on the context. Presumably there must be, minimally, an interaction with the sentence level. It is also possible that quantifiers, like 'much' or 'many', have additional semantic feature/concept representations, such as PLENTY and ATOMIC/INDIVIDUATED or NONATOMIC/UNINDIVIDUATED. The target determiner lemma node could be selected through activation of the lexical-syntactic property [mass]/[count] and the conceptual-semantic representation.

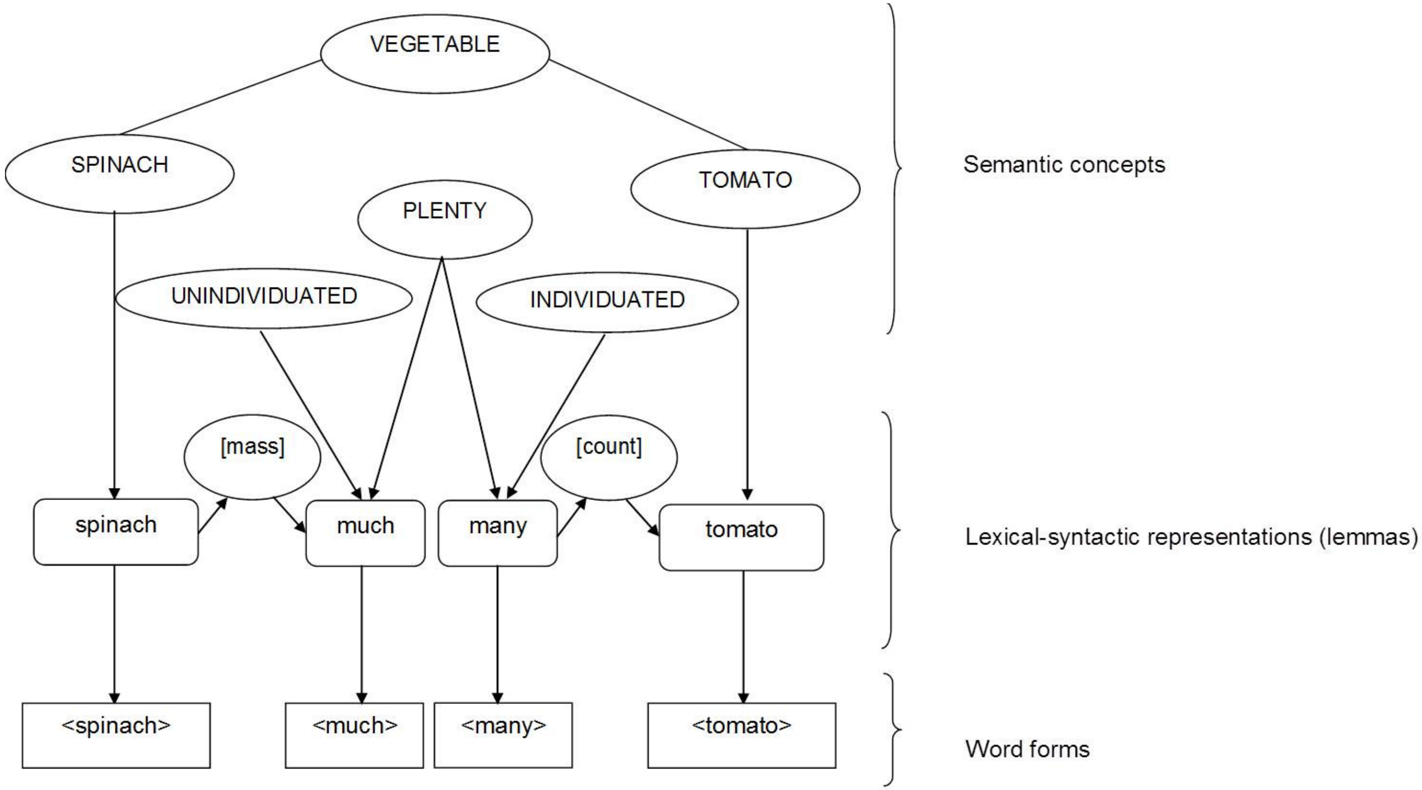

Figure 7. Illustration of the processing and representation of mass nouns (e.g., spinach) and count nouns (e.g., tomato) in a theory of language production derived from Levelt et al.'s (1999) theory, assuming separate count and mass properties at the lexical-syntactic (lemma) level, and the semantic concepts/features INDIVIDUATED for count nouns and UNINDIVIDUATED for mass nouns at the conceptual-semantic level.

We noted in the section above that some nouns are 'dual' nouns with both mass and count interpretations (e.g. lamb, fish). While we primarily concentrate on those nouns which are not dual nouns, we will briefly consider how these dual nouns might be represented. Probably the most straightforward account is that these nouns are a special case of homophones - they have the same word form but different meanings, and different lexical-syntactic properties (i.e. [mass] vs. [count]). This account, unlike that of Taler and Jarema (2006) avoids the need to suggest a different lexical-syntactic representation for dual nouns to other (non-dual) nouns.

Having extended Levelt et al.'s (1999) theory of language production to countability, the question remains regarding how mass and count nouns might be represented and processed in language comprehension? Levelt et al.'s (1999) theory of spoken word production was developed further by Roelofs (2003b) who described word comprehension and its relationship to spoken word planning within Levelt et al.'s (1999) theory. The comprehensive description of the lexical-syntactic (lemma) level makes Levelt et al.'s theory attractive for an extension to the process of language comprehension. Such an extended theory is required in order to be able to account for effects of countability in, for example, lexical decision. Two levels of the word production model can be directly assigned to a model for word comprehension: the conceptual-semantic and the lexical-syntactic (lemma) level. Levelt and colleagues (1999) regarded both levels as modality-neutral and therefore accessible for language production and comprehension. Hence, the conceptual-semantic and/or lexical-syntactic representation of mass and count nouns within the model of word production can be incorporated into the model of word comprehension (see Figure 8). In order to comprehend a noun, auditory or written input could be either, first analysed and parsed regarding its morphemes (Taft & Forster, 1975), processed as full complex form (Butterworth, 1983) or both (e.g., Schreuder & Baayen, 1995; Caramazza, Laudanna & Romani, 1988) depending on the theory. The input (full form or morphemes) activates the corresponding input representation(s) at the word form level. Roelofs (2003b) assumed that subsequent to the selection of the perceived word form, activation spreads from the word form to the target lemma node as well as to the output word form[10]. The lemma node forwards activation to its lexical-syntactic attributes and the associated semantic concept. While in language production lexical-syntactic attributes become only selected if they are grammatically required, it is unclear what this might mean for language comprehension. To produce a noun phrase or sentence, the appropriate quantifier/determiner (e.g., many or much) has to be activated through the lexical-syntactic [mass]/[count] property. However, in language comprehension quantifier/determiner lemmas are directly activated through their word forms and could subsequently send activation to their corresponding semantic concepts (PLENTY; see Figure 7, earlier). Hence, unlike for sentence production, it is questionable whether the activation of lexical-syntactic [mass]/[count] properties is required for sentence comprehension. It seems superfluous for [mass]/[count] properties to be selected for the comprehension of bare nouns, where the features are not needed to control agreement like in noun phrases (not much rice vs. *not many rice).

[10] With this assumption Roelofs (2003b) accounted for interference and facilitation effects in picture naming from auditorily presented words in picture-word-interference tasks.

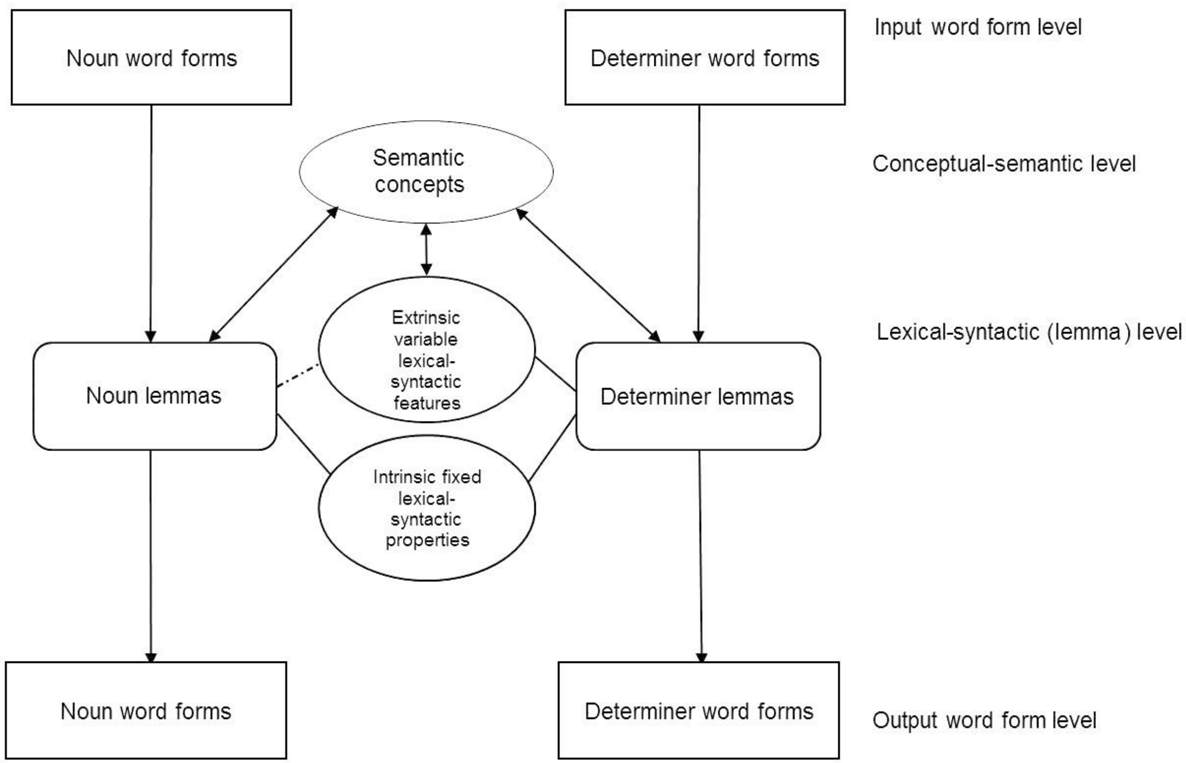

Figure 8. General illustration of the different levels involved in language processing and production of noun phrases derived from Levelt et al.‘s (1999) theory. Extrinsic variable lexical-syntactic features are activated exclusively or at least predominantly through semantic features/concepts hence the dotted link between noun lemma and features.

In sum, we have extended Levelt et al.'s (1999) theory of language production to include language comprehension processes and a specification of the representation of countability at the lexical-syntactic (lemma) level. However, there remain three potential variants of this extended theory. The first includes both mass and count properties, we will refer to this as the *Count And Mass Marked hypothesis* (see Figure 6a, earlier). The second variant of the theory has only mass nouns marked for countability, with count nouns unmarked, we will refer to this as the *Count Unspecified Mass Marked hypothesis* (see Figure 6b, earlier). The third variant of the theory has only count nouns marked for countability, with mass nouns unmarked, we will refer to this as the *Mass unspecified Count Marked hypothesis* (see Figure 6c, earlier).

To develop, test and extend theories and distinguish between competing theories, researchers rely on experimental data. In the next section we will give an overview of experimental studies which have investigated processing of mass and count nouns in language production and comprehension. Following this, we will discuss the interpretation of these results within the different theoretical accounts.

First, we will introduce language production studies (Biedermann, Ruh, Nickels & Coltheart, 2008; Vigliocco et al., 1999) which assessed whether lexical-syntactic information like countability can be accessed during a Tip-of-the-Tongue state, when a person has access to the semantics of a word but cannot retrieve the word form itself. Subsequently, we will discuss studies which investigated processing of mass and count nouns in language comprehension (e.g., Gillon, et al., 1999; Taler & Jarema, 2007; Mondini et al., 2009). Experimental investigations of mass and count nouns have also been carried out with individuals with language impairments (e.g., Herbert & Best, 2010; Semenza et al., 1997). In the last section, we will present these case studies which demonstrate selective impairments of mass nouns.

Investigations of Mass and Count Nouns in Language Production:

Availability of Mass/count Information in Tip-of-the-Tongue State

Vigliocco et al. (1999) examined the availability of mass and count information during a Tip-of-the-Tongue (TOT) state. The TOT state is a common phenomenon which is experienced by speakers of any language. Speakers in a TOT state feel that they know the target word without being able to retrieve and produce the word form at that particular moment. Nevertheless, they might be able to retrieve pieces of phonological and/or grammatical information (e.g., initial phoneme, the number of syllables, the grammatical gender of a noun). While TOTs occur spontaneously, they can also be induced experimentally by giving a person a definition or picture of a low-frequency word. In Vigliocco et al.'s (1999) experiment, native English speakers were tested using mass and count nouns of low frequency. The participants were asked to name a noun when provided with a definition which was read aloud by the examiner. When participants could not produce the target, they were asked to answer a questionnaire, composed of three different sections. In the first section, participants were asked to choose the correct context for the word: There is __/There is a __.; There won't be much__/There won't be many__.; There is some__/There are a few__. These questions probed the availability of lexical-syntactic information regarding mass/count status. In the second part, the participants' task was to guess the number of syllables in the word. In the final step, they were required to guess any letters or sounds and their positions within the word. The questions in sections two and three probed the accessibility of metrical and segmental information independent of the retrieval of the word form. The examiner then provided the participants with the target. The response was scored as a positive TOT state if the target word matched the word which the participant had in mind and as negative TOT state (i.e. not in a TOT state) if both words did not match.

The comparison of positive TOT states and negative TOT states revealed that lexical-syntactic information was significantly more accessible when participants were in a (positive) TOT state than when they were not. Vigliocco et al. concluded that lexical-syntactic attributes (i.e. countability) can be retrieved independently of the word form. Further, Tests of independence showed no correlation between the retrieval of phonological and lexical-syntactic information. Based on these results, Vigliocco et al. concluded that word form retrieval is independent from lexical-syntactic information. The results were replicated by Biedermann, et al. (2008) for English and extended to German.

In summary, results of both TOT studies give evidence for a lexical-syntactic representation of countability information. Moreover, failure to access lexical-syntactic mass/count information even with semantic access (assured through provision of definitions), supports the argument that the mass/count status of words cannot be fully derived from their semantics. Hence, the results support the proposal that in Levelt et al.'s (1999) theory countability is represented in the form of fixed intrinsic lexical-syntactic properties at the lexical-syntactic (lemma) level. Moreover, these experiments show that countability information at the lexical-syntactic level is separate from conceptual-semantic and from phonological information. However, the fact that independent access of phonological information from lexical-syntactic information was found requires the possibility that (at least partial) word form access can be achieved without selection of lexical-syntactic attributes (Biedermann et al., 2008; Schriefers et al., 2002). The results from the two TOT studies do not allow us to draw further conclusions about lexical-syntactic markedness and therefore to distinguish between the three hypotheses discussed earlier.

Investigations of Mass and Count Nouns in Language Perception/Comprehension

Gillon et al. (1999) used two visual lexical decision tasks to examine the influence of the lexical-syntactic attributes [mass] and [plural] on reaction times for word recognition. In their first experiment, native speakers of English were tested with a set of stimuli which consisted of mass, count and dual nouns. The nouns were divided further into subgroups including: nonatomic mass nouns (e.g., water), atomic mass nouns (e.g., furniture), dual nouns (nouns that can be both mass and count, e.g., rope) and regular count nouns (e.g. table)[11]. The results showed that mass nouns produced significantly longer reaction times than count nouns. Gillon et al. accounted for this difference by suggesting there was an increase of processing load through the additional attribute [mass] which is only accessed for mass nouns. Although they did not specify how mass and count nouns are represented, Gillon et al.'s account is consistent with that of Taler and Jarema (1996; see Figure 1, earlier).

Gillon et al. (1999) investigated mass and count nouns further in a second experiment which involved lexical decision with morphosyntactic priming. The test material comprised grammatical and ungrammatical prime-target combinations

[11] Gillon et al. did not specify whether their stimuli were matched for lexical and semantic variables.

which consisted of a determiner or adjective and a mass or count stimulus (e.g., grammatical prime: ‘much$_{mass}$’, ungrammatical prime: ‘*many$_{count}$’, target for lexical decision: MUD$_{mass}$). The primes were presented prior to the target. As in the simple lexical decision task, the results for the grammatical condition revealed a significant difference in the reaction times between mass and count nouns, with mass nouns (atomic and nonatomic) being slower than count nouns. However, there was also an interaction with condition: atomic mass nouns showed shorter reaction times in the ungrammatical condition than in the grammatical condition whereas the opposite pattern was found for count nouns and nonatomic mass nouns which showed shorter reaction times in the grammatical condition than in ungrammatical combinations. The longer reaction times for count nouns and nonatomic mass nouns in the ungrammatical condition were accounted for by a mismatch between the attributes which are activated by the prime determiner and target noun (e.g., ‘much’ activates the lexical-syntactic attribute [mass] and the target noun activates the count reading). The shorter reaction times for atomic mass nouns in the ungrammatical condition were explained by semantic priming of the semantic feature ATOMIC which is shared by count nouns and count noun determiners but also by atomic mass nouns.

Taler and Jarema (2007) conducted a similar visual lexical decision study (without priming) with (singular and plural) count, mass and dual nouns in English. Half of the nouns of each group had high-frequency stems and the other half had stems of low-frequency. Here we focus on the findings for mass and singular count nouns. As in Gillon et al.’s (1999) study, singular count nouns were responded to faster than mass nouns. This effect was stronger for low-frequency stimuli. Taler and Jarema (2007) argued that their results provided evidence for a distinction in the way mass and count nouns are represented in the lexicon. However, they rejected their earlier theory (Taler & Jarema, 2006) that it is solely the access and computation of the lexical-syntactic attribute [mass] which slows down processing of mass nouns. Taler and Jarema (2007) suggested instead that “the feature [mass] must also comprise semantic information, possibly reflecting the greater cost of activating an unindividuated referent.” (p 28).

Taler and Jarema’s results were replicated by Mondini et al. (2009) with Italian-speaking participants. However, there are also studies involving lexical decision tasks in the context of an event related potential (ERP) experiment which did not find different reaction times for mass and count nouns (Mondini, Angrilli, Bisiacchi, Spironelli, Marinelli & Semenza, 2008; Yagoubi, Mondini, Bisiacchi, Chiarelli, Angrilli & Semenza, 2006). In fact, the ERP results, showed different patterns of early automatic (N150) activation for concrete mass nouns compared to count nouns (Mondini et al., 2008; Yagoubi et al, 2006). Count nouns elicited greater negativity in left occipito-parietal regions whereas the pattern for mass nouns was more widespread and included a greater negativity in left frontal regions. According to Mondini et al. (2008) different patterns of early activation can be accounted for by semantic differences between mass and count nouns. Count nouns represent concrete objects and therefore activate areas responsible for object recognition and categorisation. Mass nouns represent substances/aggregates which are less concrete and therefore more difficult to process than count nouns. Consequently, processing of mass nouns requires the activation of a wider neural network.

Prior to Mondini et al.’s (2008) study, conceptual-semantic processing of concrete mass and count nouns was investigated by Bisiacchi, Mondini, Angrilli, Marinelli & Semenza (2005) in a semantic categorisation task. Subsequent to starting the experiment, participants were instructed about the semantic differences between mass and count nouns. During the task, participants were required to categorise visually presented words into mass and count by button press. The results showed that participants required longer processing times for the categorisation of mass compared to count nouns (reported in Mondini et al., 2008). The ERP results showed further a significant difference in early automatic (N150) activation. Similar to Mondini et al.'s results, activation patterns for mass nouns were more widespread including the right hemisphere. However, in contrast to Mondini et al.'s (2008) results, count nouns showed a strong left anterior instead of posterior activation.

Semantic and lexical-syntactic processing of mass and count nouns (abstract and concrete) was tested by Yagoubi et al. (2006) in semantic categorisation and grammaticality judgement tasks. In the semantic categorisation task, participants were asked to categorise words into abstract and concrete by button press. The results revealed a significant interaction with abstract count nouns requiring longer processing times than any other noun category. In the grammatical task, participants were asked to judge sentences with mass or count noun syntax for grammaticality. Results showed that participants needed significantly longer decision times for grammatically correct sentences with concrete mass nouns compared to the other types of sentences.

In summary, findings of the different lexical decision studies with mass and count nouns are inconsistent. Some studies found longer reaction times for mass nouns (Gillon et al. 1999; Taler & Jarema, 2007; Mondini et al., 2009) while others (Mondini et al., 2008; Yagoubi et al., 2006) found no countability specific effect.

Hence one set of results, longer reaction times for mass nouns, could potentially support Taler & Jarema's theory where only mass nouns are specified for countability by the (marked) attribute [mass] (*Count Unspecified Mass Marked hypothesis*). While the other results, no difference between mass and count, could support an account where both mass and count nouns are equally specified for countability at the lexical-syntactic (lemma) level (*Count And Mass Marked hypothesis*). However, Barner and Snedeker's account, where only count nouns are specified for countability (*Mass unspecified Count Marked hypothesis*) does not appear to be compatible with any of the findings as it would predict longer reaction times for count than for mass nouns.

Results of the lexical decision and semantic categorisation tasks (Bisiacchi et al., 2005; Mondini et al., 2008) found countability specific effects which were interpreted as reflecting a semantic difference between mass and count nouns, where mass nouns represent typically substances or nonatomic entities and count nouns concrete atomic objects. Moreover, concrete (atomic) mass nouns which are semantically more similar to count nouns have been shown to be processed differently to other (nonatomic, abstract) mass nouns (e.g., substances) (Gillon et al., 1999; Yagoubi et al., 2006). Similarly, semantic categorisation of abstract count nouns was more difficult than of mass nouns and concrete count nouns (Yagoubi et al., 2006). This suggests that mass or count nouns with semantic characteristics that are atypical of the category in general (e.g., atomic mass nouns) are harder to process. Taken together, the results suggests that both mass and count nouns are semantically specified for countability and therefore do not support fully Taler and Jarema (2007) or Barner and Snedeker's (2005, 2006) theory where either mass or count nouns, but not both, are semantically specified for UNINDIVIDUATED / INDIVIDUATED. However, it has been shown that the semantic representations of mass nouns can lead to longer processing times compared to count nouns.

Although these theoretical interpretations seem plausible, it is important to remember that most of the studies which showed an influence of countability in bare noun processing were *lexical decision studies*. In Levelt et al.’s (1999) theory, word processing proceeds serially. Hence, for word recognition, semantic or lexical-syntactic information becomes available only after word form information has been retrieved. Levelt et al.’s theory would predict that semantic or lexical-syntactic variables should have little or no effect on tasks, like lexical decision, which are based on word form selection. We will revisit this in the Discussion.

Investigations of Mass and Count Nouns through Case Studies of Individuals with Language Impairments

We now turn to explore individuals with language impairment to investigate the representation of countability. Some individuals with language impairments have been shown to have the same pattern as participants without language impairment. For example, Taler and Jarema (2006) looked at individuals with Alzheimer’s disease and mild cognitive impairments and found no specific deficits in processing of bare mass and count nouns in a lexical decision task. Taler, Jarema and Saumier (2005) and Garrad et al. (2004) found similar results in a study with two individuals with semantic dementia, JH and Oscar. However, there have also been a number of reports of specific impairments in the processing of mass and count nouns which we describe in detail below.

Semenza et al.[12] (1997) reported the case of a 73 year old, Italian speaking woman, FA, who had anomic aphasia and showed difficulties with mass noun grammar. Her performance on mass and count nouns was investigated in seven tasks (i.e., two naming tasks; two semantic tasks; three morphosyntactic tasks). FA did not show a countability specific effect in the first four tasks: naming to definition (e.g., What animal barks?), naming through sentence completion (e.g., That ... is chained because otherwise it would bite.), semantic judgments (judging the acceptability of written sentences; e.g., The dog mews.), semantic association (matching of written words which are semantically associated; e.g., ‘dog’ to either ‘bone’ or ‘flower’). However, she showed an isolated impairment of mass nouns in the last three tasks which focused on lexical-syntax. In the first task, FA was asked to judge the grammaticality of sentences which involved correct or incorrect mass/count noun determiners and quantifiers. (e.g., *There is <u>much</u> desk in this classroom.). In another task she was required to complete sentences by choosing the correct determiner or quantifier (e.g., I would like...water, please. *a, some, *many). In the final task she was asked to form a semantically and syntactically correct sentence with a target noun (count or mass) and a semantically associated noun (e.g., roll/butter). Overall, FA’s errors resulted from either treating mass nouns as count nouns by pluralizing them and choosing count noun determiners and quantifiers, or by substituting and omitting the mass nouns. She showed no

[12] In a second single case study, Semenza et al. (2000) described CN, a 72 year old woman with anomic aphasia who showed a pattern of performance opposite to that of FA. CN’s performance on mass and count nouns was investigated with six of the tasks which were used in Semenza et al.’s (1997) study. The tasks were repeated twice, 2 and 3 months later. CN’s performance in the syntactic and semantic tasks was no different to that of the control group. However, the name retrieval tasks revealed deficits particularly with regard to count nouns. Semenza et al. (2000) proposed an impairment in the lexical retrieval of count noun word forms. However, we do not address this case in detail here as the difference between mass and count conditions was very small and reached significance only when it was summed over three occasions.

consistency in the affected items and in the type of errors she made. Semenza et al. ascribed her deficit to an isolated problem with the grammar of mass nouns due to a loss or inaccessibility of their grammatical rules.

How far does the data from Semenza and colleagues, inform our understanding of the representation of countability? FA had impairments in morphosyntactic tasks that were restricted to mass nouns, and Semenza et al. (1997) ascribed her deficit to a loss or inaccessibility of grammatical rules for mass nouns. In terms of our proposed extension of Levelt et al.'s theory, FA's difficulties can be described as damage to the lexical-syntactic [mass] node at the lemma level (under either the Count And Mass Marked or the Count Unspecified Mass Marked hypothesis). This would affect any task which required selection of the lexical-syntactic property [mass], but would leave processing of count nouns unaffected. FA's ability to name (bare) mass nouns supports Levelt et al.'s assumption that fixed intrinsic lexical-syntactic properties (e.g., grammatical gender, countability) are only selected when they are grammatically required. This assumption also predicts FA's intact performance for mass and count nouns in semantic tasks. Barner and Snedeker's theory (implemented as Mass unspecified Count Marked hypothesis) however, cannot explain a lexical-syntactic deficit restricted to mass nouns since mass nouns remain lexical-syntactically unspecified and hence cannot be selectively impaired at this level.

Another single case who showed an advantage for naming count nouns over mass nouns is reported by Herbert and Best (2010). MH was diagnosed with a non-fluent agrammatic aphasia and severe anomia. Her word reading was impaired due to deep dyslexia. MH's performance on tasks which demanded semantic and phonological processing and visual perception was in normal range.

To investigate MH's processing of mass and count nouns, Herbert and Best conducted four different tests: (a) spoken picture naming of bare mass and count nouns, (b) syntactic judgement of determiner plus noun combinations, (c) repetition and reading aloud of determiner plus mass/count noun combinations, and (d) spoken picture naming with and without syntactic cues. MH showed particular problems in naming pictures of mass nouns compared to count nouns. Results of the cued picture naming task showed that MH's mass noun production improved when syntactic determiner cues were presented ('This is a/an...' for count nouns and 'This is some...' for mass nouns). While naming of count nouns remained the same, the improvement in mass noun naming led to similar naming accuracies between mass and count nouns. In the syntactic judgement task, MH was presented with the picture of a count/mass noun and the two determiners 'a' and 'some' in spoken and written form. She was asked to decide which of the determiners could be combined with the name of the picture. Her results showed a preference for the determiner 'a'/'an' over 'some'. Tests of repetition and reading aloud of noun phrases were conducted to investigate whether the preference was due to a syntactic impairment for mass nouns or a specific deficit of the determiner 'some'. The noun phrases were composed of either the determiner 'a' and a singular count noun or the determiner 'some' and a plural count or a mass noun. Herbert and Best predicted that a deficit restricted to the lexical item 'some', should cause problems in the production of phrases with both mass nouns and plural count nouns. A syntactic deficit for mass nouns however, should lead exclusively to problems in the production of mass noun phrases. The results revealed, once again, significantly better performance for singular count nouns than for mass nouns in reading aloud and repetition. The errors for singular count nouns consisted mainly of omissions and substitutions of the determiner ‘a’ by ‘the’. However, MH tended to omit the determiner ‘some’ for all mass and most of the plural count nouns. Thus, MH’s performance supported a deficit of the determiner ‘some’, rather than a mass noun impairment. MH’s determiner deficit can be accounted for by an impairment of specific determiner lemma nodes (e.g., some, much) and/or the links from these specific determiner lemma nodes to their lexical-syntactic attributes (e.g., [mass], [plural]). As a result of such an impairment, activation which is sent from noun lemma nodes to lexical-syntactic attributes and forwarded to the affected determiner lemma nodes would not be sufficient for the determiner’s selection. The retrieval of the determiners ‘a’ and ‘the’ could have been unimpaired, due to their higher frequency. Overall, MH’s determiner specific deficit can be explained in two of the possible extension of Levelt et al’s theory described above (Count And Mass Marked, the Count Unspecified Mass Marked hypotheses). However, in addition to her determiner problems in noun phrase and sentence production, MH had a deficit in naming bare mass nouns which remained unexplained in Herbert & Best’s discussion. MH’s naming impairment for bare mass nouns cannot be accounted for in any of our extensions of Levelt et al.’s theory unless we assume that lexical-syntactic information is required for the selection of noun lemmas. In this scenario, the selection of a noun lemma relies on the activation of and/or feedback from its lexical-syntactic attributes and determiner lemmas. Hence, one has to assume that noun lemmas, lexical-syntactic information and determiners are connected via bidirectional links. The same impairment which affected the links between low frequency determiners and lexical-syntactic attributes ([mass], [plural]) resulting in determiner specific difficulties could account for MH’s difficulties with bare mass nouns. Alternatively, MH's deficit could be explained through an impairment of mass specific features such as UNINDIVIDUATED or NON-ATOMIC at the conceptual-semantic level. Herbert and Best showed that MH's performance on mass nouns improved when the syntactic cue 'some' was provided. The auditory presentation of 'some' would activate its determiner lemma node which in turn, via its conceptual-semantic representation(s) (e.g., UNINDIVIDUATED) would activate noun lemma nodes which comprise this feature (i.e., many mass nouns). Hence, for MH, the determiner 'some' facilitated the selection of mass noun lemma nodes by virtue of shared semantic representation(s).

Discussion and Conclusions

In this review, we first specified the characteristics of mass and count nouns and discussed ideas regarding the basis of their differences in semantics and syntax. Theoretical accounts of mass and count noun processing were introduced (Barner and Snedeker, 2005, 2006; Levelt, 1989; Levelt et al., 1999; Taler and Jarema, 2006). These accounts were extended to provide potential mechanisms for processing of mass and count nouns in language production and comprehension using the theory of Levelt et al. (1999) as a basis. In the *Count and Mass Marked hypothesis*, countability information is hypothesised to be represented in the form of two separate nodes, a [mass] node for mass nouns and a [count] node for count nouns, by analogy to Levelt et al.'s handling of grammatical gender. In the *Count UnSpecified Mass Marked hypothesis*, derived from Taler and Jarema (2006), both count and mass nouns are represented by a countability node, mass nouns however are marked and possess an additional lexical-syntactic attribute [mass]. In the *Mass UnSpecified Count Marked* *hypothesis* based on Barner and Snedeker (2005, 2006), count nouns are specified by a lexical-syntactic attribute [count] and a conceptual-semantic feature INDIVIDUATED and mass nouns remain syntactically and semantically unspecified.

We then presented research with normal speakers and language impaired speakers which delivered insights into the representation and processing of mass and count nouns. In most of these studies specific impairments and/or differential effects were found related to the manipulation of the categories of mass and/or count. Each of these experimental investigations also allowed us to evaluate the theoretical accounts.

Vigliocco et al. (1999) and Biedermann et al. (2008) showed that participants, given a definition, were able to retrieve lexical-syntactic information regarding the mass and count status of nouns in TOT states at rates greater than when not in TOT states. This supported the proposal that countability is represented at a lexical-syntactic (lemma) level. In addition, the fact that access of phonological information was found to be independent from lexical-syntactic information suggests that (at least partial) word form access can be achieved without selection of countability attributes. The fact that bare noun processing may proceed without selection of lexical-syntactic attributes of countability is also supported by Semenza et al.'s case FA, who showed an isolated impairment of mass nouns, but only when lexical-syntactic processing was required.

The lexical decision data is harder to integrate, not least because it seems counterintuitive that lexical-syntactic/semantic information about countability is accessed for lexical decision on bare nouns. Moreover, Levelt et al.'s (1999) theory assumes serial processing. Hence, tasks like lexical decision which require only word form selection should be independent of the effects of representation at subsequent levels such as the lexical-syntactic level and the conceptual-semantic level. However, semantic variables such as imageability and concreteness have been found to influence lexical decision tasks: highly imageable or concrete words showing faster reaction times than low imageable or abstract words (Cortese, Simpson & Woolsey, 1997; de Groot, 1989; Strain & Herdman, 1999; Strain, Patterson & Seidenberg, 1995; Zevin & Balota, 2000). Hence, differences between mass and count nouns in the lexical decision tasks discussed earlier could in fact reflect conceptual-semantic differences as suggested by Mondini et al. (2008) and Taler and Jarema (2007), rather than being lexical-syntactic. Mondini et al. (2008) argued that count nouns are semantically more concrete possibly because they represent individuated objects with clear boundaries. While mass nouns are semantically more abstract (or less concrete), representing unindividuated substances/aggregates without clear boundaries. The distinction between semantically more concrete versus abstract representations has been often explained by a difference in their semantic richness (Allport, 1985; Breedin, Saffran & Coslett, 1994; Strain, Patterson & Seidenberg, 1995). Semantic richness can be defined by the number of semantic features, with concrete words/objects having more semantic features than abstract words (Plaut & Shallice, 1993; Strain, Patterson & Seidenberg, 1995). Hence according to the ‘number of features’ account, perhaps mass nouns tend to be less concrete due to a relatively lower number of semantic features (e.g., milk: white, liquid, creamy, comes from cows; rice: white/brown/black, small grains, grows in Asia) compared to count nouns (e.g., cat: animal, pet, purrs, has whiskers, has a long tail, has four legs, has fur, catches mice, dislikes dogs etc.). Words with a higher number of conceptual-semantic features, and hence with a richer conceptual-semantic representation have been shown to facilitate word recognition in lexical decision studies compared to words with a lower number of conceptual-semantic features (Pexman, Lupker & Hino, 2002). Within this account, orthographic word forms activate their conceptual-semantic representations which then send activation back the target word form via feedback links. Semantic feedback increases activation and therefore facilitates the selection of word forms (Hino & Lupker, 1996; Pexman & Lupker, 1999, Pexman, Lupker & Hino, 2002). According to the number of features account and the semantic feedback assumption, a lower number of semantic features for mass compared to count nouns could lead to less feedback activation and therefore longer processing times for mass noun word forms. Differences in the semantic representation of mass and count nouns cannot only account for the countability effects in the lexical decision and ERP studies (Bisiacchi et al., 2005; Mondini et al, 2008), but also in the semantic categorisation task (Bisiacchi et al., 2005). Count nouns could be easier to categorise as their semantic representation is richer and therefore more explicit than the semantic representation of mass nouns. The semantic account is also consistent with the fact that countability effects in lexical decision were only found for low-frequency words: low-frequency words need longer processing times and hence semantic features could have a greater influence on word form selection. Even though the number of features account can explain the countability effects in language comprehension studies, only objective feature counts of mass and count nouns will enable verification. The number of features account requires two amendments to Levelt et al's theory: first, there must be feedback from lexical-syntax to input word forms to allow effects of semantics to influence lexical decision. Second, the conceptual-semantic level must include semantic features for a number of features to influence processing. Levelt et al (1999) propose that word meanings are represented nondecompositionally; however, they do assume the existence of some semantic features such as MULTIPLE for plural nouns. Hence, it is not entirely implausible to propose semantic features such as INDIVIDUATED and UNINDIVIDUATED at the conceptual-semantic level which are activated and selected for mass and/or count nouns.

Our extended version of Levelt et al.'s theory, is also able to explain some of the countability specific impairments in aphasia in either of the theories where mass nouns are marked by a lexical-syntactic attribute (*Count And Mass Marked hypothesis, Count Unspecified Mass Marked hypothesis*) but not when mass nouns are unmarked (as in the *Mass unspecified Count Marked hypothesis*). FA's mass noun deficits in lexical-syntactic tasks can be accounted for by an impairment of the [mass] node at the lexical-syntactic level. MH's determiner specific deficit can be explained by an impairment of specific determiner lemma nodes and/or the links from determiner lemma nodes to the lexical-syntactic attributes [mass] and [plural]. MH's difficulties in naming bare mass nouns, however, could not be explained in any of the three theories due to Levelt et al.'s assumption (supported by empirical data as described above) that lexical-syntactic attributes are only selected when needed for grammatical processing. Instead we can again consult the conceptual-semantic account in which mass and count nouns differ in terms of semantic features at the conceptual-semantic level. Hence, an impairment of these features could result in difficulties in naming mass or count nouns. MH's bare noun difficulties can be accounted for either by a specific semantic impairment of one or several mass features (e.g., UNINDIVIDUATED, NON-ATOMIC) or by a general semantic impairment which would affect mass nouns more than count nouns as their semantic representation is underspecified, or less rich compared to count nouns.

In summary, the experimental evidence suggests that mass and count nouns are both specified at the lexical-syntactic level for countability under an account we have labelled the Count and Mass Marked account. However, it also appears that conceptual-semantic differences between mass and count nouns can influence processing. We therefore incorporate conceptual-semantic differences within the Count and Mass Marked account (see Figure 9).

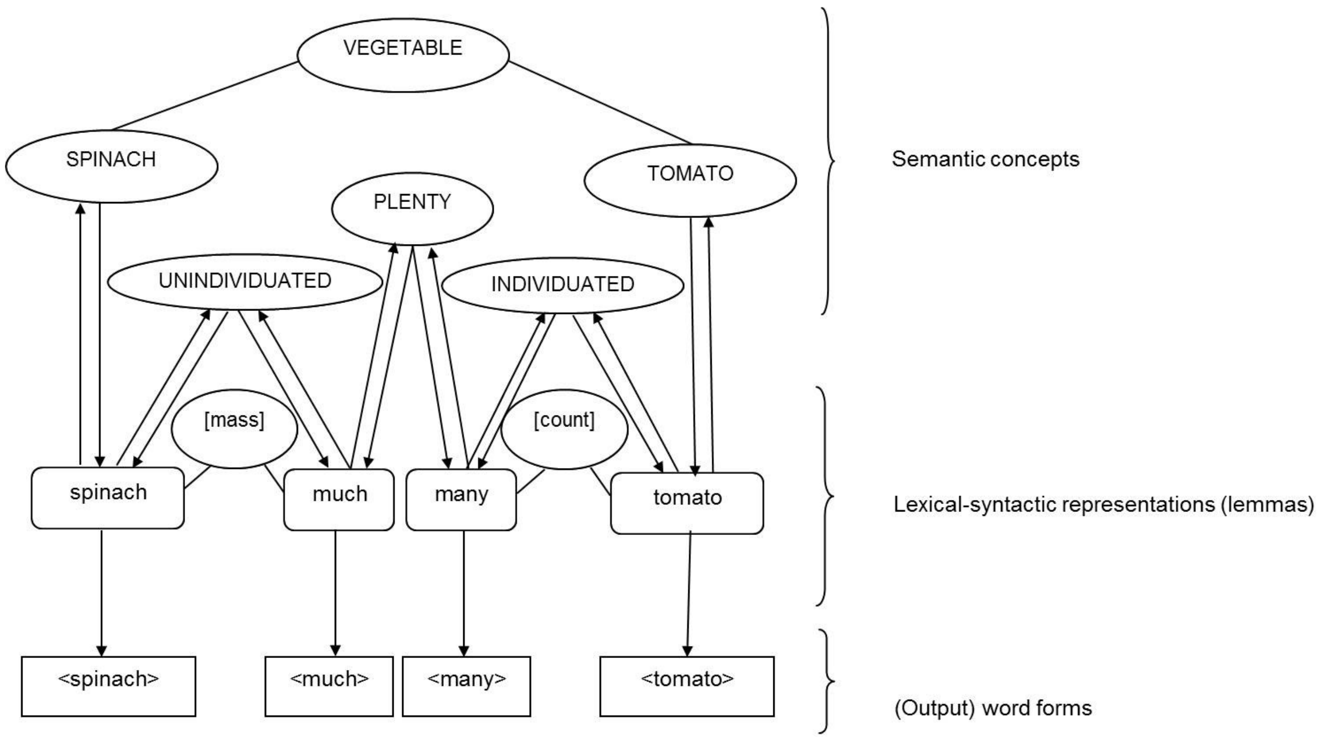

Figure 9. Illustration of the processing and representation of mass nouns (e.g., spinach) and count nouns (e.g., tomato) in a theory of language production derived from Levelt et al.'s (1999) theory, with separate count and mass properties at the lexical-syntactic (lemma) level, and semantic concepts/features INDIVIDUATED for count nouns and count noun determiners and UNINDIVIDUATED for mass nouns and mass noun determiner at the conceptual-semantic level. Even though it seems logical that both noun and determiner lemma nodes have access to appropriate lexical-syntactic attributes (e.g. [mass]), this would contradict Levelt et al.'s (1999) assumption of unidirectional activation flow from noun lemma nodes to determiner lemma nodes via lexical-syntactic attributes. Therefore, we have left the direction of activation flow between representations at the lexical-syntactic (lemma) level unspecified.

Finally, we note that many of the studies in the literature leave room for concern regarding the stimuli used. For instance, the matching for variables such as frequency, imageability, and age of acquisition is sometimes less than optimal. In addition, an important consideration for future research is to control mass nouns more tightly for their mass status, to ensure that dual nouns are not included as mass stimuli. CELEX (Baayen, Piepenbrock, & van Rijn, 1993), for example, separates nouns into the following subclasses: noun lemmas which are countable and not uncountable (count nouns), lemmas which are uncountable and not countable (mass nouns) and lemmas which can be both countable and uncountable (dual nouns).

Much work lies ahead in this field and many questions still remain. We have drawn together the data from the research to date and used it to develop a preliminary theoretical account. Further research will serve to evaluate and extend the adequacy of this account.

References

Allan, K. (1980). Nouns and Countability. *Language*, *56*, 541-547.

Allport, D.A. (1985). Distributed memory, modular systems and dysphasia. In S.K. Newman & R. Epstein (Eds.). *Current perspectives in dysphasia* (pp.30-60). Edinburgh, Scotland: Churchill Livingstone.

Armon-Lotem, S., Crain, S. & Varlokosta, S. (2004). Interface Conditions in Child Language: Cross-Linguistic Studies on the Nature of Possession. *Language Acquisition*, *12*(3&4), 171-217.

Baayen, R.H., Piepenbrock, R. & van Rijn, H. (1993). *The CELEX lexical database.* Philadelphia. PA: Linguistic Data Consortium. University of Pensylvania.

Baayen, R.H., Burani, C. & Schreuder, R. (1996). Effects of semantic markedness in the processing of regular nominal singulars and plurals in Italian. In G.E. Booij & J.V. Marle (Eds.).*Yearbook of morphology*. Dordrecht: Kluwer Academic.

Baayen, R.H., Dijkstra, T. & Schreuder, R. (1997). Singulars and Plurals in Dutch: Evidence for a Parallel Dual-Route Model. *Journal of Memory and Language*, 37, 94-117.

Badecker, W., Miozzo, M. & Zanuttini, R. (1995). The two-stage model of lexical retrieval: evidence from a case of anomia with selective preservation of grammatical gender. *Cognition*, 57, 193-216.

Barner, D. & Snedeker, J. (2005). Quantity judgements and individuation: evidence that mass nouns count. *Cognition*, 97, 41-66.

Barner, D. & Snedeker, J. (2006). Children's Early Understanding of Mass-Count Syntax: Individuation, Lexical Content, and the Number Asymmetry Hypothesis. *Language Learning And Development*, 2(3), 163-194.

Bates, E. & MacWhinney, B. (1982). Functionalist approaches to grammar. In E. Wanner & L.R. Gleitman (Eds.) *Language acquisition: the state of the art* (pp. 173-218).Cambridge, England: Cambridge University Press.

Berg, T. (1992). Prelexical and postlexical features in language production. *Applied Psycholinguistics*, 13, 199-235.

Biedermann, B., Ruh, N., Nickels, L. & Coltheart, M. (2008). Information Retrieval in Tip of the Tongue States: New Data and Methodological Advances. *Journal of Psycholinguistic Research*, 37, 171-198.

Bisiacchi, P., Mondini, S., Angrilli, A., Marinelli, K. & Semenza, C. (2005). Mass and count nouns show distinct EEG cortical processes during an explicit semantic task. *Brain and Language*, 95, 98-99.

Bloomfield, L. (1933). *Language* (pp. 266-268). New York: Holt & Co.

Breedin, S.D., Saffran, E.M. & Coslett, H. (1994). Reversal of the concreteness effect in a patient with semantic dementia. *Cognitive Neuropsychology*, 11, 617-660.

Butterworth, B. (1983). Lexical representation. In B. Butterworth (Ed.). *Language production. Volume 2.* San Diego: Academic Press.

Caramazza, A., Laudanna, A. & Romani, C. (1988). Lexical access and inflectional morphology. *Cognition*, *28*, 297-332.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Psychology*, 33, 497-505.

Cortese, M.J., Simpson, G.B. & Woolsey, S. (1997). Effects of association and imageability on phonological mapping. *Psychonomic Bulletin & Review*, 4, 226-231.

De Groot, A.M. (1989). Representational aspects of word imageability and word frequency as assessed through word association. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 15, 824-845.

Del Viso, S., Igoa, J.M. & Garcia-Albea, J.H. (1987). *Corpus of spontaneous slips of the tongue in Spanish*. Unpublished materials.

Garrard, P., Carroll, E., Vinson, D. & Vigliocco, G. (2004). Dissociation of Lexical Syntax and Semantics: Evidence from Focal Cortical Degeneration. *Neurocase,*10(5), 353-362.

Gillon, B.S., Kehayia, E. & Taler, V. (1999). The mass/count distinction: Evidence from online psycholinguistic performance. *Brain and Language*, *68*, 205-211.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex*, 46(3), 329-342.

Hillis, A.E. & Caramazza, A. (1991). Category-specific naming and comprehension impairment: a double dissociation. *Brain*, 114, 2081-2094.

Hino, Y. & Lupker, S.J. (1996). Effects of polysemy in lexical decision and naming: An alternative to lexical access accounts. *Journal of Experimental Psychology: Human Perception & Performance*, 22, 1331-1356.

Imai, M. & Gentner, D. (1997). A cross-linguistic study on early word meaning. Universial ontology and linguistic influence. *Cognition*, 62, 62, 169-200.

Iwasaki, N. Vinson, D.P. & Vigliocco, G. (2010). Does the grammatical count/mass distinction affect semantic representations? Evidence from experiments in English and Japanese. *Language and Cognitive Processes*, 25(2), 189-223.

Jackendoff, R. (1991). Parts and boundaries. Cognition, 41, 9-45.

Jacobsen, T. (1999). Effects of Grammatical Gender on Picture and Word Naming: Evidence from German. *Journal of Psycholinguistic Research*, *28*(5), 499-514.

Jescheniak, J.D. & Levelt, W.J.M. (1994). Word Frequency Effects in Speech Production: Retrieval of Syntactic Information and of Phonological Form. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(4), 824-843.

Jescheniak, J.D. (1999). Gender Priming in Picture Naming: Modality and Baseline Effects. *Journal of Psycholinguistic Research*, *28*(6), 729-737.

La Heij, W., Mak, P., Sander, J. & Willeboordse (1998). The gender-congruency effect in picture-word tasks. *Psychological Research*, *61*, 209-219.

Langacker, R.W. (1987). Nouns and verbs. *Language*, *63*, 53-94.

Levelt, W.J.M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W.J.M. (1993). Lexical Selection, or How to Bridge the Major Rift in Language Processing. In F. Beckmann & G. Heyer (Eds). *Theorie und Praxis des Lexikons*. Berlin, New York: de Gruyter.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences*, *22*, 1-75.

Macnamara, J. (1972). Cognitive basis of language learning in infants. *Psychology Review*, 79, 1-13.

Macnamara, J. (1982). *Names for things: A study of human learning*. Cambridge, MA: MIT Press.

Middleton, E.L., Wisniewski, E.J., Trindel, K.A. & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language*, *50*, 371-394.

Mondini, S., Angrilli, A., Bisiacchi, P., Spironelli, C., Marinelli, K. & Semenza, C. (2008). Mass and Count nouns activate different brain regions: An ERP study on early components. *Neuroscience Letters* 430, 48-53.

Mondini, S., Kehayia, E., Gillon, B., Arcara, G. & Jarema, G. (2009). Lexical access of mass and count nouns. How word recognition reaction times correlate with lexical and morpho-syntactic processing. *Mental Lexicon*, 4(3), 354-379.

Nickels, L., Biedermann, B., Fieder, N. & Schiller, N.O. (submitted) The Lexical syntactic representation of number. *Language and Cognitive Processes,* invited paper.

Palmer, F.R. (1971). *Grammar* (pp. 34-35). Harmondsworth, UK: Penguin Books.

Pexman, P.M. & Lupker, S.J. (1999).Ambiguity and visual word recognition: Can feedback explain both homophone and polysemy effects? *Canadian Journal of Experimental Psychology*, 53, 323-334.

Pexman, P.M., Lupker, S.J. & Hino, Y. (2002). The impact of feedback semantics in visual word recognition: Number-of-features effects in lexical decision and naming tasks. *Psychonomic Bulletin & Review*, ((3), 542-549.

Plaut, D.C. & Shallice, T. (1993). Deep Dyslexia: A case study of connectionist neuropsychology. *Cognitive Neuropsychology*, 10, 377-500.

Quine, W.V.O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Roelofs, A. (1992a). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, 42, 107-142.

Roelofs, A. (1993). Testing a non-decompositional theory of lemma retrieval in speaking: Retrieval of verbs. *Cognition*, 47, 59-87.

Roelofs, A. (2003b). Modeling the relation between the production and recognition of spoken word forms. In A.S. Meyer & N.O. Schiller (Eds.). *Phonetics and phonology in language comprehension and production: Differences and similarities* (pp. 115-158). Berlin: Mouton.

Schiller, N. O. & Caramazza, A. (2002). The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German. *Brain and Language*, 81, 342-357.

Schiller, N. O., Münte, T. F., Horemans, I. & Jansma, B. M. (2003). The influence of semantic and phonological factors on syntactic decisions: An event-related brain potential study. *Psychophysiology*, 40, 869-877.

Schreuder, R. & Baayen, R.H. (1995). Modeling Morphological Processing. In L.B. Feldman (Ed.). *Morphological aspects of language processing.* Hillsdale: Erlbaum.

Schriefers, H. (1993). Syntactic Processes in the Production of Noun Phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(4), 841-850.

Schriefers, H. & Jescheniak, J.D. (1999). Representation and Processing of Grammatical Gender in Language Production: A Review. *Journal of Psycholinguistic Research*, *28*(6), 575-600.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2002). Determiner Selection In Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28(5), 941-950.

Semenza, C., Mondini, S. & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Semenza, C., Mondini, S. & Marinelli, K. (2000). Count and Mass Nouns: Semantics and Syntax in Aphasia and Alzheimer`s disease. *Brain and Language, 74*, 395-431.

Shapiro, L.P., Zurif, E., Carey, S. & Grossman, M. (1989). Comprehension of lexical subcategory distinctions by aphasic patients: proper/common and mass/count nouns. *Journal of Speech and Hearing Research*, *32*, 481-488.

Soja, N.N., Carey, S. & Spelke, E. (1991). Ontological categories guide young children's inductions of word meaning: Object terms and substance terms. *Cognition*, 38, 179-211.

Sonnenstuhl, I. & Huth, A. (2002). Processing and Representation of German –n Plurals: A Dual Mechanism Approach. *Brain and Language*, 81, 276-290.

Steinhauer, K., Pancheva, R., Newman, A.J., Gennari, S. & Ullman, M.T. (2001). How the mass counts: An electrophysiological approach to the processing of lexical features. *Cognitive Neuroscience and Neuropsychology*, 12(5), 999-1005.

Strain, E., Patterson, K. & Seidenberg, M.S. (1995). Semantic effects in single-word naming. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 21, 1140-1154.

Strain, E. & Herdman, C.M. (1999). Imageability effects in word naming: An individual differences analysis. *Canadian Journal of Experimental Psychology*, 53, 347-359.

Strain, E., Patterson, K. & Seidenberg, M.S. (1995). Semantic Effects in Single-Word Naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21(5), 1140-1154.

Taft, M. & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, *14*, 638-647.

Taler, V., Jarema, G. & Saumier, D. (2005). Semantic and syntactic aspects of the mass/count distinction: A case study of semantic dementia. *Brain and Cognition,* 57, 222-225.

Taler, V. & Jarema, G. (2006). On-Line lexical processing in AD and MCI: An early measure of cognitive impairment? *Journal of Neurolinguistics, 19*, 38-55.

Taler, V. & Jarema, G. (2007). Lexical access in younger and older adults: The case of the mass/count distinction. *Canadian Journal of Experimental Psychology*, *61*, 21-34.

Van Berkum, J.J.A. (1997). Syntactic processes in speech production: the retrieval of grammatical gender. *Cognition*, *64*, 115-152.

Vigliocco, G., Vinson, D.P., Martin, R.C. & Garrett, M.F. (1999). Is “Count” and “Mass” Information Available When the Noun Is Not? An Investigation of Tip of the Tongue States and Anomia. *Journal of Memory and Language, 40*, 534-558.

Vigliocco, G., Lauer, M., Damian, M.F. & Levelt, W.J.M. (2002). Semantic and Syntactic Forces in Noun Phrase Production. *Journal of Experimental Psychology: Learning,Memory, and Cognition*, 28(1), 46-58.

Warrington, E.K. & Crutch, S.J. (2005). The semantic organisation of mass/count nouns and the representational locus of the mass/count distinction. *Brain and Language*, 95, 90-91.

Wierzbicka, A. (1988). *The semantics of grammar*. Amsterdam: John Benjamins.

Wisniewski, E.J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and cognitive processes*, 18(5/6), 583-624.

Yagoubi, R.E., Mondini, S., Bisiacchi, P., Chiarelli, V., Angrilli, A. & Semenza, C. (2006). The electrophysiological basis of mass and count nouns processing. *Brain and Language*, 99, 8-219.

Zevin, J.D. & Balota, D.A. (2000). Priming and attentional control of lexical and sublexical pathways during naming. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 26, 121-135.

Author Note

During the preparation of this paper, Nora Fieder was funded by a Macquarie University Research Excellence (MQRES) scholarship, Lyndsey Nickels was funded by an Australian National Health and Medical Research Council Senior Research Fellowship and Britta Biedermann by a Macquarie University Research Fellowship.

Chapter 3

Garlic and ginger are not like apples and oranges. Effects of mass/count information on the production of noun phrases in English.

Nora Fieder, Lyndsey Nickels & Britta Biedermann

ARC Centre of Excellence for Cognition and its Disorders (CCD)

Department of Cognitive Science

Macquarie University, Sydney, Australia

Submitted to ***Journal of Memory and Language***

Abstract

A picture-word interference paradigm was used to investigate how grammatical mass/count information is represented and processed during noun phrase production in English. Levelt, Roelofs and Meyer's (1999) theory distinguishes between two different types of lexical-syntactic information: variable extrinsic lexical-syntactic features such as number (singular, plural) and fixed intrinsic lexical-syntactic properties such as grammatical gender (e.g., masculine, feminine). Previous research using the picture-word interference paradigm has found effects of distractor lexical-syntactic congruency for grammatical gender but no congruency effects for number. In two experiments we used this phenomenon to determine whether mass/count information is represented in the form of variable extrinsic lexical-syntactic features or fixed intrinsic lexical-syntactic properties and further whether the selection of mass/count information and/or selection of determiners is competitive in nature. In a picture-word interference experiment, participants named pictures of mass or count objects using determiner noun phrases (not much$_{mass}$ porridge$_{mass}$, not many$_{count}$ oysters$_{count}$), while ignoring superimposed distractors which were countability congruent or incongruent nouns (Experiment 1) or determiners (Experiment 2). The results of Experiment 1 revealed a countability congruency effect for mass and count noun targets similar to that found previously for grammatical gender suggesting that countability is represented as a fixed intrinsic lexical-syntactic property. A reversed countability congruency effect with longer naming latencies in the countability congruent condition compared to the incongruent condition was found in Experiment

2 indicating competition for selection between determiners rather than between lexical-syntactic mass/count properties.

Introduction

Nouns have a number of characteristics which can affect the form of grammatical units such as noun phrases. For example, lexical-syntactic information, is required in order to select the appropriate determiner and/or the appropriate suffix. In German, for instance, each noun has a grammatical gender (feminine, masculine or neuter). The noun's specific gender determines the form of the definite or indefinite determiner in the same noun phrase (e.g., **der**$_{masc}$ schlaue Fuchs (the sly fox) versus **die**$_{fem}$ schwarze Katze (the black cat)). Similarly, number also influences the form of determiners and adjectives to generate agreement between words in a phrase (e.g., **die**$_{plural}$ schlau**en**$_{plural}$ F**ü**chs**e**$_{plural}$ (the sly foxes)).

Levelt, Roelofs and Meyer's (1999) theory is one of the most prominent theories of language production and includes detailed hypotheses regarding the representation of lexical-syntactic information (e.g., number, grammatical gender, word category). According to Levelt et al., lexical syntax is represented at an abstract grammatical level (lemma level) which is part of the lexicon. The theory distinguishes between three major levels: a level of lexical concepts (conceptual-semantic level), a lexical-syntactic (lemma) level and a word form level. The lemma level mediates between the level of lexical concepts and the word form level. Each lexical item is represented by an empty lemma node which is linked to the word's specific lexical-syntactic characteristics such as word category, grammatical gender and number information (e.g., the lemma node for the German word 'Katze' (cat) points to the features: noun, feminine, singular). Lexical-syntactic features can be further connected to the lemmas of agreement targets[13] (e.g., the syntactic feature [feminine] is linked to the determiners 'die$_{fem}$' (the) and 'eine$_{fem}$' (a)). Activation flows unidirectionally from the noun's lemma to its lexical-syntactic features. Although lexical-syntactic features always receive activation when a noun, phrase or sentence is produced, Levelt et al. propose that selection of the features is bound to their grammatical necessity, such as when agreement is required within a noun phrase using gender specific determiners. For example, in order to form agreement in the German noun phrase 'die$_{fem}$ Katze' (the cat), the lexical-syntactic feature [feminine] has to be selected in order to activate and select the appropriate gender specific determiner 'die'. Following activation of lemmas the most active lemma is selected and only this node activates its corresponding word form.

Even though number and grammatical gender both represent lexical-syntactic information, the nature of this information is different. Grammatical gender represents an unchanging characteristic of a specific noun (e.g., the German word 'Katze' (cat) is a noun which always retains the grammatical gender 'feminine'). It is a purely grammatical property whose form is not influenced by conceptual-semantic information[14], hence, in Levelt et al's theory, a noun's grammatical gender and gender

[13] Agreement targets are words which have to agree in specific features (e.g., gender, number) with another word in the phrase or sentence, thus they are syntactically dependent. In our example, adjectives or determiners are the agreement targets and depend on the lexical-syntactic features of the noun in a noun phrase.

[14] Even though grammatical gender is a grammatically derived and hence a fixed lexical-syntactic property, in some cases its selection can be influenced by conceptual-semantic information. For example, Schiller, Muente, Horemans & Jansma (2003) found that participants made faster gender decisions for words which have biological sex (e.g., die$_{fem}$ Frau$_{fem}$ – the woman) and are congruent regarding their grammatical and biological gender compared to words with no biological sex (e.g., der$_{masc}$ Tisch$_{masc}$ – the table) (see also Nickels, Biedermann, Fieder & Schiller, submitted).

specific determiner can only be accessed and selected through the noun's lemma node. Features such as grammatical gender are referred to as 'intrinsic features' (Caramazza, 1997) or 'lexical-syntactic properties' (Levelt et al., 1999; Roelofs, 1992; Schriefers & Jescheniak, 1999).

Number, in contrast, is not fixed and its value depends on the speaker's intention (e.g., whether the word 'Katze' (cat) is produced in singular or plural depends on the speaker's intention to talk about one or more than one cat). Hence, the lexical-syntactic feature number is selected through conceptual-semantic information. Features such as number are referred to as 'extrinsic features' (Caramazza, 1997) or 'syntactic features' (Levelt et al., 1999; Roelofs, 1992; Schriefers & Jescheniak, 1999). For clarity, we will use the most explicit terminology: 'fixed intrinsic lexical-syntactic property' to refer to lexical-syntactic properties such as grammatical gender; 'variable extrinsic lexical-syntactic feature' to refer to a lexical-syntactic feature like number, and 'lexical-syntactic attributes' to refer to both kinds of lexical-syntactic information.

In addition to grammatical gender and number, a third lexical-syntactic attribute of nouns is their mass/count status. Many languages (e.g., English, German, and Russian) distinguish grammatically between mass nouns (e.g., milk, gold) and count nouns (e.g., house, table). The mass/count status of a word can influence the grammatical form of adjacent constituents in phrases and sentences. For example, count nouns can be specified by a preceding numeral (e.g., **two** tables), quantifiers that denumerate (e.g., **many** tables, **few** tables), and the definite or the indefinite article (e.g., **the** table, **a** table). Mass nouns in comparison can only be combined with the definite article (e.g., **the** milk vs. *a milk) and quantifiers that do not denumerate (e.g., **much** milk vs. *many milk, **little** rice vs. *few rice).

Unlike grammatical gender and number, the nature of mass/count information is less clear with the origin of the grammatical distinction between mass and count nouns still debated (see e.g., Middleton, 2008). Originally, grammatical differences between mass and count nouns were proposed to reflect conceptual-semantic differences in their representation, with mass nouns representing substances (e.g., milk, gold) and aggregates (e.g., confetti, rice) which have no definite boundaries, and count nouns representing entities with clear boundaries (e.g., house, table) (Cheng, 1973; Grandy, 1973). Another conceptual-semantic yet less perceptual and more abstract approach comes from the cognitive individuation hypothesis (Middleton, Wisniewski, Trindel & Imai, 2004; Wierzbicka, 1988; Wisniewski, Lamb & Middleton, 2003). In the cognitive individuation hypothesis, the grammatical distinction between mass and count nouns arises from how people perceive and interact with mass and count objects. For example, depending on whether objects can be perceived as individual entities and whether people interact more with a single individual element instead of with multiple elements determines the use of count syntax instead of mass syntax.

Support for this view comes from a number of 'dual nouns', nouns which can be used both as a mass noun and as a count noun depending on the context. For example, the noun 'tea' is generally used as a mass noun: 'Can I have some tea?' but can also be used as a count noun: 'Can I have a tea'; similarly the noun 'dog' is usually a count noun: 'I saw a dog.' but can be a mass noun: 'There is dog in that curry.'. Wisniewski, Lamb and Middleton (2003) argue that speakers can to some extent flexibly choose whether they refer to nouns as mass or count nouns depending on which conceptual/perceptual characteristic they want to refer to. For example, if people want to refer to or stress the spatial dimension of a count noun, they can refer to it as a mass noun: 'There is not enough table for everyone to sit at' (Allan, 1980). Similarly, if people want to refer to a type or kind of a mass noun, they can refer to it as a count noun: 'a fine wine' (Langacker, 1987).

Hence, it would seem plausible that the selection of grammatical mass/count information for a noun is driven by conceptual-semantic information, namely whether the speaker refers to an object/individuated entity or a substance/non-individuated entity similar to the variable extrinsic lexical-syntactic feature 'number'. Alternatively, mass/count information could be assumed to be a purely lexical-syntactic property of nouns and hence, a fixed property (e.g., Garrard, Carroll, Vinson & Vigliocco, 2004; Middleton, 2008; Shapiro, Zurif, Carey & Grossman, 1989; Vigliocco, Vinson, Martin & Garrett, 1999). Within this theory, each noun is specified for countability at the lexical-syntactic level in the form of a fixed intrinsic lexical-syntactic property: either [mass] for mass noun or [count] for count nouns. This property at the lexical-syntactic level can exclusively be accessed and selected through the noun's lexical-syntactic representation. Support for this view and an argument against a purely conceptual-semantic locus of the mass/count distinction comes from the lack of conceptual transparency between some mass and count nouns. For example, some nouns which refer to distinct individuated objects (e.g., broccoli, bread, bacon) are still grammatically mass nouns and some nouns which represent non-individuated entities (e.g., lentils, peas, pearls) are count nouns. Further support against a conceptually driven mass/count distinction can be found in the form of nouns which can refer to the same entities but belong to a different noun category (e.g., $\text{pebbles}_{\text{count}}$ vs. $\text{gravel}_{\text{mass}}$, $\text{garments}_{\text{count}}$ vs. $\text{clothing}_{\text{mass}}$). Finally, a conceptual distinction underlying countability becomes even harder to maintain looking cross-linguistically at cases of language-specific mass/count categorization. For example, some nouns which are mass nouns in English, are countable in other languages such as ‘dandruff’ and ‘bread’ which are count nouns in German (Schuppen, Brote) and ‘spinach’ and ‘spaghetti’ which are count nouns in Italian (spinaci, spaghetti)(Middleton, Wiesniewski, Trindel & Imai, 2004; Middleton, 2008). Further support for a syntactically driven mass/count distinction comes from an ERP study by Steinhauer, Pancheva, Newman, Gennari and Ullman (2001) which measured brain activity during reading of grammatically plausible mass and count noun sentences. Steinhauer et al. found a frontal negativity effect which reflected syntactic processing and was different to the conceptual-semantic effect (N400) found in semantically implausible sentences.

So far, we have discussed two different ways in which lexical-syntactic information is represented and accessed according to Levelt et al.’s theory (1999). In the case of countability it is far from clear what the nature of the mass/count distinction might be, and thus in which form (fixed intrinsic lexical-syntactic property vs. variable extrinsic lexical-syntactic feature) mass/count information is represented. As we will see from the results of previous picture-word interference studies, the type of lexical-syntactic attribute can have implications for lexical-syntactic processing.

A common empirical approach used to investigate how words are represented and processed is the picture-word interference task (e.g., Alario, Matos & Segui, 2004; Costa, Mahon, Savova & Caramazza, 2003; La Heij, Mak, Sander & Willeboordse, 1998; Schiller & Caramazza, 2002; Schriefers, 1993; Schriefers, Jescheniak & Hantsch, 2002; Schriefers & Teruel, 2000; Spalek & Schriefers, 2005; van Berkum, 1997). In this paradigm, participants are presented with a picture which they are asked to name with either a bare noun without a determiner or using a simple noun phrase. Additionally, they are presented auditorily or visually with a distractor word which either shares characteristics with the target word or not. Results of picture-word interference tasks have shown that picture naming latencies are affected by the type of relationship between the distractor word and target. There is interference with longer picture naming latencies when target and distractor are semantically related (Schriefers, Meyer & Levelt, 1990) but facilitation, with shorter naming latencies, when target and distractor are phonologically related (Schriefers et al., 1990).

More recently the picture-word interference paradigm has been used to investigate lexical-syntactic representation. Schriefers (1993) was the first to extend the paradigm to study processing of grammatical gender by manipulating the grammatical relationship between target pictures and distractor words. Grammatical gender was either the same (gender congruent) or different (gender incongruent) across target and distractor items. Experiments with Dutch speakers revealed a gender congruency effect with gender incongruent distractors leading to longer latencies for noun phrase production than gender congruent distractors. Schriefers interpreted longer naming latencies in the gender incongruent condition as resulting from competition between the grammatical gender of the target noun and the grammatical gender of the distractor noun at the lexical-syntactic level. In this case the two activated gender nodes compete for selection, whereas in the gender congruent condition, only one gender node is activated for selection. Schiller and Caramazza (2003, 2006) refer to Schriefer's (1993) theory as the 'gender selection interference hypothesis'. In order to extend its scope to lexical-syntactic attributes other than gender, we will refer to this hypothesis with the more general term: 'lexical-syntactic attribute selection interference hypothesis'. The gender congruency effect was replicated in Dutch by Van Berkum (1997), La Heij, Mak, Sander, and Willeboordse (1998) and Schiller and Caramazza (2003), in Croatian by Costa, Kovacic, Fedorenko, and Caramazza (2003), and in German by Schriefers and Teruel (2000), and Schiller and Caramazza (2003).

The origin of the gender congruency effect, however, was questioned (see e.g. Miozzo & Caramazza, 1999; Schiller & Caramazza, 2002, 2003) because it was only apparent when the subject was required to produce a noun phrase with a determiner and not when bare nouns were produced (La Heij, Mak, Sander & Willeboordse, 1998; Starreveld & La Heij, 2004). In noun phrases, target and distractor in the gender incongruent condition not only differed in their grammatical gender but also with regard to their determiners (Dutch has two grammatical genders, nouns of common gender are combined with the definite determiner 'de' and nouns of neuter gender with the definite determiner 'het'). Hence, an interference effect in the gender incongruent condition could have resulted from competition between different determiners rather than between gender nodes. Miozzo and Caramazza (1999) referred to this theory as the ‘determiner selection interference hypothesis’.

Schiller and Caramazza (2003) used the same paradigm to further investigate the origin of the grammatical gender effect. They made use of the fact that in German and Dutch there is form identity between the gender unmarked plural determiner (in Dutch: de; in German: die) and one of the gender specific singular determiners (in Dutch the singular common determiner: ‘de’ and in German the singular feminine determiner: die). Hence, to distinguish between the attribute and determiner selection interference hypotheses, they used target-distractor pairs that differed in grammatical gender and compared those that shared the same determiners (plural targets and plural distractors) with those that differed in their determiners (singular targets and singular distractors). In the lexical-syntactic attribute interference hypothesis, the source of interference is lexical-syntactic gender, and therefore a gender congruency effect was predicted independently of whether the determiners were the same or different. In contrast, if the source of the interference was competition between determiners, then no gender congruency effect was predicted when the target-distractor pairs shared the same determiner form. The results of this study replicated the gender congruency effect (Schriefers, 1993) for singular target pictures paired with singular distractors, when the determiners differed. However, critically, no gender congruency effect was found in the plural-plural target-distractor condition where the determiner form was shared. These results supported the determiner selection interference hypothesis, which assumes that the selection of grammatical gender is an automatic non-competitive process. According to this theory, both target and distractor activate their grammatical gender at the lexical-syntactic level and their gender specific determiner forms at the word form level. Competition is assumed to occur only in gender incongruent conditions when different determiners are activated and compete for selection.

The origin of the gender congruency effect is still debated on the basis of findings from studies in different languages using a similar methodology to Schiller and Caramazza (2003) that exploits conditions where gender differs but noun phrase constituents (e.g., determiners, pronouns, adjectives) can be the same or different (in Dutch: Janssen & Caramazza, 2003; Schiller & Caramazza, 2006; in German: Schriefers, Jescheniak & Hantsch, 2002, 2005; in French: Alario & Caramazza, 2002; Alario, Ayora, Costa & Melinger, 2008; in Czech: Bordag & Pechmann, 2008, 2009). Evidence and counterevidence has been found for both the lexical-syntactic attribute and the determiner selection interference hypotheses, which has led to the development of several alternative theories for the selection of grammatical gender and gender specific constituents (e.g., ‘primed unitized activation hypothesis’, Alario & Caramazza (2002); ‘singular-as-default hypothesis’, Schriefers et al., 2002). Even though processes and mechanisms involved in the selection of grammatical gender and gender-specific determiners are still unclear, nevertheless, a clear conclusion can be drawn about the representation of grammatical gender at the lexical-syntactic level. Namely, nouns are specified for grammatical gender in the form of a fixed intrinsic lexical-syntactic property for each gender which is activated and selected during the production of gender specific noun phrases.

Turning from grammatical gender to the variable extrinsic lexical-syntactic feature number, Schiller and Caramazza (2002) investigated effects of number congruency in German using the picture-word interference paradigm. Participants were asked to name target pictures using a singular or plural noun depending on the number of objects displayed in the picture. Each target picture was combined with a number congruent and a number incongruent written distractor noun and found no number congruency effects for the production of bare nouns. Schiller and Caramazza (2003) found no effect of number congruency for the production of noun phrases in Dutch or German, in contrast to the effect of gender congruency in these languages. Schiller and Caramazza (2003) accounted for the absence of a number congruency effect by suggesting that the number feature could be determined extra-lexically. However, they did not further specify how this could prevent competition between determiners and/or attributes. We will discuss possible theoretical accounts for non-competitive selection of number in the Discussion.

Based on the results of the picture-word interference literature, it seems to follow that grammatical gender and number differ in their representation and processing. The lexical-syntactic representation of number is activated by conceptual-semantic information, whereas gender is activated via a noun's lemma node. In addition, there is competition for gender but not for number. However, a question arises, regarding how lexical-syntactic mass/count information is represented and processed. This study consists of two experiments which address this issue. There are relatively few studies which have investigated mass and count noun representation (Barner & Snedeker, 2005, 2006; Gillon, Kehayia & Taler, 1999;

Mondini, Kehayia, Gillon, Arcara & Jarema, 2009; Taler & Jarema, 2006, 2007; Vigliocco, Vinson, Martin & Garrett, 1999) and this is the first to use the picture-word interference paradigm. In Experiment 1, we investigate whether mass/count information is represented in the form of a variable extrinsic lexical-syntactic feature or as a fixed intrinsic lexical-syntactic property. If the latter (like grammatical gender), we would predict a countability congruency effect with longer naming latencies for target pictures which are paired with a countability incongruent distractor compared to a countability congruent distractor. Alternatively, if countability is represented as a variable extrinsic lexical-syntactic feature like number, we would expect no countability congruency effect. Experiment 1 also allows us to investigate further the effects of number congruency in English.

Following the demonstration of an effect of countability congruency in Experiment 1, Experiment 2 investigates whether this effect is the result of competition between the lexical-syntactic attributes [mass] and [count] or between the different determiners.

Experiment 1: Countability and Number Congruency

In this experiment, native English speakers were required to name a set of pictures of mass nouns and plural count nouns with the grammatically appropriate noun phrase: ‘not much...’ for mass nouns and ‘not many...’ for plural count nouns. Each picture had a superimposed written distractor noun. This could be either: countability congruent (i.e., a mass noun for a mass picture, a plural count noun for a plural count picture) or countability incongruent (i.e., a plural count noun for a mass picture, a mass noun for a plural count picture). In addition, we included an identity condition (the target noun), which we expected to show facilitation of naming and thereby demonstrate that the distractor was being processed. We also included a singular count noun distractor condition for two reasons. First, it enabled us to examine whether there was a (lack of a) number congruency effect and hence to replicate Schiller and Caramazza's findings (2002, 2003) in another language (English) and another context (mass/count rather than grammatical gender). Second, the singular distractor condition compared to the plural distractor condition for mass and plural count noun targets allows us to separate possible number congruency effects from countability congruency effects: If there is a countability congruency effect we would expect it to be independent of the number of the count noun distractor. That is, we would expect the same effects for singular and plural count noun distractors compared to mass noun distractors (shorter naming latencies when paired with plural count target pictures; longer naming latencies when paired with mass noun pictures).

Table 1 summarises the conditions in the experiment.

Table 1 *Representation of the different target-distractor conditions*

	Target Pictures			
	Count (pillows)		Mass (bacon)	
Distractor condition	Distractor noun	Distractor noun category	Distractor noun	Distractor noun category
Countability Congruent	Lemons	plural count noun *(number congruent)*	denim	mass noun
Countability Incongruent	Mutton	mass noun	sofas	plural count noun
Identity	Pillows	plural count noun	bacon	mass noun
Singular Count	Cherry	singular count noun *(number incongruent)*	ladle	singular count noun *(countability incongruent)*

Method

Participants

48 participants (18-45 years) took part in this experiment, in exchange for course credits or $15. All participants were students from Macquarie University and native speakers of English.

Materials

48 pictures, 24 representing mass nouns and 24 representing plural count nouns, were selected for the experiment. Plural count nouns and mass nouns were depicted as 2-5 objects. The number of depicted objects was matched across the two conditions. Mass noun and count noun stimuli were matched listwise for log transformed written and spoken lemma frequency from the CELEX database (Baayen, Piepenbrock & van Rijn, 1993; Baayen, Piepenbrock & Guliker, 1995), number of syllables, phonemes and graphemes using the MRC Psycholinguistic database (Coltheart, 1981), bigram and trigram frequency, phonological and orthographic neighbourhood density from the English lexicon project (Balota et al., 2007), and for imageability, concept familiarity, age of acquisition, image agreement, name agreement, naming latencies (data collected by the authors) (see Appendix A for matching data). 30 participants provided objective measures of name agreement and naming speed in a picture naming experiment. Participants were instructed to name the pictures as quickly and as accurately as possible. Ratings were obtained by the authors from 20 participants for imageability, concept familiarity and visual complexity and from 30 participants for age of acquisition and image agreement, using the instructions from Gilhooly and Hay (1977) for Age of Acquisition, Paivio,

Yuille and Madigan (1968) for imageability, and Alario and Ferrand (1999) for the remaining variables.

In the picture-word interference task, each stimulus picture was paired with 4 different written distractors: (a) countability congruent distractor (target-distractor: plural count noun- plural count noun; mass noun-mass noun), (b) countability incongruent distractor (target-distractor: plural count noun-mass noun; mass noun-plural count noun), (c) singular count noun distractor, (d) identity distractor (written name of the target) (see Appendix B for stimuli). Items in the 3 distractor conditions (singular count nouns, plural count nouns and mass nouns) were matched listwise for log transformed written and spoken lemma frequency from the CELEX database (Baayen, Piepenbrock & van Rijn, 1993; Baayen, Piepenbrock & Guliker, 1995), number of syllables and graphemes using the MRC Psycholinguistic database (Coltheart, 1981), bigram and trigram frequency, phonological and orthographic neighbourhood density from the English lexicon project (Balota et al., 2007) (see Appendix C for details of distractor matching). Distractors were not semantically or phonologically related to their target pictures. For both target groups (count nouns and mass nouns) the same mass noun, plural count noun and singular count noun distractors were used, to ensure that differences between conditions did not arise due to differences in the distractors. Moreover, like plural count noun, mass noun targets were displayed as multiple objects to prevent possible strategic effects (e.g., several heads of broccoli rather than just one). To further prevent visual differences between mass and count noun pictures, we predominantly chose mass nouns that could be depicted as discrete entities (e.g., a bulb of garlic, a loaf of bread, a head of broccoli).

The pictures appeared as coloured photographs on a white background. The size of each picture was 10x10cm. Distractors were displayed in black characters, written in Arial 16 point font. Pictures were displayed in the centre of the screen with the distractor words appearing at slightly different positions around fixation to prevent participants from ignoring the distractor. The position of all 4 distractor words for an individual picture, however, was always the same.

Procedure

Participants were tested individually in a quiet room. The experimenter sat in the room to score errors. The items were presented on a Diamond Digital 1998E computer screen. On each trial participants saw a fixation point for 600 ms in the centre of the screen. The target picture followed with a superimposed distractor word. Participants were asked to name each picture as fast and as accurately as possible with a noun phrase while ignoring the distractor word. Naming latencies were measured by means of a voice key, which was activated at the onset of the target presentation. Target and distractor remained on the screen until a vocal response was provided or until the timeout of 3000 ms. The next trial started 500 ms after the end of the previous trial. Trial sequences were controlled by DMDX (Forster & Forster, 2003).

Design

Before the beginning of the test phase, participants received a familiarisation phase followed by a practice phase. In the familiarisation phase, participants were presented with each of the target pictures without their distractors (48 pictures). Each picture remained on the screen for 2000 ms in total. Participants were instructed to study the picture. After 1000 ms the picture's name was displayed below the picture which had to be read aloud by the participant. Participants were asked to use only the name provided on the computer in the subsequent phases of the experiment.

In the practice phase, each target picture was again presented without its distractor (48 pictures). The participants were instructed to name the picture with the appropriate one of two noun phrases: 'not many_(picture name)' or 'not much_(picture name). Each trial started with a fixation point (+) for 600 ms followed by the picture. The picture remained on the screen for 3000 ms. After completion of the practice phase, participants received corrective feedback on those pictures for which they had not used the designated name or the correct noun phrase. The practice phase was adopted to make sure that participants knew the correct word and determiner for each target and to provide familiarisation with the procedure.

All participants saw the 48 target pictures in all four distractor conditions. Target-distractor conditions were distributed evenly between four blocks (24 items per word group (24 mass nouns, 24 plural count nouns)/ 4 conditions = 6 items of each distractor condition for each of the two word groups (mass nouns and count nouns per block). No target picture appeared more than once in a block. Participants received the 4 blocks with a short break between blocks. The order of the blocks was counterbalanced across the participants. Order of stimuli within each block was randomised for each participant. The experimental phase started with 14 training pictures to familiarise participants with the new requirements. The procedure was similar to the practice phase with the exception that the participants did not receive any feedback. The entire experiment lasted approximately 40 minutes.

Analysis

A repeated measures analysis of variance (ANOVA) was carried out with target word category (two levels: mass noun targets, plural count noun targets) and noun distractor condition (three levels: countability congruent noun distractor, countability incongruent noun distractor, identical noun distractor to target word) as factors. Subsequently, a series of planned comparisons using related *t* tests (two-tailed) with mass and count noun targets combined was conducted to investigate the following factors predicted to affect performance: countability (countability congruent versus countability incongruent), identity (identity versus countability congruent & identity versus countability incongruent) and number (plural count noun targets: singular count noun distractors versus plural count noun distractors). Finally, we examined whether there was an effect of number on countability congruency with mass and plural count noun targets combined by comparing countability congruent distractors (plural count noun targets combined with singular count noun distractors and mass noun targets combined with mass noun distractors) with countability incongruent distractors (plural count noun targets combined with mass noun distractors, mass noun targets combined with singular count noun distractors). Similar analyses were conducted on error rates. We considered,the overall error rate and the error rate for determiners separately. We hypothesized that countability incongruency was more likely to result in determiner errors than in noun errors.

Results

Two count noun targets (steaks, melons) were excluded due to their 'dual' status - the fact that they were commonly used as both mass nouns and count nouns. To ensure that the remaining count noun targets and mass noun targets were matched for all the variables noted above, two mass noun targets (basil, mustard) were also excluded. All response trials were checked for accuracy and timing using CheckVocal[15] (Protopapas, 2007) to ensure that the voice-trigger mechanism had correctly registered the beginning of the response. Trials which were mistriggered (e.g., through lip smacking, heavy breathing, movements or sound volume) were adjusted with CheckVocal. Trials in which the participant responded incorrectly (220 data points, 2.6%), 'no responses' (12 data points, 0.14%) and where the participants stuttered or hesitated noisily (e.g., hesitation fillers such as 'ahm' or coughing) (203 data points, 2.4%) were excluded. We then removed trials with naming latencies faster than 300 ms and slower than 1500ms and those which were more than three

[15] CheckVocal is a Windows program which aims to facilitate the manual processing of spoken responses. It determines response accuracy, and it also ensures that the voice-trigger mechanism has correctly registered the participant's naming response, because it is very likely that voice keys are triggered by non-speech sounds made by the participant prior to the response (e.g., lip smacking, coughing, and hesitation fillers), or late responses to the preceding items. Although it is possible to exclude some sources of timing errors by setting absolute thresholds (e.g., discarding response times below 100 ms or above a certain delay), it is not possible to ensure reliable response times entirely automatically (Protopapas, 2007, p. 859).

standard deviations above or below the mean of the participant (208 data points, 2.58 %). The mean naming latencies and error rates are summarised in Table 2.

Table 2 *Mean picture naming latencies (in ms) and standard deviations (SD), percentage errors and standard deviations (SD) for Experiment 1.*

	Target condition					
	Count (Plural)			Mass		
Distractor condition	Latency (SD)	Errors (SD)	Distractor noun category	Latency (SD)	Errors (SD)	Distractor noun category
Countability Congruent	730 (108.1)	2.1% (0.7)	plural count noun *(number congruent)*	757 (104.5)	3.8% (1.0)	mass noun
Countability Incongruent	745 (115.4)	2.5% (0.7)	mass noun	769 (102.7)	4.0% (1.0)	plural count noun
Identity	683 (97.6)	1.4% (0.6)	plural count noun	694 (84.0)	0.9% (0.5)	mass noun
Singular Count	733 (109.2)	1.7% (0.7)	singular count noun *(number incongruent)*	761 (109.9)	3.2% (1.0)	*singular count noun (countability incongruent)*
Total	*738 (119.2)*	*1.9% (1.7)*		*758 (115.8)*	*3.0% (2.5)*	

Latency Analyses

There was a significant effect on latency of target word category in the participant analysis ($F_1(1,47) = 16.259$, $p < .001$) but not in the item analysis ($F_2(1,21) = 2.779$, $p = .110$; count nouns, 735 ms (SD 119.2); mass nouns, 755 ms (SD 115.8))[16]. . However, there was a significant effect of noun distractor condition ($F_1(2, 94) = 90.175$, $p < .001$; $F_2(2,42) = 111.764$, $p < .001$). The interaction between target word category and noun distractor condition was not significant in either the participant (($F_1(2,94) = 2.453$, $p = .092$) or the item analysis ($F_2(2,42) = 1.532$, $p = .229$). This indicates that the noun distractor conditions had similar effects on the naming latencies of the two target word categories (plural count nouns, mass nouns).

Planned comparisons: countability congruency, identity and number.

Naming of targets with countability congruent noun distractors (758 ms) was significantly faster than with countability incongruent noun distractors (772 ms) ($t1(47) = 3.87$, $p < .001$; $t2(43) = 3.07$, $p = .004$). The identity noun distractor condition (706ms) was faster than the countability congruent ($t1(47) = 9.33$, $p < .001$; $t2(43) = 10.65$, $p < .001$) and countability incongruent noun distractor condition ($t1(47) = 11.06$, $p < .001$; $t2(43) = 13.89$, $p < .001$). No effect of number was found ($t1(47) = 0.06$, $p = .955$; $t2(21) = 0.25$, $p = .801$): plural count noun targets were named as fast when combined with number congruent (plural count) noun distractor (740 ms) as with a number incongruent (singular count) noun distractor (741 ms).

[16] If results are only significant when averaged over subjects but not over items then they are inconclusive (Clark, 1973) and ambiguous (Andrews & Lo, 2013), hence, the effect is not reliable and can therefore not be generalised.

Planned comparison: countability congruency with singular count noun distractors.

The results showed a significant countability congruency effect ($t1(47) = 2.83$, $p = .007$; $t2(43) = 2.03$, $p = .048$) similar to the effect shown (above) with plural count noun distractors.

Error Analyses

Responses in which participants hesitated or stuttered were excluded from the error analysis. Errors included errors such as determiner and noun substitutions (e.g., not much oysters) and false starts (e.g., not mu many pears, not much gar mhm ginger), and determiner and noun omissions. A separate error analysis was conducted looking at determiner errors only (determiner substitutions and false starts of determiners) for responses which included the target noun. Percentage of the relevant error subtypes are summarised in Table 3.

Table 3 *Experiment 1 error data: Errors of each type as a percentage of total errors in each condition (determiner substitutions include countability congruent and incongruent determiner substitutions and false starts of determiners) and other error types (e.g., noun substitutions, omissions of nouns or determiners) and error sum for each target - distractor category.*

	Count noun conditions				Mass noun conditions			
Error types	Countability congruent	Countability incongruent	Count singular	Identity	Countability congruent	Countability incongruent	Count singular	Identity
Determiner substitution								
Countability incongruent	40.6%	63.3%	45.5%	41.2%	29.3%	47.7%	40.0%	70.0%
Countability congruent	0%	0%	0%	0%	0%	0%	0%	0%
Other Errors	59.4%	36.7%	54.6%	58.8%	70.7%	52.3%	60.0%	30.0%
Total number of errors	*32*	*30*	*22*	*17*	*41*	*44*	*35*	*10*

As in the latency data, there was no significant effect of target word category on errors ($F_1(1,47) = 1.736$, $p = .194$; $F_2(1,21) = 0.375$, $p = .455$), but there was a significant effect of distractor noun condition ($F_1(2,94) = 18.917$, $p < .001$; $F_2(2,42) = 10.109$, $p < .001$). The interaction between target word category and distractor condition was close to significance in the participant but not in the item analysis ($F_1(2,94) = 2.891$, $p = .064$; $F_2(2,42) = 1.667$, $p = .209$; see footnote 4, earlier).

The separate analysis of determiner errors revealed no effect of target word category ($F_1(1,47) = 0.009$, $p = .927$; $F_2(1,21) < .001$, $p = 1.00$), but a significant effect of noun distractor condition ($F_1(2,94) = 8.724$, $p = .001$; $F_2(2,42) = 4.086$, $p = .032$). There was no interaction between target word category and distractor condition ($F_1(2,94) = 0.107$, $p = .860$; $F_2(2,42) = 0.160$, $p = .801$).

Planned comparisons: countability congruency, identity and number.

In contrast to the latency analysis, no countability congruency effect was found in the overall error data ($t1(47) = 0.00$, $p = 1.00$; $t2(43) = 0.00$, $p = 1.00$), but, as in the latency data, there was a significant identity advantage for both countability congruent ($t1(47) = 4.45$, $p < .001$; $t2(43) = 4.83$, $p < .001$) and incongruent conditions ($t1(47) = 4.77$, $p < .001$; $t2(43) = 4.30$, $p < .001$). The lowest error rate was obtained in the identity condition (12%), compared to countability congruent (32%) and incongruent (32%) noun conditions. Consistent with the latency data, no significant effect of number (singular versus plural count noun distractors) was found for the plural count noun targets ($t1(47) = 1.16$, $p = .253$; $t2(21) = 1.42$, $p = .171$).

The separate analysis of determiner errors revealed results consistent with the latency data: a countability congruency effect which was significant in the participant and marginally significant in the item analysis ($t1(47) = 2.23$, $p = .031$; $t2(43) = 1.81$, $p = .077$); an identity effect with fewer errors (14%) compared to the countability congruent condition (24%), $t1(47) = 2.68$, $p = .010$; $t2(43) = 1.70$, $p = .09$), and the countability incongruent condition (39%), $t1(47) = 2.83$, $p = .007$; $t2(43) = 3.50$, $p = .001$). There was no effect of number on error rates for plural count noun targets ($t1(47) = 0.68$, $p = .497$; $t2(21) = 0.77$, $p = .451$).

Planned comparison: countability congruency with singular count noun distractors.

The results showed no significant countability congruency effect ($t1(47) = 0.22$, $p = .828$; $t2(43) = 0.16$, $p = .872$), for the overall error rates. The analysis of determiner errors revealed a significant countability congruency effect in the participant, but not in the item analysis ($t1(47) = 2.04$, $p = .047$; $t2(43) = 1.34$, $p = .188$; see footnote 4, earlier).

Discussion

This experiment investigated the processing of mass and count nouns during the production of noun phrases. The results demonstrated, first, that producing noun phrases using mass nouns or plural count nouns in response to pictures was significantly faster and more accurate in the identity distractor condition than in all of the other conditions (countability congruent condition, countability incongruent condition, and singular count noun condition). The presence of this identity advantage demonstrates both that the distractor words were processed and that the experiment was sensitive enough to generate effects.

Second, the results showed no significant effect of number congruency on noun phrase production: noun phrases containing plural count nouns were produced with the same latency and the same accuracy whether the distractors were singular or plural count nouns. This result replicates, in English, the absence of a number congruency effect found in earlier studies for German, Dutch and French (Alario, Ayora, Costa & Melinger, 2008; Schiller & Caramazza, 2002, 2003). These results are compatible with a theory which assumes separate number features for singular and plural at the lexical-syntactic level. These features are either solely activated and selected through conceptual-semantic information reflecting multiple to-be-expressed entities, or they could additionally receive some activation via the noun's lemma (see dotted line in Figure 1). The lack of a number congruency effect could be explained by the target picture activating the level of lexical concepts (and the MULTIPLE concept) more rapidly than the distractor word (Chapnik Smith & Magee, 1980; Glaser & Glaser, 1989). An alternative explanation could be that written distractor words bypass the semantic-conceptual level and instead send activation directly to their lexical-syntactic attributes via their noun lemma nodes. Number, as an extrinsic variable feature, must be set by conceptual-semantic activation. Consequently, activation from the distractor noun's lemma node to the number feature and subsequently determiner lemma node(s) would be insufficient to cause competition with the target's number feature/determiner. In both accounts the activation and setting of the number feature would be determined by the target (see Figure 1). Both accounts would be compatible with theories of either determiner or feature competition (Miozzo and Caramazza, 1999; Schriefers, 1993).

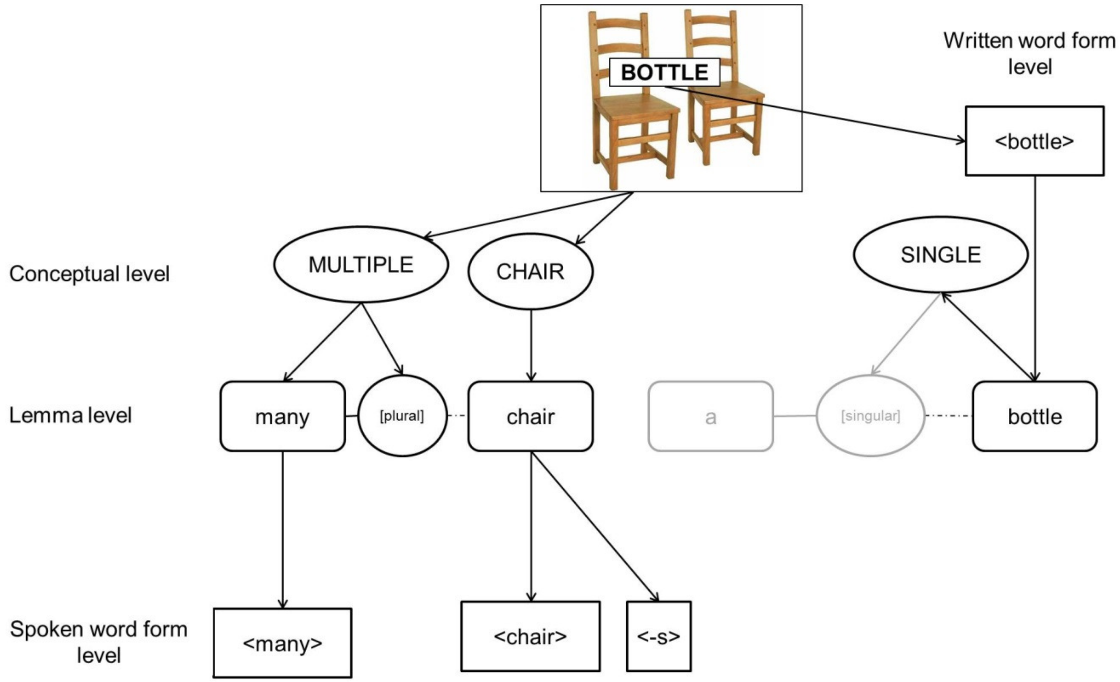

Figure 1. An illustration of number/determiner selection in the picture-word interference task (based on Levelt et al., 1999).

The setting of the extrinsic lexical-syntactic feature number requires predominantly, or solely, activation from a number concept (SINGLE or MULTIPLE). The target picture (chairs) directly activates the number concept (MULTIPLE) which activates the lexical-syntactic number feature ([plural]). The distractor word (bottle) has to activate first its orthographic word form and noun lemma representations before accessing the number concept (SINGLE). Therefore, the lack of number congruency can be explained by a delayed activation of the distractor word's number feature ([singular]) via the number concept, or by weak activation of the number feature through its noun lemma node if access of the conceptual-semantic level is bypassed.

Finally, and most importantly, this experiment demonstrated a countability congruency effect for mass nouns and count nouns: Naming pictures with plural count noun phrases (not many_) was significantly faster with a count noun distractor than a mass noun distractor, and naming pictures with mass noun phrases (not much_) was significantly faster when the distractor was a mass noun rather than a count noun. This countability congruency effect was obtained for both mass and count noun targets in the naming latency and determiner error data, as reflected in the absence of an interaction between target word category and distractor condition.

The countability congruency effect confirms that grammatical mass/count information has a psychological reality. Moreover, since we controlled for semantic variables (imageability, concept familiarity) and used predominantly mass nouns or images of mass nouns which depict them as discrete entities (e.g., a loaf of bread, a bulb of garlic, a bottle of mascara), we can infer that the grammatical effect is relatively independent of conceptual-semantic information. Consequently, we can conclude that nouns are specified for countability at the lexical-syntactic (lemma) level.

The symmetrical patterns of countability congruency found here are identical to those found in the experiments on grammatical gender (Costa, Kovacic, Fedorenko & Caramazza, 2003; La Heij, Mak, Sander & Willeboordse, 1998; Schiller & Caramazza, 2003; Schriefers, 1993; Schriefers & Teruel, 2000; Van Berkum, 1997). Thus, it seems plausible that countability is represented in a similar way to grammatical gender, as a fixed intrinsic lexical-syntactic property (like gender) opposed to a variable extrinsic lexical-syntactic feature (like number).

Even though we can draw conclusions about the representation of countability information at the lexical-syntactic level and hence extend Levelt et al.'s theory, we cannot identify the source of interference in the picture-word interference experiment. In other words, we cannot distinguish whether the countability congruency effect is the result of competition between the fixed intrinsic lexical-syntactic properties [mass] versus [count] or between the two determiners 'much' versus 'many' for the target and distractor noun. Therefore, this issue is addressed in our second experiment. To identify the source of the countability congruency effect, we used countability specific determiners instead of nouns as distractors. So far, only one picture-word interference study has used determiners as distractors. Alario et al. (2008) used determiner distractors which were more or less similar to the target determiner in terms of grammatical gender and definiteness to investigate determiner selection in French, Spanish and German. The results revealed an identity and gender congruency effect which showed that noun phrase production latencies were influenced by the properties of determiner distractors.

Experiment 2: Determiner Congruency

Like Experiment 1, Experiment 2 used a picture-word interference paradigm in which participants were asked to name mass and count noun pictures with a noun phrase ('not many_' for count nouns, 'not much_' for mass nouns). In order to detect whether the countabilty congruency effect could be ascribed to competition between fixed intrinsic lexical-syntactic properties or between determiners the following five determiner distractor conditions were included: (a.) countability congruent ('few' for count nouns; ‘little’ for mass nouns), (b) countability incongruent (‘little’ for count nouns; ‘few’ for mass nouns), (c) baseline (a row of four Xs), (d) identity (‘many’ for count nouns; ‘much’ for mass nouns); (e) nonidentity (‘much’ for count nouns; ‘many’ for mass nouns) (see Table 4).

Table 4 *Representation of the different target-distractor conditions for Experiment 2.*

	Target Pictures			
	Count (apples)		Mass (bacon)	
Distractor condition	Distractor determiner	Distractor determiner category	Distractor determiner	Distractor determiner category
Countability Congruent	few	plural count noun determiner	little	mass noun determiner
Countability Incongruent	little	mass noun determiner	few	plural count noun determiner
Identity	many	plural count noun determiner	much	mass noun determiner
Non-Identity	much	mass noun determiner	many	plural count noun determiner
Baseline	XXXX	-	XXXX	-

The main focus of this experiment lies in the comparison between the countability congruent and incongruent condition in order to determine the source of the countability congruency effect. A neutral distractor condition (i.e. XXXX) was included in the attempt to identify whether any congruency effects were due to facilitation or competition. The non-identity condition served only as a filler condition to ensure that participants do not recognize the identity condition and therefore strategically pay only attention to determiners which are identical to the target determiner.

Under the assumption that determiner distractors also activate their lexical-syntactic attributes (Alario et al., 2008), we can make the following predictions: If the countability congruency effect, observed in Experiment 1, reflects competition between the fixed intrinsic lexical-syntactic properties [mass] and [count], we would expect to find a countability congruency effect in Experiment 2, and hence the naming latencies of the countability congruent condition (a) to be shorter than of the countability incongruent condition (b). If the countability congruency effect is a result of determiner competition, we would expect to find no countability congruency effect and consequently no difference between the congruent and incongruent determiner conditions (a) and (b) as in both conditions the determiner distractors are different to the target determiner. Alternatively, Alario et al. (2008) proposed that competition between target and distractor determiners could be stronger in a lexical-syntactically congruent condition compared to an incongruent condition. They argued that this arises due to the target and distractor determiner similarity in lexical-syntax in the congruent condition (e.g. mass noun phrase (not much broccoli) with a mass noun distractor ‘little’) which could lead to an increase of activation for the distractor determiner and consequently result in increased competition between distractor and target determiner (see General Discussion). Hence, an alternative prediction for determiner competition is a reversed congruency effect with countability congruent determiner distractors (condition a), leading to longer naming latencies than countability incongruent determiner distractors (condition b).

Method

Participants

40 students (18-55 years) from Macquarie University, who were native speakers of English and did not take part in the previous experiment, participated in this study. Participants received either course credits or $15 in exchange for their participation.

Material

The material was similar to that of Experiment 1. 60 picture stimuli were used with 30 pictures representing mass nouns (including 50% of the mass noun items from Experiment 1) and 30 pictures representing plural count nouns (including 33% of the plural count noun items from Experiment 1) (see Appendix D). Both noun groups were matched for the same variables as in Experiment 1 (see Appendix E).

In this experiment, we controlled the selection of mass and count noun items even more tightly than in Experiment 1, using Vigliocco, Vinson, Martin and Garrett’s (1999) technique for rating countability: 20 participants were given a list of nouns and three different pairs of sentence contexts of which one was grammatically restricted to count nouns and the other to mass nouns ((a) There is …$_{mass}$ vs. There is a …$_{count}$, (b) There won't be much…$_{mass}$ vs. There won't be many…$_{count}$, (c) There is some…$_{mass}$ vs. There are a few…$_{count}$). The participants were asked to select the appropriate one for each noun and also to decide whether the noun could form a plural. The average number of mass noun contexts and count noun contexts were calculated for each word. Only those nouns with an average of more than 3.5 out of a possible four for the appropriate context were selected.

Design and Procedure

The design and procedure was identical to the one in Experiment 1, except for the number of items and conditions. The testing phase consisted of 5 blocks. Each block comprised 60 target pictures with a superimposed distractor from one of the five determiner distractor conditions. Target-distractor conditions were distributed evenly between the five blocks so that each block contained 6 items of each determiner distractor condition for the two target noun groups (mass vs. count). The order of blocks was counterbalanced across participants through a Latin Square design. The entire experiment lasted approximately 45 minutes.

Analysis

As in Experiment 1, we looked first for main effects of target noun type and distractor conditions and any interactions using repeated measures ANOVA with target word category (two levels: mass noun targets, plural count noun targets) and (determiner) distractor condition (four levels: countability congruent determiner distractor, countability incongruent determiner distractor, identical determiner distractor and Baseline) as factors. Subsequently, a series of planned comparisons using related *t* tests (two-tailed) with mass and count noun targets combined was conducted to investigate the following effects of noun distractor conditions further: countability (countability congruent versus countability incongruent), identity (identity versus countability congruent, identity versus countability incongruent, identity versus baseline) and baseline (countability congruent versus baseline, countability incongruent versus baseline). Similar analyses were conducted on the overall error rate and separately on the determiner errors.

Results

As in Experiment 1 response trials were checked for accuracy and timing using CheckVocal (Protopapas, 2007). Participants' errors (236 data points, 2.0%), 'no responses' (4 data points, 0.03%) and hesitations (178 data points, 1.5%) were excluded. Trials where naming latencies were faster than 300 ms and slower than 1500 ms, and those which were more than three standard deviations above or below the mean of the participant (223 data points, 1.9%) were removed. The mean naming latencies and error rates are summarised in Table 5.

Table 5 *Mean picture naming latencies (in ms) and standard deviations (SD), percentage errors (%) and standard deviations (SD) for Experiment 2.*

	Target condition					
	Count (Plural)			Mass		
Distractor condition	Latency (SD)	Errors (SD)	Distractor determiner category	Latency (SD)	Errors (SD)	Distractor determiner category
Countability Congruent	716 (96.7)	2.3% (1.0)	plural count	719 (96.1)	1.7% (0.6)	mass
Countability Incongruent	712 (94.7)	2.8% (1.5)	mass	707 (92.2)	1.1% (0.5)	plural count
Identity	680 (95.4)	2.8% (1.1)	plural count	689 (96.8)	1.8% (0.7)	mass
Baseline	698 (86.7)	1.9% (0.8)	-	709 (88.9)	0.8% (0.5)	-
Total	*705 (91.3)*	*2.4% (3.7)*		*709 (92.3)*	*1.4% (1.3)*	

Latency Analyses

There was no significant effect on latency of target word category (mass versus count) ($F_1(1,39) = 1.256$, $p = .269$; $F_2(1,29) = 0.469$, $p = .499$). The effect of determiner distractor type was highly significant by participants and by items ($F_1(3,117) = 26.887$, $p < .001$; $F_2(3,87) = 26.718$, $p < .001$). The interaction between target word category and determiner distractor type was significant by participants, but not by items (($F_1(3,117) = 3.930$, $p = .013$; $F_2(3,87) = 1.556$, $p = .209$; see footnote 4, earlier).

Planned comparisons: countability congruency, identity and baseline.

There was a (reverse) countability congruency effect which was marginally significant by participants and significant by items ($t1(39) = 1.97$, $p = .056$; $t2(59) = 2.38$, $p = .021$): Target pictures were named faster with countability incongruent determiner distractors (709 ms) than with countability congruent determiner distractors (718 ms). The identity determiner condition resulted in significantly faster naming latencies compared to countability congruent determiner distractors ($t1(39) = 6.87$, $p < .001$; $t2(59) = 8.03$, $p < .001$), countability incongruent determiner distractors ($t1(39) = 8.26$, $p < .001$; $t2(59) = 6.23$, $p < .001$) and the baseline ($t1(39) = 5.84$, $p = .001$; $t2(59) = 4.68$, $p < .001$). Finally, the baseline condition (703ms) was significantly faster than the countability congruent determiner distractor condition (718ms) ($t1(39) = 3.33$, $p = .002$; $t2(59) = 3.76$, $p < .001$) and the countability incongruent condition (709ms) by participants, but not by items ($t1(39) = 2.11$, $p = .041$; $t2(59) = 1.30$, $p = .197$; see footnote 4, earlier).

Error Analyses

Percentage of the relevant error subtypes are summarised in Table 6.

The analysis of the overall error rates revealed a significant effect for target word category in both participant and item analyses ($F_1(1,36) = 6.250$, $p =.017$; $F_2(1,29) = 6.845$, $p = .014$). Participants produced more errors when they named plural count noun pictures compared to mass noun pictures. The effect of determiner distractor type was only marginally significant by participants but not significant by items ($F_1(3,108) = 2.551$, $p =.059$; $F_2(3,87) = 1.816$, $p = .151$). The interaction between target word category and determiner distractor type was not significant ($F_1(3,108) = 0.875$, $p = .446$; $F_2(3.87) = 1.041$, $p = .361$).

The analysis of determiner errors only revealed a significant effect for target word category ($F_1(1,39) = 7.501$, $p =.009$; $F_2(1,29) = 16.208$, $p < .001$) with plural count noun targets leading to a higher error rate than mass noun targets. There was no significant effect of determiner distractor type ($F_1(3,117) = 2.072$, $p =.117$; $F_2(3,87) = 1.345$, $p = .268$) nor a significant interaction between target word category and determiner distractor type ($F_1(3,117) = 1.332$, $p =.270$; $F_2(3,87) = 1.046$, $p = .373$).

Table 6 *Experiment 2 error data: Errors of each type as a percentage of total errors in each condition (determiner substitutions include countability congruent and incongruent determiner substitutions and false starts of determiners) and other error types (e.g., noun substitutions, omissions of nouns or determiners) and error sum for each distractor category.*

	Count nouns				Mass nouns			
Error types	Countability congruent	Countability incongruent	Count Baseline	Identity	Countability congruent	Countability incongruent	Count Baseline	Identity
Determiner substitution								
Countability incongruent	40.7%	55.9%	60.9%	57.6%	40.0%	15.4%	40.0%	27.3%
Countability congruent	0%	2.9%	0%	0%	0%	0%	0%	0%
Others	59.3%	41.2%	39.1%	42.4%	60.0%	84.6%	60.0%	72.7%
Total number of errors	*27*	*34*	*23*	*33*	*20*	*13*	*10*	*22*

Discussion

As in Experiment 1, Experiment 2 showed an identity effect on naming latencies confirming that the experiment was sensitive enough to generate effects even with determiners as distractors. The identity condition was faster compared to the baseline and all of the other determiner distractor conditions which can be attributed to additional converging activation for the target determiner from the target picture and the presented written determiner.

Most importantly, as in Experiment 1, Experiment 2 revealed a countability congruency effect. However, the countability congruency effect in Experiment 2 was reversed leading to faster naming latencies for the countability incongruent condition compared to the countability congruent condition. The reversed countability congruency effect stands in contrast with predictions of either a 'classical' countability congruency effect in the case of competition between the fixed intrinsic lexical-syntactic properties [mass] and [count], or no countability congruency effect in the case of determiner competition. Instead, this effect is consistent with an account of determiner competition whereby countability congruent determiner distractors are stronger competitors with the target determiner than countability incongruent distractors due to their shared lexical-syntactic attributes. A countability congruent determiner distractor could be thought to be activated not only by the written word but also receive activation from the target noun's lexical-syntactic property [mass] or [count] (see Figure 2) and hence be more highly activated than a countability incongruent determiner distractor. Even though the fixed intrinsic lexical-syntactic properties [mass]/[count] are a crucial requirement in the creation of this effect, the countability congruency effect itself can be best explained by determiner competition.

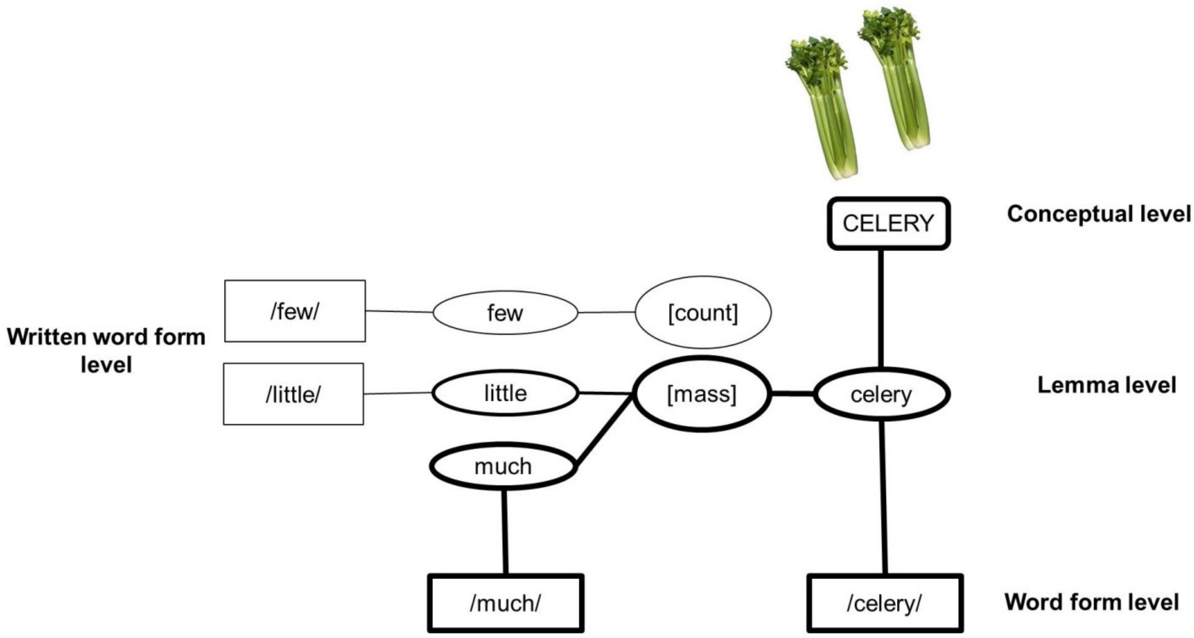

Figure 2. Competition between the target mass noun determiner ‘much’ and the countability congruent determiner distractor ‘little’, compared to the countability incongruent determiner ‘few’.

Finally, the results of the baseline (row of Xs) are in line with our predictions for determiner competition. Naming latencies were significantly longer for pictures with countability congruent determiner distractors compared to the baseline as predicted by a competition account. No reliable effect (only significant by subjects) was found for countability incongruent determiner distractors. Even though a similar baseline condition has been used in previous picture-word interference studies (e.g., Janssen, Melinger, Mahon, Finkbeiner & Caramazza, 2010; Pechmann, Garrett & Zerbst, 2004), the results should be interpreted carefully as there has been debate regarding the nature of this distractor on processing: its effects could be based on, for example, the fact that it is visually less complex (Bloem & La Heij, 2003) and non-lexical (Alario et al., 2008) and therefore faster (Jonides & Mack, 1984) and more accurately processed compared to lexical distractors.

General Discussion

This is the first reported series of experiments to use the picture-word interference paradigm to investigate the effects of countability congruency on noun phrase production. Moreover, Experiment 2 is one of only a few to use determiners, instead of nouns as distractors. The aim of this study was to investigate the representation and selection of countability information and mass/count noun specific determiners at the lexical-syntactic level. More specifically, we were interested in whether countability information is represented in the form of a fixed intrinsic lexical-syntactic property or a variable extrinsic feature and whether the selection of these attributes or their determiners is competitive. The two picture-word interference experiments reported here showed that noun phrase production was influenced by lexical-syntactic properties of both noun and determiner distractors: Both experiments showed an effect of countability congruency. In the first experiment with nouns as distractors, we found a classical congruency effect with faster naming latencies for countability congruent distractors than for countability incongruent distractors. Similar effects have been found in previous picture-word interference studies which (a) investigated other grammatical properties such as grammatical gender, and (b) used nouns as distractors (e.g. Schriefers, 1993; Schiller & Caramazza, 2003). We therefore suggest that countability is represented in a similar way to grammatical gender, in the form of a fixed intrinsic lexical-syntactic property rather than as a variable extrinsic lexical-syntactic feature (like number).

In the second experiment using determiners as distractors, we found a reversed countability congruency effect with faster naming latencies for countability incongruent distractors than for countability congruent distractors. This result could not be explained by competition/facilitation between lexical-syntactic properties. Instead, the direction of the countability congruency effect supports previous assumptions of determiner competition (Alarion et al., 2008) where a linguistically more similar (congruent) determiner competes more strongly with the target determiner than a linguistically less similar (incongruent) determiner. Faster naming latencies for the baseline condition compared to the countability congruent condition in Experiment 2 could be taken as additional evidence for determiner competition.

At first glance, the countability congruency effects found in Experiments 1 and 2 seem to be conflicting, however, both effects can be explained with the same mechanism of activation and selection: competition between determiners as described for Experiment 2 (see Figure 2 earlier). The differences in results across the experiments can be accounted for by the difference in processing steps for noun distractors compared to determiner distractors. In Experiment 1, noun distractors activate their lexical-syntactic properties [mass] or [count]. These lexical-syntactic properties in turn activate their corresponding determiners. For example, in Figure 3, the picture of *celery* activates its concept and then its noun lemma. The noun lemma in turn activates the [mass] node which activates the lemmas of determiners, such as, 'much' and 'little' (mass noun determiners). At the same time, the written distractor word *soccer* activates its lemma (soccer), which in turn activates the [mass] node and the mass noun determiners. In the *countability congruent condition*, the determiners activated by the distractor are the same as those activated by the target noun (e.g., little, much) and include the target determiner. Hence, in the congruent condition, the target determiner receives activation twice, once from the target noun and once from the distractor noun. The target determiner always receives more activation than alternative determiners due to being part of the response set (much, many). Consequently, the target noun determiner remains the most highly activated determiner (see Figure 3). In contrast, in the *countability incongruent condition*, it is determiners which are countability incongruent to the target noun which are activated by the noun distractor, while the target noun determiner receives only activation from the target noun. Hence, in Figure 4, the written distractor *zebras* activates the corresponding lemma zebra which activates the [count] node. In turn this activates count noun determiners such as 'many' and 'few'. These determiners will be almost as highly activated as the target determiner (and particularly many which is in the response set) which leads to stronger competition and therefore longer naming latencies compared to the countability congruent condition.

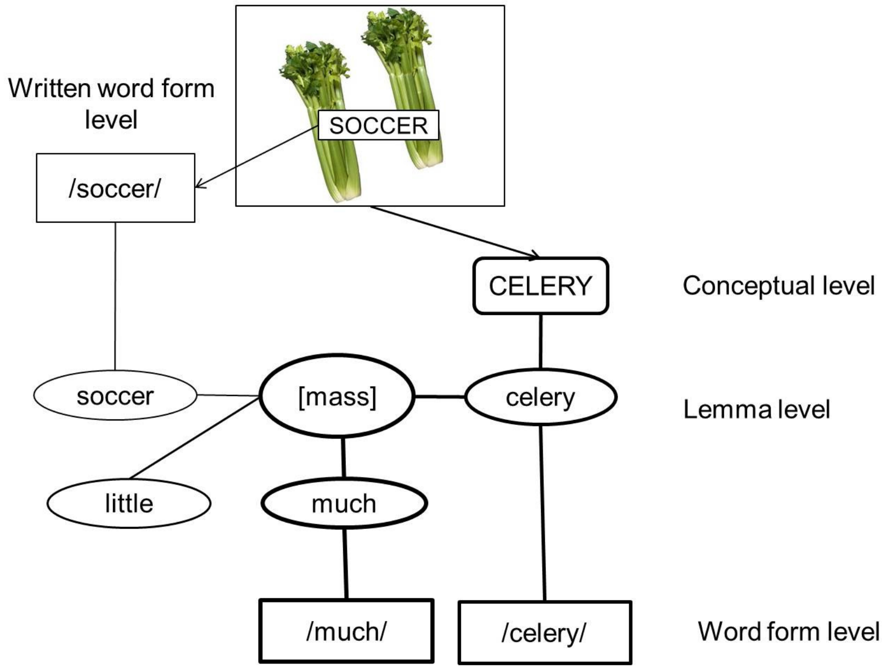

Figure 3. Competition between the target mass noun determiner ‘much’ and the countability congruent determiner ‘little’ activated by the distractor noun.

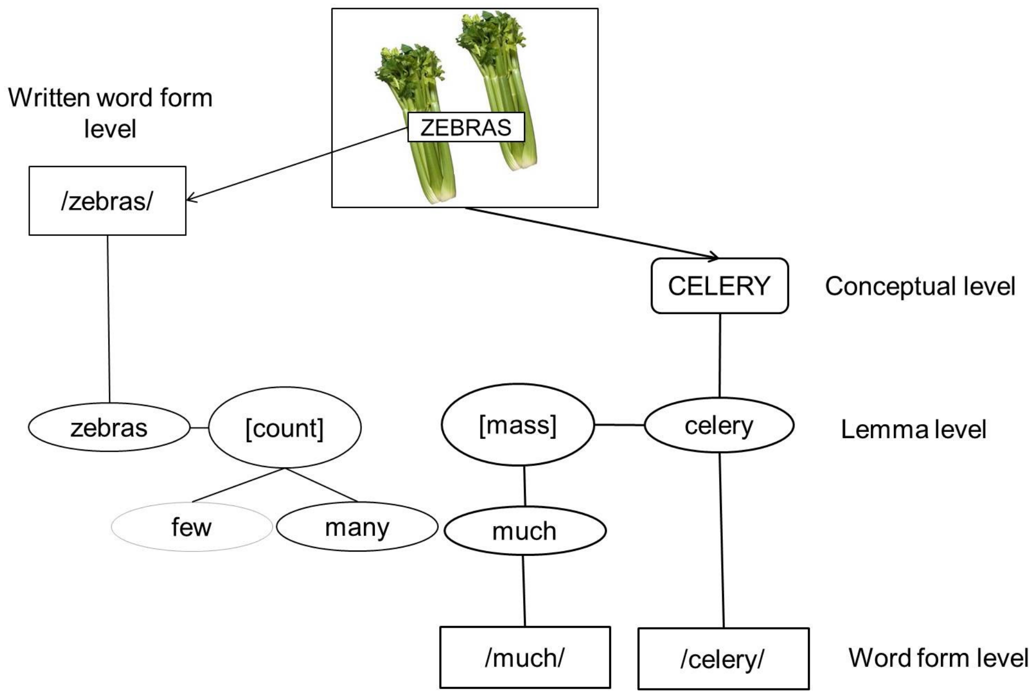

Figure 4. Competition between the target mass noun determiner ‘much’ and the countability incongruent determiner ‘many’ activated by the distractor noun.

In Experiment 2, the target noun activates its lexical-syntactic properties [mass]/[count] and subsequently lemma nodes of appropriate determiners, these will include not only the target determiner (e.g. ‘much’ for mass nouns) but also other countability congruent determiners, which will include the distractor determiner (e.g. little; see Figure 2, earlier). Hence, the countability congruent distractor determiner (little/few) receives activation twice, once from the target noun picture and once from the written distractor word. Therefore, the highly activated countability congruent distractor determiner (little) is more strongly activated than the countability incongruent determiner distractor (e.g. few). The countability incongruent distractor determiner receives activation only once from its written word form but not from the target noun. Consequently it is countability congruent distractors which are the strongest activated and hence are the largest competitors for the target determiner.

Finally, in Experiment 1 we replicated in English earlier studies which failed to find a number congruency effect In German and Dutch (Schiller & Caramazza, 2002, 2003). We accounted for the absence of a number congruency effect by the late activation of the number feature by the written distractor compared to the target picture. As number is a variable extrinsic lexical-syntactic feature it needs to be set by conceptual-semantic information, which is accessed first by the target picture and only later by the written distractor word. In contrast, the setting of fixed intrinsic lexical-syntactic properties, such as mass/count is purely lexical-syntactic and can be therefore accessed directly by the noun lemma of the target picture and distractor word. This allows a ‘property’ incongruent distractor to influence the process of determiner selection.

Conclusion

Our objective was to investigate how mass/count information is represented and processed at the lexical-syntactic level. This study derived its methodology from earlier studies which found an effect of gender congruency in different languages but failed to find similar effects of number congruency (e.g., Schiller & Caramazza, 2002, 2003). These results exemplified differences in representation between fixed intrinsic lexical-syntactic properties, such as grammatical gender, and variable extrinsic lexical-syntactic features like number. Taking the conceptual-semantic and grammatical nature and usage of mass and count nouns into account, it was possible that countability could be represented in either way, as a fixed intrinsic lexical-syntactic property or as a variable extrinsic lexical-syntactic feature. Our first experiment, using picture-word interference with nouns as distractors provides the first demonstration of a countability congruency effect on noun phrase production. Our results strongly suggest that countability information is represented in a similar way to grammatical gender: by fixed intrinsic lexical-syntactic properties, [mass] for mass nouns and [count] for count nouns which are activated and selected through the noun’s specific lemma node, rather than as a variable extrinsic syntactic feature whose selection depends on conceptual-semantic information. The results of our second picture-word interference study with determiners as distractors showed a reversed countability congruency effect which is consistent with the account of determiner competition. We conclude that the selection of mass and count specific determiners is a competitive process the outcome of which depends on the strength of activation from the noun’s lexical-syntactic properties, [mass] and [count].

References

Alario, F.-X., Ayora, P., Costa, A. & Melinger, A. (2008). Grammatical and Nongrammatical Contributions to Closed-Class Word Selection. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(4), 960-981.

Alario, F.-X. & Caramazza, A. (2002). The production of determiners: evidence from French. *Cognition*, 82, 179-223.

Alario, F.-X. & Ferrand, L. (1999). A set of 400 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. *Behavior Research Methods, Instruments, & Computers,* 31(3), 531-552.

Alario, F.-X., Matos, R.E. & Segui, J. (2004). Gender congruency effects in picture naming. *Acta Psychologica,* 117, 185-204.

Allan, K. (1980). Nouns and Countability. *Language, 56*, 541-547.

Andrews, S. & Lo, S. (2013). Is morphological priming stronger for transparent than for opaque words? It depends on individual differences in spelling and vocabulary. *Journal of Memory and Language*, 68(3), 279-296.

Baayen, R. H., Piepenbrock, R. & Gulikers, L. (1995). *The CELEX lexical database (CD-ROM).* Philadelphia, PA: Linguistic Data Consortium. University of Pensylvania.

Baayen, R. H., Piepenbrock, R. & van Rijn, H. (1993). *The CELEX Lexical Database (Release 1) [CD-ROM].* Philadelphia: PA: Linguistic Data Consortium. University of Pensylvania.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B. & Treiman, R. (2007). The English Lexicon Project. Behavior Research Methods, 39, 445-459.

Barner, D. & Snedeker, J. (2005). Quantity judgments and individuation: evidence that mass nouns count. *Cognition,* 97, 41-66.

Barner, D. & Snedeker, J. (2006). Children's Early Understanding of Mass–Count Syntax: Individuation, Lexical Content, and the Number Asymmetry Hypothesis. *Language Learning and Development,* 2(3), 163-194.

Bloem, I. & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, 48, 468-488.

Bordag, D. & Pechmann, T. (2008). Grammatical Gender in Speech Production: Evidence from Czech. *Journal of Psycholinguistic Research*, 37, 69-85.

Bordag, D. & Pechmann, T. (2009). Externality, Internality, and (In)Dispensability of Grammatical Features in Speech Production: Evidence from Czech Declension and Conjugation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(2), 446-465.

Caramazza, A. (1997). How many levels of processing are there in lexical access?. *Cognitive neuropsychology*, *14*(1), 177-208.

Chapnik Smith, M. & Magee, L.E. (1980). Tracing the Time Course of Picture-Word Processing. *Journal of Experimental Psychology: General*, 109(4), 373-392.

Cheng, C. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Clark, H. H. (1973). The Language-as-Fixed-Effect Fallacy: A Critique of Language Statistics in Psychological Research. *Journal of Verbal Learning and verbal Behavior*, 12, 335-359.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Database,* 33, 497-505.

Costa, A., Kovacic, D., Fedorenko, E. & Caramazza, A. (2003). The Gender Congruency Effect and the Selection of Freestanding and Bound Morphemes: Evidence From Croatian. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(6), 1270-1282.

Costa, A., Mahon, B., Savova, V. & Caramazza, A. (2003). Level of categorisation effect: A novel effect in the picture-word interference paradigm. *Language and Cognitive Processes,* 18(2), 205-233.

Forster, K. I. & Forster, J.C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers,* 35(1), 116-124.

Garrard, P., Carroll, E., Vinson, D. & Vigliocco, G. (2004). Dissociation of Lexical Syntax and Semantics: Evidence from Focal Cortical Degeneration. *Neurocase,*10(5), 353-362.

Gilhooly, K. J. & Hay, D. (1977). Imagery, concreteness, age-of-acquisition, familiarity, and meaningfulness values for 205 five-letter words having single-solution anagrams. *Behavior Research Methods and Instrumentation,* 9(1), 12-17.

Gillon, B., Kehayia, E. & Taler, V. (1999). The Mass/Count Distinction: Evidence from On-Line Psycholinguistic Performance. *Brain and Language,* 68, 205-211.

Glaser, W.R. & Glaser, M.O. (1989). Context Effects in Stroop-Like Word and Picture Processing. *Journal of Experimental Psychology: General*, 118(1), 13-42.

Grandy, R.G. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Janssen, N. & Caramazza, A. (2003). The selection of closed-class words in noun phrase production: The case of Dutch determiners. *Journal of Memory and Language*, 48, 635-652.

Janssen, N., Melinger, A., Mahon, B. Z., Finkbeiner, M. & Caramazza, A. (2010). The word class effect in the picture-word interference paradigm. The *Quarterly Journal of Experimental Psychology*, 63(6), 1233-1246.

Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. *Psychological Bulletin*, 96(1), 29-44.

La Heij, W., Mak, P., Sander, J. & Willeboordse, E. (1998). The gender-congruency effect in picture-word tasks. *Psychological Research*, 61, 209-219.

Langacker, R. W. (1987). Nouns and Verbs. *Language*, 63(1), 53-94.

Levelt, W. J. M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences,* 22, 1-75.

Middleton, E. L., Wisniewski, E.J., Trindel, K.A. & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language,* 50, 371-394.

Middleton, E.L. (2008). Mass Matters. *Dissertation Abstracts International*, 70(02), (UMI No. 3347451).

Miozzo, M., & Caramazza, A. (1999). The Selection of Determiners in Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 25(4), 907-922.

Mondini, S., Kehayia, E., Gillon, B., Arcara, G. & Jarema, G. (2009). Lexical access of mass and count nouns. How word recognition reaction times correlate with lexical and morpho-syntactic processing. *Mental Lexicon,* 4(3), 354-379.

Nickels, L., Biedermann, B., Fieder, N. & Schiller, N.O. (submitted) The Lexical syntactic representation of number. *Language and Cognitive Processes,* invited paper.

Paivio, A., Yuille, J.C. & Madigan, S. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monograph,* 76(1/2).

Pechmann, T., Garrett, M. & Zerbst, D. (2004). The time course of recovery for grammatical category information during lexical processing for syntactic construction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(3), 723-728.

Protopapas, A. (2007). CheckVocal: A program to facilitate checking the accuracy and response time of vocal responses from DMDX. *Behavior Research Methods,* 39(4), 859-862.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, 42, 107-142.

Schiller, N. O. & Caramazza, A. (2002). The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German. *Brain and Language,* 81, 342-357.

Schiller, N. O. & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. *Journal of Memory and Language,* 48, 169-194.

Schiller, N. O. & Caramazza, A. (2006). Grammatical gender selection and the representation of morphemes: The production of Dutch diminutives. *Language and Cognitive Processes,* 21(7-8), 945-973.

Schiller, N. O., Münte, T. F., Horemans, I. & Jansma, B. M. (2003). The influence of semantic and phonological factors on syntactic decisions: An event-related brain potential study. *Psychophysiology*, 40, 869-877.

Schriefers, H. (1993). Syntactic Processes in the Production of Noun Phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19(4), 841-850.

Schriefers, H. & Jescheniak, J.D. (1999). Representation and processing of grammatical gender in language production: A review. *Journal of Psycholinguistic Research*, 28(6), 575-600.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2002). Determiner Selection in Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 28(5), 941-950.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2005). Selection of Gender-Marked Morphemes in Speech Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 31(1), 159-168.

Schriefers, H., Meyer, A.S. & Levelt, W.J.M. (1990). Exploring the Time Course of Lexical Access in Langugae Production: Picture-Word Interference Studies. *Journal of Memory and Language,* 29, 86-102.

Schriefers, H. & Teruel, E. (2000). Grammatical Gender in Noun Phrase Production: The Gender Interference Effect in German. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 26(6), 1368-1377.

Shapiro, L.P., Zurif, E., Carey, S. & Grossman, M. (1989). Comprehension of lexical subcategory distinctions by aphasic patients: proper/common and mass/count nouns. *Journal of Speech and Hearing Research*, *32*, 481-488.

Spalek, K. & Schriefers, H.J. (2005). Dominance affects determiner selection in language production. *Journal of Memory and Language,* 52, 103-119.

Starreveld, P.A. & La Heij, W. (2004). Phonological facilitation of grammatical gender retrieval. *Language and Cognitive Processes*, 19(6), 677-711.

Steinhauer, K., Pancheva, R., Newman, A.J., Gennari, S. & Ullman, M.T. (2001). How the mass counts: An electrophysiological approach to the processing of lexical features. *Cognitive Neuroscience and Neuropsychology*, 12(5), 999-1005.

Taler, V. & Jarema, G. (2006). On-line lexical processing in AD and MCI: An early measure of cognitive impairment? *Journal of Neurolinguistics,* 19, 38-55.

Taler, V. & Jarema, G. (2007). Lexical Access in Younger and Older Adults: The Case of the Mass/Count Distinction. *Canadian Journal of Experimental Psychology,* 61(1), 21-34.

Van Berkum, J. J. A. (1997). Syntactic processes in speech production: the retrieval of grammatical gender. *Cognition,* 64, 115-152.

Vigliocco, G., Vinson, D.P., Martin, R.C. & Garrett, M.F. (1999). Is "Count" and "Mass" Information Available When the Noun Is Not? An Investigation of Tip of the Tongue States and Anomia. *Journal of Memory and Language,* 40, 534-558.

Wierzbicka, A. (1988). *The semantics of grammar*. Amsterdam: John Benjamins.

Wisniewski, E. J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and Cognitive Processes,* 18(5/6), 583-624.

Author Note

During the preparation of this paper, Nora Fieder was funded by a Macquarie University Research Excellence (MQRES) scholarship, Lyndsey Nickels was funded by an Australian National Health and Medical Research Council Senior Research Fellowship and an Australian Research Council Future Fellowship and Britta Biedermann by a Macquarie University Research Fellowship, and an ARC Australian Post-Doctoral Fellowship. We would like to thank Wendy Best, David Howard, Eva Marinus and Niels Schiller for helpful discussion.

Appendix A

Stimuli characteristics averaged by target category (plural count nouns, mass nouns) for Experiment 1.

	plural count noun targets	mass noun targets	t(21)	p
Log (written frequency)	2.18	2.22	-0.26	0.80
Log (spoken frequency)	0.51	0.63	-0.58	0.57
bigram frequency	17735	13636	1.37	0.19
trigram frequency	2040	1287	1.31	0.21
number of syllables	1.71	1.83	-0.53	0.60
number of phonemes	5.13	4.75	0.81	0.43
number of graphemes	6.08	5.71	0.76	0.45
phon. neighbourhood density	6.87	9.26	-0.78	0.45
orth. neighbourhood density	3.04	4.09	-0.74	0.47
imageability	5.94	5.91	0.32	0.75
concept familiarity	3.64	3.87	-1.20	0.24
age of acquisition	3.15	3.54	-1.49	0.15
visual complexity	2.50	2.22	1.70	0.10
image agreement	4.56	4.39	1.57	0.13
naming agreement	78.79	74.29	0.80	0.43
naming speed (ms)	984.7	1047.3	-1.65	0.11

Appendix B

Stimuli for Experiment 1

		Distractor word condition		
Target picture name	Count/ Mass	Countability Congruent	Countability Incongruent	Singular Count Noun
apricots	Count	vases	poker	raven
axes	Count	hyenas	caviar	bikini
eels	Count	mugs	clay	dune
hoses	Count	boas	cola	kiwi
kings	Count	doves	yeast	broom
lanterns	Count	buns	veal	crab
mattresses	Count	canoes	soccer	puddle
medals	Count	koalas	sesame	banana
muffins	Count	closets	sulphur	dolphin
nuns	Count	cubs	dust	chef
ovens	Count	zebras	hockey	corset
oysters	Count	bins	dirt	harp
pears	Count	arenas	saliva	violin
pillows	Count	lemons	mutton	cherry
plums	Count	emus	yoga	menu
pumpkins	Count	owls	spam	kite
spiders	Count	rulers	tennis	coffin
toads	Count	buckets	jasmine	hammock
towers	Count	razors	cotton	dragon
trays	Count	lizards	gravel	bracket
wallets	Count	llamas	bingo	jewel
whales	Count	sofas	denim	ladle
garlic	Mass	poker	vases	raven
wheat	Mass	caviar	hyenas	bikini
bread	Mass	clay	mugs	dune
money	Mass	cola	boas	kiwi
mascara	Mass	yeast	doves	broom
mud	Mass	veal	buns	crab
dough	Mass	soccer	canoes	puddle
hay	Mass	sesame	koalas	banana
ginger	Mass	sulphur	closets	dolphin
butter	Mass	dust	cubs	chef
graffitti	Mass	hockey	zebras	corset
porridge	Mass	dirt	bins	harp
rice	Mass	saliva	arenas	violin
gold	Mass	mutton	lemons	cherry
lava	Mass	yoga	emus	menu
parsley	Mass	spam	owls	kite
broccoli	Mass	tennis	rulers	coffin
rhubarb	Mass	jasmine	buckets	hammock
soup	Mass	cotton	razors	dragon
cinnamon	Mass	gravel	lizards	bracket
spinach	Mass	bingo	llamas	jewel
bacon	Mass	denim	sofas	ladle

Appendix C

Noun distractor characteristics averaged by target category (plural count nouns, singular count nouns, mass nouns) for Experiment 1.

	Noun distractors			plural count-singular count		plural count-mass		singular count-mass	
	Plural count	Singular count	Mass	t(21)	p	t(21)	p	t(21)	p
Log (written frequency)	1.95	1.91	1.92	0.26	0.80	-0.19	0.86	0.90	0.93
Log (spoken frequency)	0.38	0.40	0.59	-0.19	0.85	1.71	0.10	1.37	0.19
bigram frequency	291.95	241.73	296.55	0.95	0.35	0.09	0.93	1.11	0.28
trigram frequency	40.36	29.64	29.59	0.90	0.38	-1.05	0.31	-0.01	1.00
number of syllables	1.86	1.86	1.86	0	1.00	0	1.00	0	1.00
number of graphemes	5.32	5.32	5.27	0	1.00	-1.00	0.33	-1.00	0.33
phon. neighbourhood density	5.23	6.42	5.36	-0.59	0.56	0.17	0.87	-0.54	0.60
orth. neighbourhood density	3.27	2.27	3.05	1.12	0.28	-0.36	0.73	1.35	0.19

Appendix D

Stimuli for Experiment 2

Target picture name	Count/ Mass	*Target picture name*	Count/ Mass
apples	Count	asparagus	Mass
axes	Count	bacon	Mass
bags	Count	broccoli	Mass
blankets	Count	butter	Mass
bottles	Count	celery	Mass
cars	Count	coal	Mass
caves	Count	cotton	Mass
chairs	Count	cream	Mass
eagles	Count	denim	Mass
forks	Count	dough	Mass
ghosts	Count	garlic	Mass
hoses	Count	gold	Mass
kings	Count	grass	Mass
lanterns	Count	honey	Mass
masks	Count	ice	Mass
medals	Count	ink	Mass
noses	Count	jelly	Mass
nuns	Count	milk	Mass
ovens	Count	money	Mass
pearls	Count	mud	Mass
pedals	Count	mustard	Mass
pegs	Count	parsley	Mass
shadows	Count	rain	Mass
skulls	Count	rice	Mass
swords	Count	rust	Mass
tables	Count	snow	Mass
trays	Count	soup	Mass
vases	Count	steam	Mass
wheels	Count	sugar	Mass
whips	Count	water	Mass

Appendix E

Stimuli characteristics averaged by target category (plural count nouns, mass nouns) for Experiment 2.

	plural count noun targets	mass noun targets	t(21)	p
Log (written frequency)	2.68	2.58	0.69	.499
Log (spoken frequency)	1.01	1.07	-0.38	.702
bigram frequency	7360	7566	-0.21	.834
number of syllables	1.47	1.63	-1.15	.258
number of phonemes	4.50	4.27	0.75	.457
number of graphemes	5.43	5.03	1.28	.211
phon. neighbourhood density	1.72	1.52	1.43	.165
orth. neighbourhood density	1.79	1.86	-0.45	.655
imageability	0.66	0.61	0.79	.438
concept familiarity	4.49	4.57	-0.84	.406
age of acquisition	2.68	2.83	-0.70	.489
visual complexity	2.89	3.05	-0.73	.472
image agreement	4.15	4.10	0.43	.667
naming agreement	0.95	0.94	0.56	.578

Chapter 4

From ‘some butter’ to ‘a butter’: An investigation of mass and count representation and processing.

Nora Fieder[a], Lyndsey Nickels[a,b], Britta Biedermann[a] & Wendy Best[c]

[a]ARC Centre of Excellence in Cognition and its Disorders(CCD) and

Department of Cognitive Science

Macquarie University, Sydney, Australia

[b]NHMRC Centre of Clinical Excellence in Aphasia Rehabilitation,

University of Queensland, Brisbane, Australia

[c]Department of Human Communication Science

University College London, London, UK

Submitted to Journal ***Cognitive Neuropsychology***

Abstract

This paper investigates the representation of mass and count nouns at the lexical-syntactic level, an issue which has not been addressed to date in psycholinguistic theories. A single case study is reported of a man with aphasia, RAP, who showed a countability specific deficit which affected processing of mass noun grammar. RAP frequently substituted mass noun determiners (e.g., some, much) with count noun determiners (e.g., a, many). Experimental investigations determined that RAP had a modality neutral lexical-syntactic impairment.

Furthermore, a series of novel experiments revealed that RAP’s processing of mass noun determiners varied depending on how mass nouns were depicted (single vs. multiple depictions) and how congruent these were with the conceptual-semantic information of target determiners (e.g., ‘some’ corresponds to MULTIPLE but not SINGLE concepts). RAP’s determiner difficulties emerged only when mass nouns and determiners were number incongruent.

The results of this research clearly indicate that nouns are lexical-syntactically specified for countability, but that the derivation of countability can additionally be influenced by conceptual-semantics.

Introduction

Common nouns can be divided into two subcategories: mass nouns and count nouns. Count nouns are more common and are more flexible regarding the syntactic environment in which they can appear compared to mass nouns. Both noun categories are best identified by their grammatical properties. Count nouns can be preceded by numerals (e.g., one cat), the indefinite and definite article (e.g., a cat, the cat) and quantifiers that denumerate (e.g., many cats, few cats). Mass nouns in comparison are restricted to the definite article (e.g., the milk) and their quantity can be specified in relative terms by quantifiers which do not denumerate (e.g., much milk, little milk) or if preceded by a unit of measurement (e.g., two litres of milk, three bottles of milk). A second difference between mass and count nouns are their morphological characteristics. Count nouns can be pluralised (e.g., cats) whereas mass nouns cannot (e.g., *milks) (Gillon, Kehayia & Taler, 1999; Semenza, Mondini & Cappelletti, 1997; Taler & Jarema, 2007; Wisniewski, Lamb & Middleton, 2003).

Mass and count nouns are further argued to differ in their conceptual-semantic properties: Mass nouns usually represent substances (e.g., liquids: milk, water; powders: cinnamon, sugar) and aggregates (e.g., rice, confetti), whereas count nouns usually represent people and objects with clear boundaries which makes it possible to perceive them as individual entitities (Middleton, 2008; Middleton, Wisniewski, Trindel & Imai, 2004; Wierzbicka, 1988; Wisniewski, Lamb & Middleton, 2003). However, these conceptual-semantic differences are more tendencies than absolutes: there are exceptions with some mass nouns representing individual entities with clear boundaries (e.g., broccoli, celery) and some count nouns representing unindividuated aggregates (e.g., lentils, beans).

Nevertheless, there is still a debate whether the mass/count difference is grammatically or semantically driven (see Middleton, 2008). Support for the conceptual-semantic account comes, for example, from a number of nouns which can be assigned to both mass and count noun categories (e.g., cake: Peter got a cake$_{count}$ for his birthday., Each guest ate some cake$_{mass}$.; tea: Can I have some tea$_{mass}$, please?, Can I have a tea$_{count}$, please).

Representation of lexical-syntactic information

In addition to mass/count status (countability), nouns can be specified for a number of other lexical-syntactic characteristics. Most research has been focused on the lexical-syntactic representation and processing of grammatical gender (e.g., Alario, Ayora, Costa & Melinger, 2008; Alario & Caramazza, 2002; Biran & Friedmann, 2011; Bordag & Pechmann, 2008, 2009; Costa, Kovacic, Fedorenko & Caramazza, 2003; Garrard, Carroll, Vinson & Vigliocco, 2004; Janssen & Caramazza, 2003; La Heij, Mak,Sander & Willeboordse, 1998; Middleton, 2008; Schiller & Caramazza, 2003, 2006; Schriefers, 1993; Schriefers, Jescheniak & Hantsch, 2002, 2005; Schriefers & Teruel, 2000; Shapiro, Zurif, Carey & Grossman, 1989; Van Berkum, 1997; Vigliocco, Vinson, Martin & Garrett, 1999) and number (e.g., Baayen, Burani & Schreuder, 1996; Baayen, Levelt, Schreuder & Ernestus, 2008; Baayen, Schreuder & Sproat, 1998; Biedermann, Nickels & Beyersmann, 2009; Biedermann, Lorenz, Beyersmann & Nickels, 2012; Luzzatti, Mondini & Semenza, 2001; Schiller & Caramazza, 2002; Sonnenstuhl & Huth, 2002), relatively little attention has been paid to the representation of mass/count information (Gillon, Kehayia & Taler, 1999; Herbert & Best, 2010; Mondini, Kehayia, Gillon, Arcara & Jarema, 2009; Semenza, Mondini & Cappelletti, 1997;

Semenza, Mondini & Marinelli, 2000; Taler & Jarema, 2007; Vigliocco, Vinson, Martin & Garrett, 1999). As a consequence, theories discussing the representation of lexical-syntactic information have, to date, only integrated number and grammatical gender (e.g. Alario & Caramazza, 2002; Caramazza, 1997; Caramazza & Miozzo, 1998; Jescheniak & Levelt, 1994; Levelt, Roelofs & Meyer, 1999).

One of the most prominent theories for the representation of lexical-syntactic information in language production is that of Levelt, Roelofs and Meyer (1999). Levelt et al.’s theory proposes three major levels: lexical-concepts, lexical-syntax (lemmas) and word forms. The production of a word is achieved by activating and selecting first its meaning in the form of a holistic lexical-concept, then its lemma node and finally its word form.

Each noun and its lexical-syntactic characteristics are represented at the lemma level in the form of an empty lemma node which is linked to syntactic features and properties. Levelt et al. define lexical-syntactic *properties* as the purely grammatical and unchanging ‘intrinsic’ characteristics of a noun, such as grammatical gender (e.g. the German noun ‘Hund’ (dog) has always the grammatical gender masculine) which can only receive activation from noun lemmas. Lexical-syntactic *features*, on the other hand, represent changing ‘extrinsic’ characteristics of a noun which vary depending on the intention of the speaker, such as number (whether ‘dog’ or ‘dogs’ is produced depends on the intention of the speaker). Variable extrinsic lexical-syntactic features are therefore assumed to be semantically specified (e.g., the number feature ‘plural’ is semantically specified through a feature MULTIPLE) and activated by their semantic feature(s). Here we will use the term ‘lexical-syntactic attributes' to refer to both fixed intrinsic properties and variable extrinsic features. Lexical-syntactic attributes are further connected to lemma nodes of function words (e.g., determiners, quantifiers) which can form grammatical agreement with the noun. For example, the German noun ‘Hund’ (dog) is masculine and forms agreement with the definite determiner ‘der’ vs. the German noun ‘Katze’ (cat) is feminine and forms agreement with the definite determiner ‘die’. The links between noun lemmas and their lexical-syntactic attributes and agreement lemmas are assumed to be unidirectional. Hence activation can only be sent in one direction from the noun lemma to its lexical-syntactic attributes and from there to its agreement lemmas.

Another important assumption of Levelt et al.’s (1999) theory is the difference between activation and selection at the lexical-syntactic level. Even though lexical-syntactic nodes and their agreement lemmas can receive activation during the production of words, phrases and sentences, they are only selected if grammatically required in order to form grammatical agreement. For example, the production of the single word, so called ‘bare noun’ production, ‘$\text{Hund}_{\text{masc}}$’ (dog) in German does not require the selection of the grammatical gender ‘masculine’, because no other words which grammatically depend on gender have to be produced. The production of the noun phrase ‘der_{masc} $\text{Hund}_{\text{masc}}$’ (the dog), on the other hand, requires the selection of the lexical-syntactic feature ‘masculine’ in order to activate and select the appropriate definite determiner ‘der_{masc}’ instead of grammatically inappropriate determiners, such as ‘die_{fem}’. However, contrary to Levelt et al.’s assumption, determiner priming studies in German and French (Alario, Matos & Segui, 2004; Jacobson, 1999; Jescheniak, 1999) have found grammatical gender congruency effects for the processing of bare nouns: nouns produced longer picture naming latencies when primed with a syntactically incongruent determiner (e.g., masculine target noun ‘Topf’ (pot): definite determiner prime of neuter gender ‘das’; neuter target noun ‘Netz’ (net): definite determiner prime of masculine gender ‘der’) compared to a syntactically congruent determiner (e.g., masculine target noun ‘Topf’ (pot): definite determiner prime of masculine gender ‘der’; neuter target noun ‘Netz’ (net): definite determiner prime of neuter gender ‘das’)) or neutral determiner (e.g., masculine target noun ‘Topf’ (pot): indefinite determiner prime of masculine/neuter gender ‘ein’; neuter target noun ‘Netz’ (net): indefinite determiner prime of masculine/neuter gender ‘ein’).

While the lexical-syntactic representation of grammatical gender and number is supported by empirical evidence, it is less clear how mass/count information is represented. Countability information could be represented in the form of fixed intrinsic lexical-syntactic properties, similar to grammatical gender. Within this theory activation and selection of countability information is only possible via noun lemmas. This theory does not exclude the possibility that nouns are also semantically specified for countability, for example in the form of semantic features (e.g., ‘individuated’, ‘countable’ for count nouns). However, the selection of the lexical-syntactic mass/count properties would be independent of these semantic features (see Figure 1). Alternatively, countability information could be represented in the form of variable extrinsic lexical-syntactic features similar to number. Since the activation of lexical-syntactic features is determined by conceptual-semantic information, countability has to have a semantic specification which is directly connected to mass and count features at the lexical-syntactic level (see Figure 2). Evidence from studies with healthy speakers suggests that mass and count nouns are probably lexical-syntactically specified in the form of lexical-syntactic properties: [mass] for mass nouns and [count] for count nouns (Gregory, Varley & Herbert, 2012; Steinhauer, Pancheva, Newman, Gennari & Ullman, 2001).

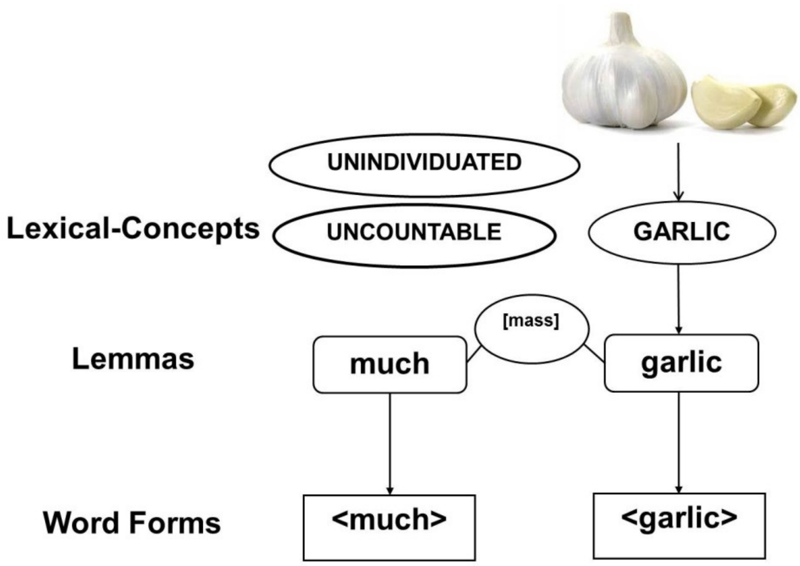

Figure 1. Mass information represented in the form of a fixed intrinsic lexical-syntactic property.

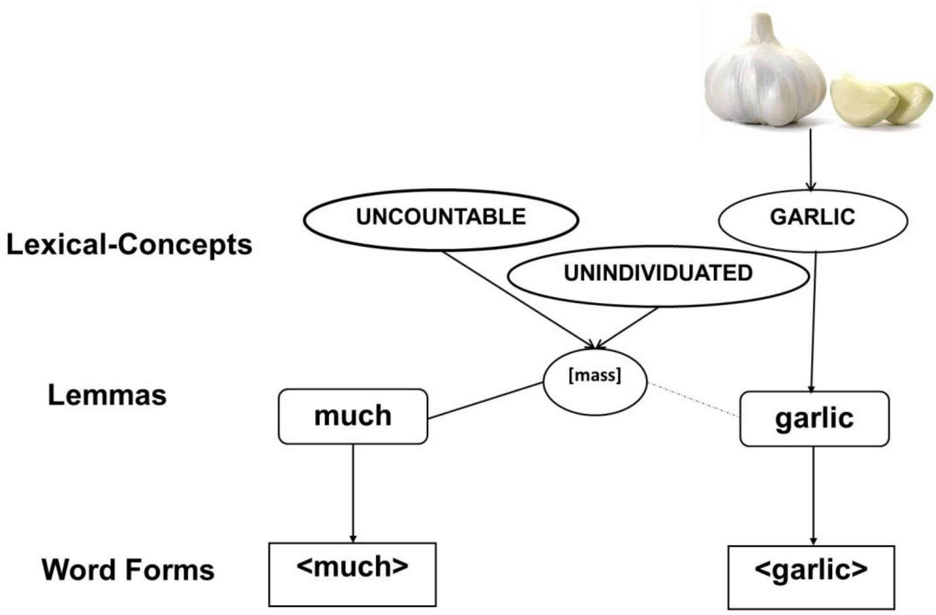

Figure 2. Mass information represented in the form of a variable extrinsic lexical-syntactic feature.

Neuropsychological investigations of countability

One of the few neuropsychological case studies to investigate the representation and processing of mass and count nouns was reported by Herbert and Best (2010). MH was a woman with non-fluent agrammatic aphasia, severe anomia and deep dyslexia. Herbert and Best used four tasks to investigate mass and count noun processing: (a) oral picture naming of bare mass and count nouns, (b) syntactic judgement of determiner plus noun phrases (e.g., a milk vs. some milk), (c) repetition and reading aloud of determiner plus mass/singular and plural count noun phrases, and (d) oral picture naming with and without syntactic cues (This is a/some _). The results revealed that MH was better able to name pictures of singular count nouns compared to mass nouns. However, this difference vanished when determiner (a/some) cues were provided, due to improved naming of mass nouns. The determiner judgement task and reading and repetition of noun phrases (determiner plus noun combinations) showed that MH had significant difficulties with noun phrases which involved mass and plural count noun determiners (e.g., some, many, most) compared to phrases with singular count noun determiners (e.g., a, every). Most of MH’s errors were omissions or substitutions of the mass/plural count noun determiner with the high frequency singular count noun determiner ‘a’. Herbert and Best concluded that MH’s difficulties with mass nouns and mass and plural count noun determiners were either caused by an impairment of specific determiner lemma nodes (e.g., some, most) or by an impairment of the rules for the use of these determiners at the lexical-syntactic level.

In a second case study, Semenza[17], Mondini and Cappelletti (1997) reported the case of an Italian speaking woman, FA, with mild anomia who showed a deficit for mass noun grammar. FA showed no impairment in written and spoken grammatical comprehension and judgement (Miceli, Laudanna and Burani’s battery, 1994). FA’s mass and count noun processing was tested in seven different tasks: (1) naming to definition (e.g., What animal barks?), (2) naming through sentence completion (e.g., That ... is chained because otherwise it would bite.), (3) semantic judgments (judging the acceptability of written sentences; e.g., *The dog mews.), (4) semantic association (matching of written words which are semantically associated; e.g., ‘dog’ to either ‘bone’ or ‘flower’), (5) grammaticality judgement of written sentences with correct/incorrect determiners (e.g., *There is <u>*much*</u> desk in this classroom.); (6) completion of written sentences by selection of the correct written determiner from three choices e.g., (I would like...water, please., 'a' or '<u>some</u>' or 'many’); (7) production of a sentence when given a target noun (count or mass) and a semantically associated noun (e.g., roll/butter). FA showed difficulties only with mass nouns and only in the last three grammatical tasks which required the use of mass noun determiners. Her errors consisted of pluralising mass nouns and/or choosing count noun determiners instead of mass noun determiners. Semenza et al. inferred from the results that FA had a mass specific impairment at the lexical-syntactic level.

How far does the data from these case studies give us insights about the

[17] In a published conference abstract, Semenza, Mondini and Marinelli (2000) reported the case of CN, a woman with fluent aphasia who showed a relative deficit in naming bare count nouns compared to mass nouns. CN’s count noun specific problem was accounted for by an impairment of word form retrieval while no difference between mass and count nouns was found in semantic and grammatical tasks. However, it should the difference in performance across mass and count conditions was very small and reached only significance when it was summed over three occasions, consequently we do not address this case in detail here.

representation of countability at the lexical-syntactic level and hence inform Levelt et al.’s theory?

Herbert and Best (2010) argue that MH’s grammatical problems with mass and plural count noun determiners can be explained by an impairment at the lemma level. This impairment was hypothesised to affect either the specific determiner lemma nodes, or the links from these determiner lemmas to their lexical-syntactic attributes (mass or plural). However it is important to emphasize that under both accounts the impairment is not mass specific since it affects plural count nouns too. Also, it is harder to account for MH's problems with producing bare mass nouns within Levelt et al.’s theory. An impairment of determiner lemma nodes, or the links from these to their lexical-syntactic attributes should not affect noun production unless (unlike in Levelt et al's theory) we assume that lexical-syntactic information plays a role in the selection of noun lemmas. In other words, the selection of a noun lemma relies on the activation of and/or feedback from its lexical-syntactic attributes and determiner lemmas. Hence, one has to assume that noun lemmas, lexical-syntactic information and determiners are connected via bidirectional links. Herbert and Best (2010) propose that individuals with aphasia require the additional activation received from lexical-syntactic nodes (e.g., via determiner cues) to successfully select a noun lemma. The assumption of bidirectional links between nodes at the lexical-syntactic level can account for MH’s difficulties in picture naming of mass nouns and her improvement when grammatically cued with mass noun determiners. An alternative explanation for MH’s difficulties with bare mass nouns could be a semantic impairment of specific concepts/features for mass nouns (e.g., UNINDIVIDUATED, UNCOUNTABLE). In this case, mass noun determiner cues could have facilitated the production of mass nouns through sending an extra jolt of activation to the shared semantic concepts/features.

Like MH, FA (Semenza et al., 1997) showed an impairment of mass noun syntax. Unlike MH, her picture naming of bare mass nouns remained unaffected. Hence, her difficulties could be explained by an impairment of the lexical-syntactic attribute mass or by an impairment of specific determiner lemmas at the lexical-syntactic level without modifications to Levelt et al.’s theory being required. However, further tests with plural count nouns would have been appropriate to identify whether FA’s deficit was mass specific and hence can be explained by an impairment of the lexical-syntactic attribute 'mass' or whether it affected plural count noun phrases in the same way and thus can be ascribed to an impairment of certain determiner lemmas. Hence, we cannot be sure that the impairment is mass specific.

In summary, there are two single case studies which have investigated lexical and grammatical processing of mass and count nouns. Even though the mass specific difficulties and the localisation of the impairment for both participants was similar, these cases were conflicting regarding their theoretical implications for the representation and processing of mass information at the lexical-syntactic level. For example, the account that was provided for MH would predict that FA should also show difficulties in selecting mass noun lemmas and hence in the production of bare mass nouns.

The present study therefore aims to add to the literature and further investigate how mass and count nouns are represented and processed at the lexical-syntactic level. We focus in particular on the following questions: Are nouns specified for being mass and/or count at the lexical-syntactic level? If this is the case, then in which form is this information represented (intrinsic lexical-syntactic properties vs. extrinsic lexical-syntactic features) and hence is its selection syntactically or semantically driven? Finally, when is the selection of countability information required (always selected vs. only selected if grammatically required)? To shed light on these questions and to evaluate and extend current psycholinguistic theories on countability, we examined the influence that mass/count information can have on language comprehension and production in an individual with aphasia, RAP.

Case Description

Participant

RAP is a right-handed 70 year old man who suffered an infarct in the territory of the left Middle Cerebral Artery. He was initially diagnosed with a severe expressive and moderate-severe receptive aphasia. RAP left school at 15 years of age and worked as a truck driver until his retirement.

At the time of testing, 7 years post onset, his spontaneous speech was non-fluent due to word finding difficulties (see Appendix A for a sample of his connected speech). RAP’s connected speech was further affected by stereotypical productions such as ‘you know’, and phonological and semantic errors. RAP had no apraxia of speech or dysarthria. His hearing and visual acuity were unimpaired.

Background language assessment

A number of background assessments were carried out to determine the general nature of RAP’s language processing impairments. The results are summarised in Table 1.

RAP’s input processing of written and spoken material is broadly intact reflected in the fact that he performs within normal limits on all semantic and auditory input tasks. However he does show some impairment on low imageability synonym judgements (auditory and written) suggesting a mild semantic impairment.

RAP’s spoken and written picture naming are both comparably impaired (McNemar’s test exact: p = .845) which suggests the same underlying deficit. RAP produced mainly phonological errors[18] in spoken picture naming (58.33% of errors) and orthographic errors in written picture naming (66.67%) and semantic errors (spoken picture naming: 33.33%; written picture naming: 16.67%). There was no significant effect of frequency, length, age of acquisition or imageability in spoken or written picture naming (although imageability was close to significance for written naming; see Table 2). Word reading and repetition are impaired to the same extent (McNemar’s test exact: p = 1.00), and performance is marginally better than for naming (McNemar’s test exact: spoken picture naming vs. word reading: p = .093; vs. repetition: p = .093). Both tasks result exclusively in phonological errors and were not affected by frequency, length, age of acquisition or imageability (see Table 2). RAP’s reading and repetition of nonwords (Nickels & Cole-Virtue) is significantly more impaired than that of words (Fisher exact: reading: p < .001 (two-tailed); repetition: p < .001)) No difference was found

[18] Phonological errors include phonologically related words, phonological nonwords.and false starts (target: flag, response: ff flag)

between nonword reading and nonword repetition (McNemar’s test, $p = .144$) which implies an impairment of the phonological output buffer. Taken together these results suggest a mild impairment at the semantic level and an impairment of the phonological output buffer (affecting all speech production tasks and particularly those without lexical support).

Finally, RAP showed problems in sentence processing, mainly in sentences which demand syntactic parsing (e.g., centre-embedded sentences), processing of singular/plural inflections and negations (TROG 2) (Bishop, 2003b) indicating an impairment of comprehension at the lexical-syntactic level.

Table 1 *Background Assessments.*

Task	N of items	%Cut-off[a]	% correct
Comprehension			
Spoken word comprehension			
PPT[b] 1 word 2 pictures	52	94	98
PALPA[c] spoken word picture matching	40	95	98
NC-V[d] spoken word picture matching	264	-	98
Written word comprehension			
PPT[b] 1 word 2 pictures	52	94	94
PALPA[c] written word picture matching	40	95	95
Semantic processing			
PALPA[c] Auditory synonym judgement	60	-	80
High imageability	30	-	90
Low imageability	30	-	70
PALPA[c] Written synonym judgement	60	87	85
High imageability	30	91	97
Low imageability	30	82	73*
Conceptual semantic processing			
PPT[b] 3 pictures	52	94	98
Grammatical comprehension			
TROG2[e]	80 (20 blocks)	18 (blocks)	76 (11 blocks)*
Speech production			
Spoken picture naming			
NC-V[d] spoken picture naming	132	-	86
Boston naming test[f]	60	66	50*
Written picture naming			
NC-V[d] written picture naming	132	-	86
Word reading			
NC-V[d] word reading	132	-	95
Word repetition			
NC-V[d] word repetition	132	-	95
Nonword reading			
NC-V[d] nonword reading	47	-	47
Nonword repetition			
NC-V[d] nonword repetition	47	-	64
Pre -lexical processing			
Auditory discrimination			
PALPA[c] minimal pairs: words	72	-	100
same	36	94	100
different	36	82	100
PALPA[c] minimal pairs: nonwords	72	-	96
same	36	96	100
different	36	85	92

[a] Cut-off for normal performance is lower end of normal range. The cut-off is the score of two standard deviations below the mean of the performance of healthy

controls; percentage at cut-off and below represents impaired performance. The ‘normal range’ is taken from the instruction manuals of the respective tests, or –if it refers to PALPA-partly taken from the Nickels & Cole-Virtue (2004) norms. Patient scores are marked with an asterisk if score is below normal range.
[b] Pyramids and Palm Trees Battery (PPT) (Howard & Patterson, 1992) assesses the ability to access semantic information from pictures, written words and spoken words.
[c] Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser, & Coltheart, 1992) assesses language processing in adults with acquired aphasia within a psycholinguistic framework.
[d] Nickels & Cole-Virtue (NC-V) (unpublished) picture stimulus set consists of 132 items and 47 matched nonwords which are analysed in subgroups that are systematically controlled and manipulated regarding semantic (concreteness, imageability, familiarity, age of acquisition), lexical (age of acquisition, frequency, phonological neighbourhood) and sublexical (length) variables to investigate language processing in adults with acquired aphasia within a psycholinguistic framework.
[e] TROG 2 (Bishop, 2003b) assess the comprehension of different grammatical structures within sentences in children and adults. Each grammatical structure is tested in a block consisting of 4 different sentences. A block counts as correct if all 4 sentences are correct. The cut-off score is 18 fully correct locks.
[f] Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 1983) assesses picture naming in adults with aphasia. The BNT cut-off score is derived from Australian controls (n=31) in RAP’s age group (70-74 years) (Worrall, Yiu, Hickson, & Barnett, 1995

Table 2 *Effects of Psycholinguistic Variables on Nickels & Cole-Virtue’s (2004) stimulus list*

Variables	frequency		aoa		phonemes		imageability	
Tasks	N of items	% correct	N of items	% correct	N of items	% correct	N of items	% correct
Spoken naming								
High (Long)	38	89	40	93	38	82	49	88
Low (Short)	38	79	40	85	38	87	49	86
Stats (Fisher exact)	*p = 0.35*		*p = 0.48*		*p = 0.75*		*p = 1.00*	
Written naming								
High (Long)	38	76	40	85	38	89	49	92
Low (Short)	38	89	40	93	38	84	49	76
Stats (Fisher exact)	*p = 0.22*		*p = 0.48*		*p = 0.74*		*p = 0.06*	
Reading								
High (Long)	38	95	40	93	38	92	49	94
Low (Short)	38	92	40	98	38	95	49	94
Stats (Fisher exact)	*p = 1.00*		*p = 0.62*		*p = 0.67*		*p = 1.00*	
Repetition								
High (Long)	38	97	40	98	38	95	49	94
Low (Short)	38	95	40	90	38	97	49	94
Stats (Fisher exact)	*p = 1.00*		*p = 0.36*		*p = 0.68*		*p = 1.00*	

Experiment 1 & 2: Testing for Mass/Count Noun Effects in Language Comprehension and Production

Experimental Tasks

A series of experiments was conducted in order to investigate processing of mass and count nouns at different levels of the language system. The aim was to identify possible deficits and to localise any functional impairment.

We will first describe the stimuli and then report the results of tasks where RAP showed no difference in performance between mass and count nouns (reading and repetition of bare nouns and noun phrases, written picture naming and grammatically cued spoken picture naming, grammaticality judgements). We follow this with description of a series of grammatical tasks, which demonstrate that RAP has particularly difficulties with the production of mass noun phrases compared to singular and plural count noun phrases (picture naming with singular and plural count noun phrases and mass noun phrases).

This is followed by further investigation of the underlying cause of RAP's countability specific deficit: We present the results of two further picture naming tasks with noun phrases which test competing hypotheses for his impairment: a determiner specific deficit at the lexical-syntactic and/or word form level or an impairment of the lexical-syntactic attribute 'mass' at the lexical-syntactic level. This is followed by a final series of picture naming tasks which strengthen the evidence for an impairment of the lexical-syntactic attribute 'mass'.

Stimuli

The stimulus set comprised picturable singular count nouns (n=38), plural count nouns (n=16) and mass nouns (n=31). These stimuli were analysed as two matched sets (which partly overlap): Set A (mass/sing), 30 mass nouns matched with 30 singular count nouns, and Set B (mass/sing/pl), 16 mass nouns matched to 16 singular count nouns, and 16 plural count nouns (see Appendix B). In addition, we included different numbers of mass and plural count noun filler items depending on the tasks to provide equal numbers of each stimulus type (e.g. spoken & written picture naming: 22 plural count noun fillers, 7 mass noun fillers). For each stimulus item we obtained a colour photograph from Hemera Photo Objects Collection I & II (1997-2000), Herbert and Best (2010) or from Google

Images.

As far as possible, mass nouns were chosen which could be depicted as discrete entities (e.g., broccoli, asparagus, a bottle of ink, a bale of hay) to avoid visual and conceptual-semantic differences between mass and count nouns. 20 unimpaired adult participants provided objective measures of name agreement in a picture naming experiment. Participants were instructed to name the pictures as accurately as possible. All noun pictures were above 85% name agreement.

All nouns were morphologically simple and all count nouns were singular-dominant (singular forms were more common than the plural forms). Sets were matched listwise for log transformed written and spoken surface and stem frequency from the CELEX database (Baayen, Piepenbrock & van Rijn, 1993; Baayen, Piepenbrock & Guliker, 1995), number of syllables, phonemes and graphemes using the MRC Psycholinguistic database (Coltheart, 1981), phonological and orthographic neighbourhood density from the English lexicon project (Balota et al., 2007), and for imageability, age of acquisition, name agreement[19] (data collected by the authors) (see Appendices C and D).

General Design & Procedure

In the first set of experimental tasks (Experiment 1 & 2) we tested RAP’s reading, repetition, and spoken picture naming with bare nouns and noun phrases, his written picture naming and cued spoken picture naming with bare nouns as well as his grammaticality judgement of noun phrases. For the naming task the pictures were presented on a computer screen in a fixed pseudorandomised order.

[19] Singular count nouns and mass nouns are matched for visual complexity in both item sets. Plural count nouns could not be matched with singular count nouns and mass nouns for visual complexity as the former were presented as multiple objects and the latter as single objects.

RAP was asked to name the picture with a single word within 15 seconds. The first response was scored.

For tasks with auditory stimuli, all word and noun phrases were presented from recordings of a native Australian English speaker. In the reading and repetition tasks, items were presented without a time limit and the first response was scored. Further details of instructions and practice items can be obtained from the authors.

Analysis

RAP’s performance was compared to an undergraduate student control group using a modified t-test (Crawford & Garthwaite, 2002; Crawford & Howell, 1998). In order to claim that RAP showed a dissociation between mass and count noun performance we required: first, that he showed a significant difference between mass and count conditions (Wilcoxon two-sample) and second that this difference was significantly greater than any difference between the conditions shown by the controls using the Revised Standarised Difference Test, RSDT (Crawford & Garthwaite, 2005) when it was possible to apply this test (when the control group performed below ceiling).

Experiment 1: Bare Nouns

RAP’s processing of bare mass and count nouns was tested using different word production tasks in order to localise the level of any countability impairment. Reading and repetition of bare nouns was used to exclude a mass/count specific deficit at a later post-lexical level. According to Levelt et al.’s theory (1999), we would not expect lexical-syntactic mass/count information to influence picture naming with bare nouns since this information is not grammatically required to complete this task (but see our discussion of Herbert & Best (2010) above). However, to investigate this further we conducted a set of cued spoken picture naming tasks to see whether picture naming can be facilitated and hence influenced by grammatical cues. The aim of the cued picture naming task was to determine the conditions under which the selection of lexical-syntactic information such as mass/count information is required.

Design & Procedure

The material for the spoken and written picture naming, reading and repetition task with bare nouns were as described above. The cued spoken picture naming task consisted of three different tasks all of which compared naming when given determiners which were either grammatically correct for the depicted noun or grammatically incorrect. One was a control task with mass/count noun neutral determiner cues in which the participant was presented with 30 singular count and 30 mass nouns and either a grammatically correct determiner cue (the) or a grammatically incorrect determiner cue (these). Two other tasks were picture naming tasks with mass/count noun specific determiner cues; one with 30 singular count nouns and 30 mass nouns and the determiner cues ‘a’ and ‘some’; one with 16 plural count nouns and 16 mass nouns and the determiner cues ‘not many’ and ‘not much’. The cued spoken picture naming tasks consisted of two blocks which were tested on separate days. Each noun appeared in both of the blocks, once with a grammatical and once with an ungrammatical determiner cue. Determiners of the mass or count noun category opposite to the target noun’s category served as ungrammatical cue.

Results

As shown in Table 3, while RAP was impaired in all tasks compared to controls[20,21], he did not show any significant difference between mass and count nouns (singular and plural) in any comparison.

[20] We did not collect control data for written picture naming as we expected similar results for written and spoken picture naming in healthy adults (Bonin, Chalard, Méot & Fayol, 2002). As controls were close to ceiling on bare noun picture naming we did not collect control data for cued picture naming.

[21] When the control group performs at or close to ceiling, we cannot be absolutely sure that there is no difference in performance across mass and count conditions: any effects could be obscured by ceiling effects (for further discussion see Best, Schröder & Herbert, 2006).

Table 3 *Mass-Count Tasks with Bare Nouns.*

	RAP						Control Mean (Standard Deviation)						RAP-Controls	
	Singular Count (n = 30)	Mass (n = 30)	Plural Count (n = 16)	Mass (n = 16)	Mass vs. Singular count (Wilcoxon two-sample)	Mass vs. Plural count (Wilcoxon two-sample)	Singular Count (n = 30)	Mass (n = 30)	Plural Count (n = 16)	Mass (n = 16)	Mass vs. Singular count (Wilcoxon matched pairs)	Mass vs. Plural count (Wilcoxon matched pairs)	Mass vs. Singular count T-Test (pvalue)[a]	Mass vs. Plural count T-Test (pvalue)[a]
Reading	1.00	0.90	0.94	1.00	.240	1.00	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00	1.00	.001*	.001*
Repetition	0.83	0.97	0.94	1.00	.201	1.00	0.99 (0.01)	1.00 (0.01)	1.00 (0)	1.00 (0)	.773	1.00	.001*	.001*
Spoken picture naming	0.60	0.70	0.69	0.81	.591	.688	0.96 (0.04)	0.97 (0.03)	0.96 (0.05)	0.93 (0.13)	.332	.751	.001*	.026*
Written picture naming	0.83	0.73	1.00	1.00	.534	.400	-	-	-	-	-	-	-	-
Cued picture naming correct cues	0.70	0.57	0.94	0.81	.426	.599	-	-	-	-	-	-	-	-
Cued picture naming incorrect cues	0.77	0.80	0.94	1.00	1.00	1.00	-	-	-	-	-	-	-	-
Cued picture naming neutral correct cues	0.80	0.83	-	-	1.00	-	-	-	-	-	-	-	-	-
Cued picture naming neutral incorrect cues	0.80	0.90	-	-	.473	-	-	-	-	-	-	-	-	-

[a] Modified t-tests compared RAP’s performance on critical count nouns (singular or plural) and mass nouns with the control group (Crawford & Garthwaite, 2002; Crawford & Howell, 1998)).

In the cued picture naming tasks, RAP did not show any significant difference in accuracy for naming pictures with grammatically correct versus grammatically incorrect determiner cues, irrespective of whether these were neutral or mass/count specific (McNemar’s test exact probability (two-tailed) grammatically correct vs. grammatically incorrect cues: ‘a’ and ‘some’: singular count nouns, $p = .688$; mass nouns, $p = 1.00$; ‘many’ and ‘much’: plural count nouns, $p = 1.00$; mass nouns, $p = .250$; neutral determiners ‘the’ and ‘these’: singular count nouns, $p = 1.00$; mass nouns, $p = .727$). Also, no grammatical priming effect was found comparing the results of the uncued bare noun picture naming tasks with those of the cued picture naming tasks (McNemar’s test exact probability (two-tailed): ‘a’ and ‘some’: singular count nouns, $p = .453$; mass nouns, $p = .344$; ‘many’ and ‘much’: plural count nouns, $p = 1.00$; mass nouns, $p = .125$; neutral determiners ‘the’ and ‘these’: singular count nouns, $p = .289$; mass nouns, $p = .109$).

Discussion

While RAP had mild difficulties in reading and repetition, there were no significant differences between mass and count nouns. Consequently, we can exclude a countability specific impairment at a post-lexical level.

While RAP’s picture naming is generally impaired, he shows no difference in his ability to name mass and count nouns. Hence, we can further rule out a countability specific impairment at the levels of semantics and/or word form. RAP’s spoken picture naming was not facilitated by any of the mass/count specific determiner cues nor the neutral determiner cue ‘the’. Hence, countability information in the form of determiners did not exert an influence on the production of bare nouns for RAP. The results stand in contrast to Herbert and Best (2010) who found that MH 's mass noun production was facilitated by determiner cues. These findings therefore do not provide evidence for lexical-syntactic facilitation of noun lemma selection through bidirectional links for RAP. However, they cannot be taken as direct support for unidirectional links at the lexical-syntactic level (Levelt et al. (1999)): the links might be bidirectional but RAP's impairment may preclude any benefit from the cues. This may be because of impairment to the links or to countability node(s) which may prevent noun lemmas from receiving activation by determiner cues. We will discuss this further below.

.

Experiment 2: Noun Phrases

We conducted a series of tasks which required the production or comprehension of noun phrases containing mass or count nouns: reading and repetition, grammaticality judgement and picture naming.

Design & Procedure

All tasks consisted of two parts. The first required the production/comprehension of singular count noun phrases (determiner ‘a’ plus noun; e.g., a horse; n=30) and mass noun phrases (determiner ‘some’ plus noun; e.g., some garlic; n=30). The second task comprised negated plural count noun phrases[22] (determiner ‘many’ plus noun; e.g., not many cats; n=16) and negated mass noun phrases (determiner ‘much’ plus noun; e.g., not much celery; n=16).

Grammaticality judgement tasks were presented once in written and once in spoken form. The participant was presented with a mass or count specific phrase which consisted of a determiner and a noun and was asked to decide whether the

[22] Noun phrases with the determiners 'many’ and ‘much’ had to be negated to sound grammatically acceptable.

phrase is grammatically correct or not. In each of the tasks the same mass and count nouns were presented once with a grammatically congruent determiner (e.g. not much honey, not many pencils) and once with a grammatically incongruent determiner where determiners of the mass/count noun category opposite to the target noun’s category served as ungrammatical determiner (e.g., *not many honey, *not much pencils). The tasks consisted of two blocks in which each noun appeared only once either in the grammatical or ungrammatical noun phrase condition. Each block was tested on a separate day.

In the picture naming task with noun phrases, the participant was presented simultaneously with a picture and the beginning of a sentence in written and spoken form: ‘I see_ _.’ for the picture naming task with singular count nouns and mass nouns; ‘I do not see _ _.’ for the picture naming task with plural count nouns and mass nouns. The participant was asked to complete the sentence with a noun phrase which included one of two possible determiners (count (singular condition: a, or plural condition: many) or mass: some or much) and the picture name (e.g., a lion, some garlic). Mass nouns were depicted as one object in the picture naming task with singular count nouns (e.g., one piece of broccoli; one jar of honey) and as multiple objects in the picture naming task with plural count nouns (e.g., three pieces of broccoli; three jars of honey) in order to prevent the participant from being able to select the correct determiner through use of a visual strategy. In both picture naming tasks practice items and written determiner cards were used to familiarise RAP with the procedure and the two determiner options.

Results: Reading, Repetition & Grammaticality Judgements

The results are summarised in Table 4. RAP was not significantly different from controls in reading and repetition of singular count noun and mass noun phrases, nor in reading of plural count noun and mass noun phrases. However, he was significantly worse than the control group in the repetition task with plural count noun and mass noun phrases.

Neither RAP nor the control group showed a difference in reading and repetition between (singular or plural) count noun and mass noun phrases.

RAP showed difficulties in all four written and spoken grammaticality judgement tasks compared to the control group. This difference however was only marginally significant for plural count nouns and mass nouns in the written grammaticality judgement task.

Neither RAP nor the control group showed a difference in auditory and written grammaticality judgements for noun phrases with plural count nouns compared to mass nouns. However, the control group was better in judging mass noun phrases compared to singular count noun phrases in both grammaticality judgement tasks. This difference was significantly greater for the control group than for RAP in the auditory grammaticality judgement task and marginally greater in the written grammaticality judgement task

Table 4 *Mass-Count Tasks with Noun Phrases.*

	RAP						Control Mean (Standard Deviation)						RAP - Controls			
Tasks	Singular Count (n = 30)	Mass (n = 30)	Plural Count (n = 16)	Mass (n = 16)	Mass vs. Singular count (Wilcoxon two-sample)	Mass vs. Plural count (Wilcoxon two-sample)	Singular Count (n = 30)	Mass (n = 30)	Plural Count (n = 16)	Mass (n = 16)	Mass vs. Singular count (Wilcoxon matched pairs)	Mass vs. Plural count (Wilcoxon matched pairs)	Mass vs. Singular count T-Test (pvalue)[a]	Mass vs. Plural count T-Test (pvalue)[a]	Mass vs. Singular count RSDT (pvalue)[b]	Mass vs. Plural count RSDT (pvalue)[b]
Reading	0.97	1.00	0.94	1.00	1.00	1.00	1.00 (0.00)	1.00 (0.00)	0.91 (0.30)	0.89 (0.30)	.637	.586	.103	0.435	n/a	n/a
Repetition	0.93	0.97	0.81	0.88	1.00	1.00	0.98 (0.03)	0.99 (0.02)	0.99 (0.03)	1.00 (0.00)	.581	.346	.102	.001*	n/a	n/a
Auditory grammaticality judgement	0.68	0.72	0.66	0.69	.843	1.00	0.95 (0.03)	0.90 (0.09)	0.92 (0.05)	0.91 (0.05)	.023*	.765	.003*	.001*	.001*	n/a
Written grammaticality judgement	0.68	0.68	0.69	0.72	1.00	1.00	0.95 (0.05)	0.88 (0.08)	0.88 (0.18)	0.93 (0.06)	.012*	0.697	.004*	.089	.090	n/a

[a] Modified t-tests were used to compare RAP’s performance on critical count nouns (singular or plural) and mass nouns with the control group (Crawford & Garthwaite, 2002; Crawford & Howell, 1998)).
[b] The Revised Standardised Difference Test, RSDT (Crawford & Garthwaite, 2005)) was used to analyse whether the difference between count and mass nouns was significantly greater than the difference by the controls.
* Significant result, p<0.05

Results: Picture Naming

Noun phrase accuracy.

The results for the picture naming task can be found in Table 5.

In the picture naming tasks using noun phrases, RAP was impaired compared to the control group (modified t-test (two-tailed) (Crawford & Garthwaite, 2002; Crawford & Howell, 1998): picture naming ‘a’ vs. ‘some’: $t(9) = -2.761$, $p = .022$; picture naming ‘many’ vs. ‘much’: $t(9) = -16.382$, $p < .001$). He also showed poorer performance in producing mass noun phrases than count noun phrases. This difference was marginally significant for mass noun compared to singular count noun phrases, and significant for mass noun compared to plural count noun phrases. The controls showed no significant differences in their ability to produce mass and count noun phrases (due to noun errors for 'much’ and ‘many' there was a trend for mass noun phrases to be worse). For the phrase as a whole, the difference between (singular and plural) count noun and mass noun phrases is significant greater for RAP compared to the control group.

However, this first analysis includes items where an incorrect noun was produced. In this case, the phrase is counted as incorrect, but yet may include the correct determiner (e.g., picture of mass noun 'garlic': (a) response 'an onion' is labelled as mass noun phrase error; (b) response 'a garlic' is also labelled as mass noun phrase error). As the sources of these errors in the language system are likely to differ, it is important to analyse the results of the two picture naming tasks with noun phrases in more detail. Hence, we also examined the accuracy of the target nouns and the determiners in the phrases separately.

Table 5 *Proportion of Correct Responses in the Picture Naming Tasks with Noun Phrases.*

	RAP			Control Mean (Standard Deviation)			RAP-Controls
Tasks	Count[a]	Mass	Mass vs. Count (pvalue)[a,b]	Count[a]	Mass	Mass vs. Count (pvalue)[a,c]	Mass vs. Count RSDT (pvalue)[a,d]
Spoken picture naming NPs							
Whole phrase accuracy							
‘a' vs. 'some'	0.9	0.67	.062	0.92 (0.05)	0.90 (0.05)	.389	.009*
‘much' vs. 'many'	0.63	0.13	.012*	0.99 (0.03)	0.92 (0.05)	.086	.037*
Noun accuracy							
‘a' vs. 'some'	0.90	0.90	1.00	0.90 (0.05)	0.92 (0.05)	.433	n/a
‘much' vs. 'many'	0.94	0.94	1.00	0.99 (0.03)	0.94 (0.06)	.086	0.307
Determiner accuracy[e]							
‘a' vs. 'some'	1	0.75	.019*	1.00 (0)	0.97 (0.03)	.024*	
‘much' vs. 'many'	0.67	0.13	.010*	1.00 (0)	1.00 (0)	1.00	
Determiner substitutions[e]							
‘a' vs. 'some'	0	0.25	.010*	0 (0)	0.01 (0.02)	.168	
‘much' vs. 'many'	0	0.53	.002*	0 (0)	0 (0)	1.00	

[a] For the determiners ‘a’ versus ‘some’ singular count nouns were compared with mass nouns; for determiners ‘much’ versus ‘many’ plural count nouns were compared with mass nouns.
[b]The Wilcoxon two-sample test was used to compare the accuracy of noun phrases, nouns and determiners and the number of correct and countability neutral determiners with the number of countability incongruent determiners between mass and count noun phrases for RAP.
[c] The Wilcoxon matched pairs test was used to compare the accuracy of noun phrases, nouns and determiners and the number of correct and countability neutral determiners with the number of countability incongruent determiners between mass and count noun phrases for the control group.

[d] The Revised Standardised Difference Test, RSDT (Crawford & Garthwaite, 2005) analysed whether the difference between count and mass nouns was significantly greater than the difference shown by the controls. This cannot be performed when controls are at ceiling.
[e] Determiner accuracy and determiner substitutions are calculated for noun phrases with the target noun independent of the target noun’s number (for example when mass nouns were pluralised).
* Significant result, $p < 0.05$.
n/a RSDT was only used when RAP and/or the control group showed a significant difference between mass and count nouns in order to confirm a possible dissociation between mass and count noun performance.

Target noun accuracy.

Focusing only on the target nouns in the phrase, RAP did not show a difference in accuracy between mass and count nouns in either determiner condition, replicating the results for bare noun naming.

The controls showed no difference for the singular count noun/mass noun set but did show a marginally significant effect for the plural count noun/mass noun set: The control group was slightly better at naming pictures of plural count nouns compared to pictures of mass nouns. This difference was not significantly greater for the control group compared to RAP.

Determiner accuracy.

Analysis was restricted to determiners in phrases which were produced with the correct target noun, as incorrect target nouns may not share the mass/count status of the target as in the garlic/onion case above.

For accurately produced target nouns, RAP showed a significant difference between determiner accuracy in count noun and mass noun phrases, being less accurate with mass noun phrases. Controls were also slightly, but only marginally significantly, more accurate with determiners in singular count noun phrases (‘a’) than determiners in mass noun phrases (some) but showed no difference for plural count noun (‘many’) and matched mass noun phrases (much) which were at ceiling. As the control group made few determiner errors we were not able to use the RSDT (Crawford & Garthwaite, 2005) to analyse whether the difference between count and mass nouns was significantly different for RAP compared to the controls.

Determiner errors in (correct target) noun phrases were further analysed.

We compared the number of phrases where determiners were replaced by a countability incongruent determiner with the number of phrases where determiners were the target determiner or a countability neutral determiner. For mass nouns, incongruent determiners were singular or plural count noun specific determiners (a, each, many) and neutral determiners were those that could be used with both mass and count nouns (that, the, some (when ‘much’ was the target)); Incongruent determiners for singular count nouns were mass noun and/or plural count noun determiners (some, many) and for plural count nouns they were singular or mass noun determiners (a, much).

For the task with singular count and mass nouns (some versus a) RAP significantly more often substituted a countability incongruent determiner for a mass noun determiner than for a singular count noun determiner, whereas no difference was found for the control group. A similar pattern was found for plural count nouns and mass nouns (much versus many): RAP more often substituted mass noun determiners than plural count noun determiners whereas no substitution errors were found for the control group.

The absence of determiner substitution errors for the control group made it impossible to use the RSDT to determine whether RAP showed a significantly different pattern to the control group.

Discussion

In repetition, reading or grammaticality judgements with noun phrases, even though he was impaired compared to controls, RAP showed no more difficulties with mass noun phrases than count noun phrases. However, in the two picture naming tasks with singular count noun and mass noun phrases, and with plural count noun and mass noun phrases, RAP showed more difficulties in naming mass noun pictures with the correct noun phrase compared to count noun pictures, in contrast to his performance with bare nouns (Experiment 1). His countability specific problem affected the production of the mass specific determiners ‘some’ and ‘much’. RAP would frequently substitute these determiners with the count noun determiners ‘a’ and ‘many’, respectively. For example, on 53% of occasions, he substituted the target determiner ‘much’ with a determiner of a different countability category, in this case the plural count noun determiner ‘many’. In contrast, he never substituted the plural count noun determiner ‘many’ with a determiner of a different category such as the mass noun determiner ‘much’. While RAP had difficulties in producing the correct mass noun determiner, the selection of target mass nouns remained unaffected leading to the production of ungrammatical mass noun phrases such as, *a mustard, *a jelly, *many butter, *many sugar.

The control group sometimes showed slightly lower accuracy for mass noun phrases compared to count noun phrases. However, unlike RAP, the control group’s errors with mass noun phrases were due to noun errors or determiner omissions: 71% of all determiner errors were omissions for the control group, whereas 100% of all determiner errors were substitutions by a countability incongruent determiner for RAP.

Taking the results of Experiments 1 and 2 together, what insights can we gain into the processing of mass and count nouns in the language system and its specific breakdown in RAP?

RAP’s reading and repetition of mass and count noun phrases was within normal range. We can therefore exclude that RAP’s mass specific impairment, in the picture naming tasks with noun phrases, has its origins at a post-lexical level. The results of the picture naming tasks and reading and repetition tasks with bare nouns revealed that RAP’s production of nouns was generally impaired but with no specific difficulties with mass nouns. Thus, we can further rule out the existence of a countability specific impairment at the word form and/or semantic level. This leaves the lexical-syntactic level as the most likely locus of RAP’s mass specific impairment. However, the picture naming task with bare nouns showed no effect of countability, hence lexical-syntactic mass/count information does not influence processing of bare nouns for RAP.

We will now discuss two possible explanations for RAP's mass specific impairments in the picture naming tasks with noun phrases and then introduce further experiments to test these hypotheses.

RAP’s mass specific deficit in producing mass noun determiners in noun phrases is compatible with either of the two accounts described in the introduction: (a) an impairment of specific determiners such as ‘some’ and ‘much’ at the lexical-syntactic and/or word form level (cf Herbert and Best, 2010), or (b) an impairment of the lexical-syntactic attribute node [mass] at the lexical-syntactic level (cf Semenza et al., 1997).

The first hypothesis suggests that activation or representation of the determiners ‘some’ and ‘much’ would be partially impaired at the lemma and/or word form level (see Figure 3). The target noun concept activates its lemma node which in turn activates its lexical-syntactic attributes in the form of [mass] or [count] nodes. For count nouns, the lexical-syntactic attribute [count] activates the appropriate determiner ‘a’/‘many’ sufficiently for its selection. The determiner ‘a’/‘many’ at the lexical-syntactic level subsequently activates its word form leading eventually to the production of the noun phrase with the correct target determiner. For mass nouns, once again, the lexical-concept activates its lemma node which forwards activation to its lexical-syntactic attributes, including the [mass] node, which subsequently activate the lemma of the target mass noun determiner. However, the partial impairment of the determiner lemma node or determiner word form leads to insufficient activation for selection of the target determiner ‘some’/‘much’.

However, this account would predict determiner omissions, whereas RAP substitutes a count noun determiner. It is likely that this occurs because the count noun determiner ‘a’/‘many’ is also activated and competes for selection[23]. There could be two sources of activation, the first is due to the fact that the count noun determiner is one of the only two eligible responses in this task and therefore part of a response set[24] (Glaser & Glaser, 1989; Klein, 1964; Proctor, 1978) and second the count noun determiner could be primed from selection in a previous trial. As a result of the mass determiner impairment, the count noun determiner may be more highly activated and therefore likely to be selected rather than the mass noun determiner ‘some’ or ’much’. This leads to the production of an ungrammatical mass noun phrase with count noun determiner (e.g., *a mustard, *much butter).

The second hypothesis for the mass specific deficit is an impairment of the lexical-syntactic attribute [mass] (Semenza et al., 1997) (see Figure 4). The

[23] For discussion of determiner competition in noun phrase production see for example Schiller and Caramazza, 2003.
[24] Response set was originally used to refer to eligible responses in Stroop tasks. For example, the ink colours blue and yellow may be included in the task but not red and green: blue and yellow therefore comprise the response set. Distractors which were members of a response set have been found to cause more interference than distractors which were not part of the response set (e.g., Participants were slower in naming the colour of the word BLUE in yellow ink than of the word RED in yellow ink) (Lamers, Roelofs & Rabeling-Keus, 2010).

difference from the hypothesis above is that it is the partial impairment of the [mass] node that causes insufficient activation of any mass determiner lemma at the lexical-syntactic level. The determiner lemmas and/or determiner word forms themselves remain unimpaired. The deficient activation of the target mass determiner lemma ‘some’/‘much’ and interference from the count noun determiner lemma ‘a’/‘many’ would frequently lead to the selection of the count noun determiner over the mass noun determiner just as in the account above.

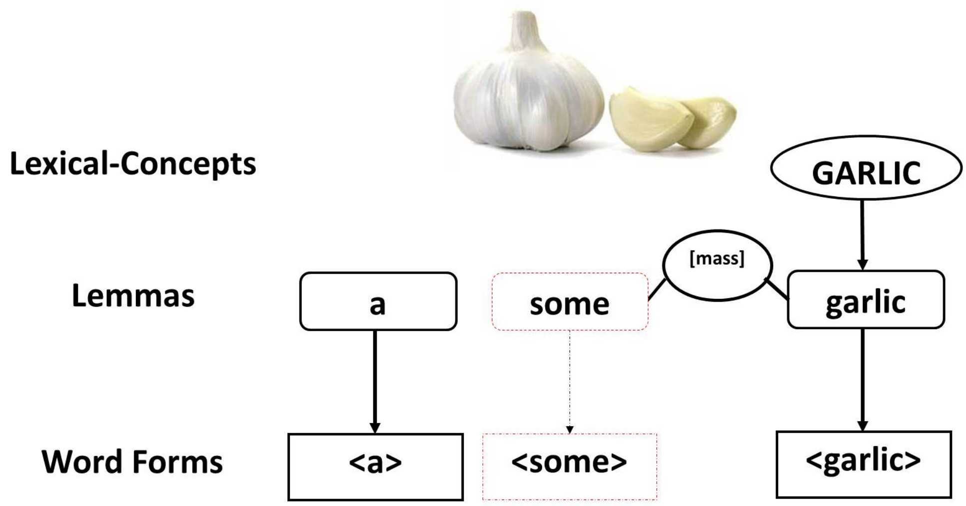

Figure 3. Impairment of the determiner ‘some’ at the lexical-syntactic and/or word form level.

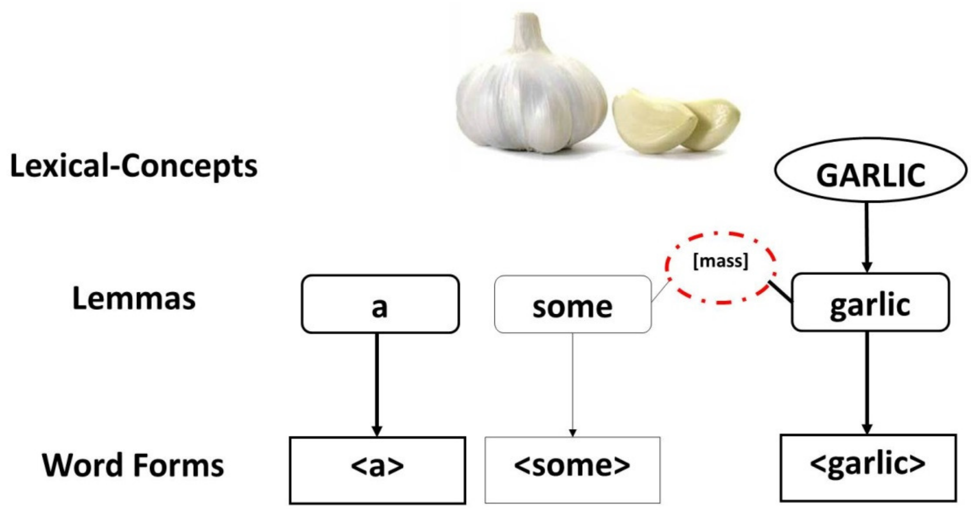

Figure 4. Effect of an impairment of the lexical-syntactic attribute [mass] on the production of the determiner ‘some’.

In order to discriminate between these two hypotheses, we developed a series of further picture naming tasks. As before, RAP was asked to name pictures with the target noun and one of the two determiners ‘a’ versus ‘some’. Within this task, the same determiner, ‘some’, was required for mass noun pictures as for plural count noun pictures. The determiner impairment hypothesis predicts impairment for both mass and plural count noun phrases as they require the same determiner (some). In contrast, the [mass] node specific impairment predicts mass noun phrases to be more impaired than plural count noun phrases.

Experiment 3: Mass and count noun phrases requiring the same determiner

The procedure was the same as in the former two picture naming tasks with noun phrases. The participant heard and saw the beginning of the sentence ‘I see _ _’ and was asked to complete the sentence by using one of the two determiners ‘a’ or ‘some’ and the noun depicted in the picture (e.g., a razor, some horses, some money).

The material consisted of 32 mass noun pictures (depicted as single objects), 23 plural count nouns (depicted as multiple objects) and 55 singular count noun pictures as filler items, such that there were equal numbers of phrases beginning with the determiner ‘a’ (55 singular count nouns) and the determiner ‘some’ (32 mass plus 23 plural count nouns).

Results

Noun phrase accuracy.

The control group did not show a difference between naming pictures with mass noun phrases (96% accuracy) and plural count noun phrases (98% accuracy) (Wilcoxon matched pairs: $p = .222$ (two-tailed)). RAP’s picture naming was impaired compared to the control group (Crawford & Garthwaite, 2002; Crawford & Howell, 1998: $t = -10.648$, $p < .001$ (two-tailed)) and was significantly better for plural count noun phrases than for mass noun phrases (Wilcoxon two-sample: $p = .034$ (two-tailed)) (see Figure 5). The difference between plural count noun phrases and mass noun phrases was significantly greater for RAP than for the control group (RSDT (Crawford & Garthwaite, 2005): $t = 3.405$, $df = 9$, $p = .004$ (two-tailed)).

Target noun accuracy.

Looking at the production of target nouns within the phrase, results revealed that, like the controls (mass noun accuracy: 96%; plural count noun accuracy: 98%), RAP did not show a difference in naming pictures with the target plural count noun compared to the target mass noun (Controls: Wilcoxon matched pairs: p = .301 (two-tailed); RAP: Wilcoxon two-sample: p = 1.00 (two-tailed)) (see Figure 5).

Determiner accuracy.

Controls showed no difference in the number of correctly produced target determiners for plural count noun phrases (99% accuracy) and mass noun phrases (100% accuracy; Wilcoxon matched pairs: p = .346 (two-tailed)). RAP, however, used the correct determiner ‘some’ for naming pictures with plural count noun phrases significantly more often than the same determiner ‘some’ for mass noun phrases (Wilcoxon two-sample: p = .009 (two-tailed)). As the control group performed at ceiling, we could not use the RSDT (Crawford & Garthwaite, 2005) to statistically compare RAP to the control group.

Analysing the number of determiner substitutions revealed that the control group did not once substitute the target determiner with a countability incongruent determiner. In contrast, RAP more often substituted the determiner ‘some’ with a determiner of different countability for mass nouns (54% of the determiners of all phrases with the correct target noun were substituted by a countability incongruent determiner) than he did for plural count nouns (0%) (Wilcoxon two-sample: p = .007 (two-tailed)).

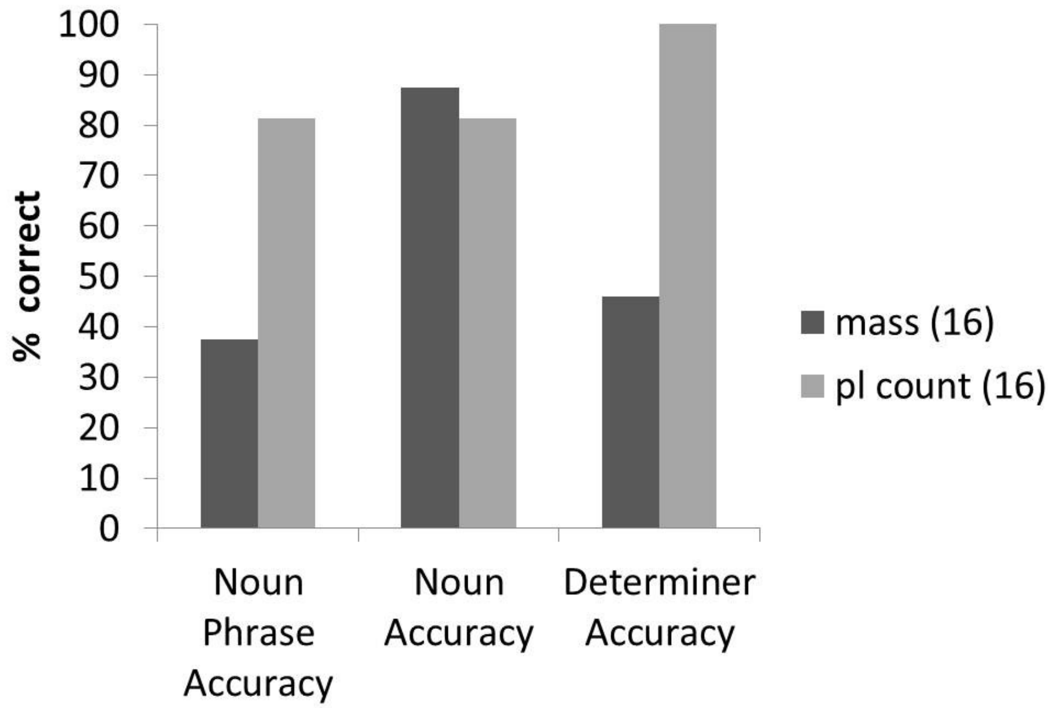

Figure 5. RAP's accuracy for noun phrases, target nouns and determiners (in phrases with correct target noun) in spoken picture naming with noun phrases requiring the determiner 'some'.

Discussion

The results of the picture naming task with noun phrases testing for a determiner impairment showed that RAP named more plural count noun pictures than mass noun pictures with the correct target noun phrase. As before, this difference resulted from more incorrect mass noun determiners than plural count noun determiners. This observation holds even though the determiner, namely ‘some’, was the same for both target noun categories (mass and plural count). We can therefore reject the hypothesis that RAP’s mass specific impairment is caused by an impairment of specific determiners, such as ‘some’, at the lexical-syntactic and/or word form level (cf Herbert & Best, 2010).

These results therefore suggest that RAP suffers from an impairment of the lexical-syntactic attribute [mass]. However, such lexical-syntactic attributes are hypothesised to be modality neutral and consequently any impairment should affect both production and comprehension. However, RAP, while impaired on the grammaticality judgements task, showed no mass specific effect.

What explanation could there be for this discrepancy? If we look at the different components involved in the completion of the picture naming task, it becomes apparent that conceptual and semantic information is accessed prior to lexical-syntactic information unlike in the grammaticality judgement task. This kind of information could affect noun and/or determiner selection at the lexical-syntactic level. But what kind of information could particularly influence the determiner selection of mass nouns? For count nouns, singular count nouns have to be depicted as a single object and plural count nouns as multiple objects. Levelt et al. (1999) suggest that for plural count nouns a node MULTIPLE is activated at the level of lexical concepts. By extension, we suggest that for singular count nouns a lexical concept SINGLE is activated by the visual input of a single object. This concept SINGLE would result in activation of determiners which comprise the meaning of *one* or *single*, such as the singular count noun determiner ‘a’. Similarly, the MULTIPLE node would result in activation of determiners consistent with the meaning of more than one, such as ‘some’ or ‘many’.

How then, might the activation of MULTIPLE and SINGLE lexical concepts affect the production of mass noun phrases? We first consider the task with ‘a’ and ‘some’ (Experiment 2). Here, to avoid visual cues to countability status, mass nouns were presented as single objects (e.g. a single jar of honey, a single bulb of garlic). If the presence of a single visual object activates the lexical concept

SINGLE, this could hinder the selection of the target mass noun determiner ‘some’ by activating the competitor determiner ‘a’. Since the determiner lemma ‘some’ has not received sufficient activation for its selection from the partially impaired mass node, the co-activated count noun determiner ‘a’ is selected instead (see Figure 6a).

A similar process can be assumed for the picture naming task with the determiners ‘much’ versus ‘many’. In this task, mass nouns were depicted as multiple objects (see Figure 6b). The visual information of multiple objects activates the lexical-concept node MULTIPLE. This MULTIPLE node would send activation to appropriate determiners such as ‘many’ at the lexical-syntactic level but not to the determiner ‘much’ since ‘much’ is conceptually uncountable. As a result, activation by the lexical concept MULTIPLE would be only advantageous for the production of the plural count noun determiner ‘many’ whereas it would interfere with the selection of the mass noun determiner ‘much’.

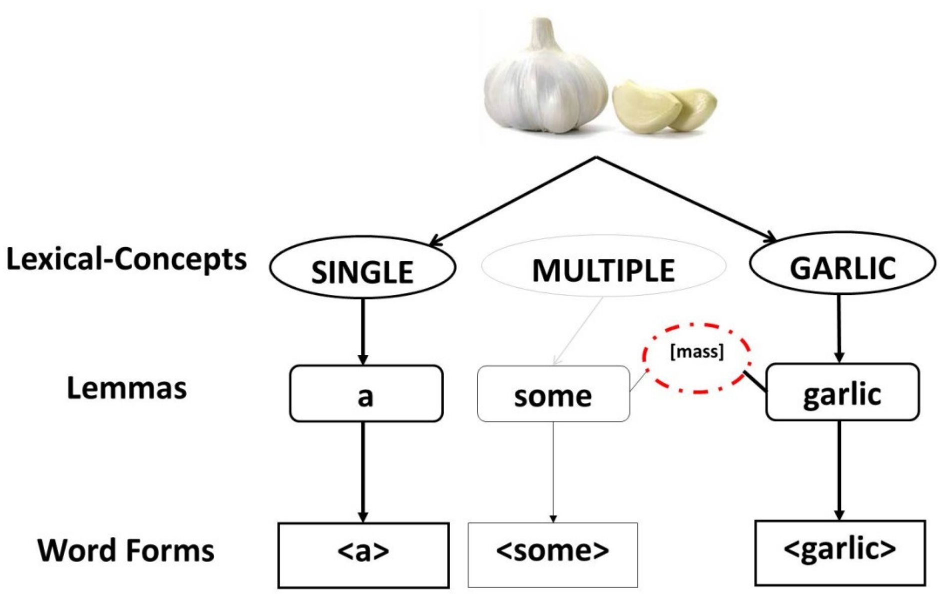

Figure 6a. Influence of visual and conceptual-semantic information SINGLE on the selection of ‘some’.

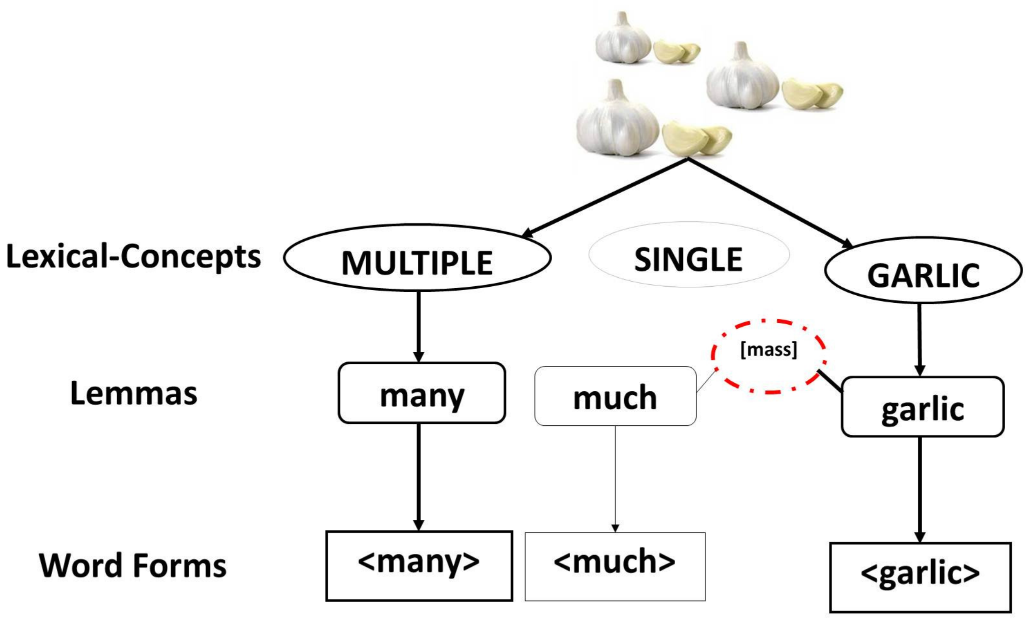

Figure 6b. Influence of the visual and conceptual-semantic information MULTIPLE on the selection of ‘much’.

Returning to the grammaticality judgement task, here there is no visual and subsequently conceptual-semantic information, rather the lexical-syntactic representations for determiners and nouns are activated from auditory input. Consequently, there is no biasing visual/conceptual input to activate erroneous determiner competitors. As a result of the absence of strong competition, mass noun determiners and lexical-syntax are not selectively disadvantaged compared to count noun determiners and lexical-syntax.

In order to test the hypothesis that visual/conceptual input affects determiner selection, we developed a second picture naming task where mass noun pictures were presented as multiple objects like plural count noun pictures. If RAP’s deficit results from an impairment of the lexical-syntactic attribute [mass] and becomes apparent through the influence of visual and conceptual-semantic information, mass noun phrases should be named more accurately in this condition where the mass noun determiner is the same as that activated by visual and conceptual-semantic information (some).

Experiment 4: Mass noun phrases with pictorial stimuli congruent for determiner number

The materials used and the procedure applied were the same as in Experiment 3 with the only difference that mass nouns were depicted as multiple objects (e.g. three bulbs of garlic; three jars of honey). In order to test for an influence of visual and conceptual-semantic information on the production of mass noun phrases, we compared both mass with plural count noun phrases, and with mass nouns presented as single objects in Experiment 3.

Results

Noun phrase accuracy.

RAP’s picture naming with noun phrases was impaired compared to the control group ($t = -3.307$, $p = .009$ (two-tailed)). Neither the control group (noun phrase accuracy: mass: 95%; count: 98%) nor RAP (see Figure 5) showed a difference in accuracy for naming pictures with plural count noun phrases compared to pictures with mass noun phrases (Controls: Wilcoxon matched pairs: $p = .222$ (two-tailed); RAP: Wilcoxon two-sample: $p = .338$ (two-tailed)). Comparing accuracy of the differently depicted mass nouns revealed that RAP more accurately produced noun phrases for pictures of multiple mass nouns than pictures of single mass nouns (see Figure 7), unlike the control group (control noun phrase accuracy: single mass nouns (Experiment 3): 96%, multiple mass nouns: 95% (Experiment 4), (Wilcoxon: Controls: $p = 1.00$ (two-tailed); RAP: $p =$

.008 (two-tailed)). The difference between RAP and the control group was significant (RSDT (Crawford & Garthwaite, 2005): $t = 15.339$, $df = 9$, $p < .001$ (two-tailed)).

Target noun accuracy.

There was no difference in target noun accuracy between mass and plural count nouns for either the control group (mass: 95%, plural count: 98%; Wilcoxon matched pairs: $p = .155$ (two-tailed)) or RAP (see Figure 7) (Wilcoxon two-sample: $p =.338$ (two-tailed)). Moreover, no difference was found between single mass nouns and multiple mass nouns for either RAP or the control group (accuracy for single mass nouns: 96%, multiple mass nouns: 95%) (Wilcoxon matched pairs: Controls: $p = 1.00$ (two-tailed); RAP: $p = .424$(two-tailed)).

Determiner accuracy.

There was no difference in determiner accuracy between plural count noun and mass noun phrases for either the control group (plural count determiners: 99%, mass determiners: 99%; Wilcoxon matched pairs: $p = .786$ (two-tailed)) or RAP (Wilcoxon two-sample: $p = 1.00$ (two-tailed)). Furthermore, the results for the number of determiner substitutions revealed no significant difference for the control group (number of noun phrases with correct target noun with a countability incongruent determiner: mass: 1%; plural count: 0%; Wilcoxon matched pairs: $p = 1.00$ (two-tailed)) or RAP (Wilcoxon two-sample: $p = 1.00$ (two-tailed)). RAP did not once substitute the determiner ‘some’ with another determiner when he named mass noun pictures depicted as multiple objects with mass noun phrases. The comparison of determiner accuracy for single mass nouns with multiple mass nouns revealed a significant difference for RAP (Wilcoxon two-sample: p = .005 (two-tailed)) but not for the control group (single mass nouns: 100%, multiple mass nouns: 99%; Wilcoxon matched pairs: p = 1.00 (two-tailed)). Again, the RSDT could not be used as the control group did not once substitute the determiner ‘some’ for single mass nouns.

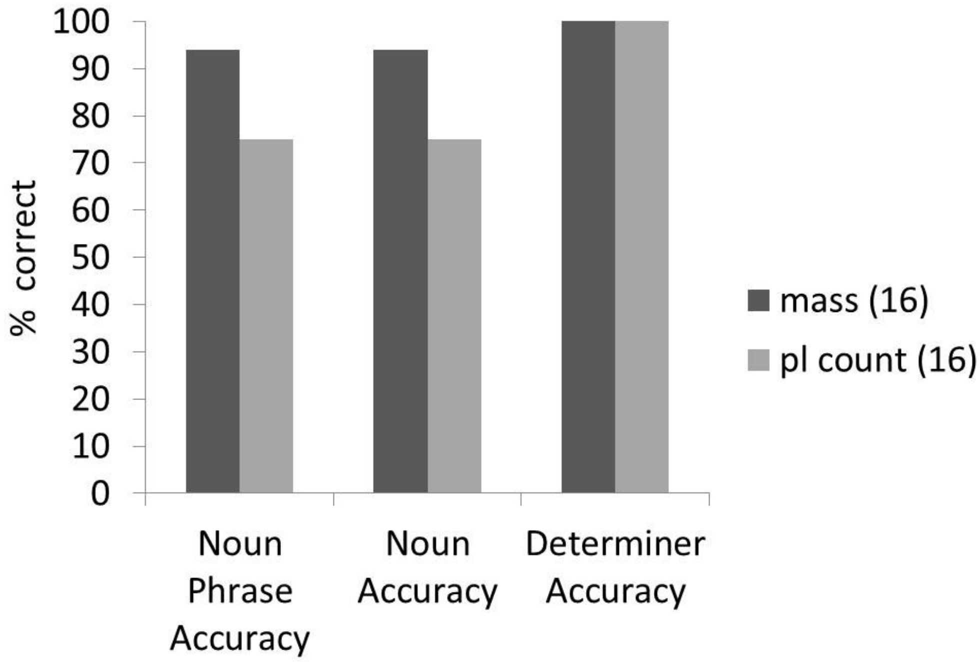

Figure 7. RAP’s accuracy for noun phrases, target nouns and determiners (in phrases with correct target noun) in spoken picture naming with mass nouns depicted as multiple objects.

Discussion

In stark contrast to the previous noun phrase production tasks, in this experiment RAP showed no impairment for mass noun phrases. Furthermore, the comparison of the differently depicted mass nouns revealed that RAP produced correct determiners significantly more often when mass nouns were depicted as multiple objects (e.g. three jars of honey, three bulbs of garlic) than as single objects (e.g. one jar of honey, one bulb of garlic). These results confirm our hypothesis that the effect of the mass impairment on the production of mass noun determiners can be influenced by visual and conceptual-semantic information such as the number of objects in a picture.

To summarise, our data support a theory in which RAP’s mass specific deficit is localised at the lexical-syntactic level and is caused by an impairment of the lexical-syntactic attribute node [mass]. However, as we have seen in the results of the grammaticality judgement task, the mass specific deficit only surfaces if visual and/or conceptual-semantic information leads to the activation of competitor determiners at the lexical-syntactic and maybe subsequently at the word form level.

We now present the results of a further experiment (Experiment 5) which provides converging evidence for this hypothesis using different determiner pairs. In these tasks the mass nouns share their determiners with either plural count nouns, or singular count nouns and are systematically manipulated regarding their visual and conceptual-semantic information. According to our hypothesis we would expect RAP to be better with mass nouns which share the visual information of the critical mass/count noun determiner (e.g., mass nouns presented as multiple objects share the visual information MULTIPLE with the target determiner ‘some’) than with mass nouns which do not share this information (e.g., mass nouns presented as single objects do not share the visual information MULTIPLE with the target determiner ‘some’).

The picture naming tasks involved the production of noun phrases with one of the two determiner pairs: ‘a’ versus ‘enough’ (mass=plural count), ‘this’ versus ‘these’ (mass=singular count), and ‘that’ versus ‘those’ (mass=singular count).

Experiment 5: Replication of the effect of determiner number congruency on mass noun phrase accuracy.

Design & Procedure

For the picture naming task with ‘a’ versus ‘enough’, the procedure and material was similar to that of Experiments 3 and 4 combined. The participant heard and saw the beginning of the sentence ‘Have you seen _ _?’ and was asked to complete the sentence by using either the determiner ‘a’ or ‘enough’ and the noun depicted in the picture (e.g., a lion, enough turtles, enough butter). The materials consisted of 23 plural count noun pictures plus 32 mass noun pictures as critical items and 55 singular count noun pictures as fillers. Half of the pictures (55) required the determiner ‘a’ (singular count noun pictures) and the other half the determiner ‘enough’ (plural count noun and mass noun pictures). The same mass nouns were presented both depicted as single and multiple objects.

In the two picture naming tasks with the determiners ‘this’ versus ‘these’, and ‘that’ versus ‘those’, the participant heard and saw the beginning of the sentence ‘I can see _ _.’ and was asked to use one of the two determiners plus the noun depicted on the picture to complete the sentence (e.g., this lion, these turtles, this butter). The material for each of the two tasks consisted of 48 singular count noun pictures, 32 mass noun pictures as critical items and 80 plural count nouns as fillers. The objects depicted on the pictures were counterbalanced regarding their determiners. In the picture naming task ‘this’ versus ‘these’, half of the pictures (80) required the determiner ‘this’ (singular count noun and mass noun pictures) and the other half the determiner ‘these’ (plural count nouns). The same applied to the picture naming task ‘that’ versus ‘those’.

All three tasks consisted of two blocks in which half of the mass nouns were presented as single and the other half as multiple objects and the reverse in the second block. Each block was presented on separate days. RAP was familiarised with the procedure and the two determiners of each task through practice items and written determiner cards.

Results

The results are presented in Table 6.

Noun phrase accuracy.

RAP was significantly more impaired on all three picture naming tasks than the control group (‘a’ vs. ‘enough’: $t(9) = -2.421$, $p = .035$; ’this’ vs. ‘these’: $t(9) = -11.997$, $p < .001$; ‘that’ vs. ‘those’: $t(9) = -10.542$, $p < .001$). The control group showed no difference in naming single mass noun depictions compared to multiple mass noun depictions in any of the three tasks.

In the picture naming task with the determiners *‘a’ versus ‘enough’*, where the mass noun determiner is the same as the plural count noun determiner, RAP was significantly better at producing complete noun phrases for pictures of multiple mass nouns compared to single mass nouns. This difference was significantly greater for RAP than for the control group.

In the two picture naming tasks *‘this’ versus ‘these’,* and *‘that’ versus ‘those’*, where the mass noun determiner is the same as the singular count noun determiner, RAP had more difficulties in naming pictures with noun phrases for multiple mass nouns compared to single mass nouns. This difference was significantly greater for RAP than the control group for both tasks.

Table 6 *Proportion of Correct Responses in the Picture Naming Tasks with Noun Phrases.*

	RAP			Control Mean (Standard Deviation)			RAP-Controls
Tasks	Mass single	Mass multiple	Mass single vs. Mass multiple (pvalue)[a]	Mass single	Mass multiple	Mass single vs. Mass multiple (pvalue)[a]	Mass single vs. Mass multiple RSDT (pvalue)[b]
Spoken picture naming NPs							
Whole phrase accuracy							
‘a' vs. 'enough'	0.56	0.94	.020*	0.94 (0.08)	0.95 (0.08)	.773	.001*
‘this' vs. 'these'	0.75	0.06	.003*	0.99 (0.03)	0.96 (0.07)	.174	.014*
‘that' vs. 'those'	0.38	0	.020*	0.96 (0.07)	0.95 (0.06)	.586	.001*
Noun accuracy							
‘a' vs. 'enough'	0.94	0.94	.637	0.96 (0.07)	0.95 (0.08)	.773	n/a
‘this' vs. 'these'	1	0.56	.012*	0.99 (0.03)	0.98 (0.04)	.346	.001*
‘that' vs. 'those'	0.63	0.44	.299	0.96 (0.07)	0.96 (0.06)	.637	n/a
Determiner accuracy[c]							
‘a' vs. 'enough'	0.6	1	.020*	0.98 (0.03)	1 (0.00)	.174	
‘this' vs. 'these'	0.75	0.07	.003*	1 (0.00)	0.98 (0.04)	.371	
‘that' vs. 'those'	0.44	0	.011*	1 (0.00)	0.99 (0.04)	1.00	
Determiner substitutions[c]							
‘a' vs. 'enough'	0.33	0	.037*	0.01 (0.02)	0 (0.00)	1.00	
‘this' vs. 'these'	0.25	0.93	.005*	0 (0.00)	0.11 (0.31)	.371	
‘that' vs. 'those'	0.56	1	.011*	0 (0.00)	0.01 (0.02)	1.00	

[a] The Wilcoxon matched pairs test was used to compare the accuracy of noun phrases, nouns and determiners and the number of correct and countability neutral determiners with the number of countability incongruent determiners between single mass and multiple mass noun phrases for RAP and the control group.
[b] The Revised Standardised Difference Test, RSDT (Crawford, & Garthwaite, 2005)) analysed whether the difference between single mass nouns and multiple mass nouns was significantly greater than any difference between the conditions shown by the controls.
[c] Determiner accuracy and determiner substitutions are calculated for noun phrases with the target noun independent of the target noun’s number (for example when mass nouns were pluralised)
* Significant result: $p<0.05$
n/a RSDT was only used when RAP and/or the control group showed a significant difference between mass and count nouns in order to confirm a possible dissociation between mass and count noun performance.

Target noun accuracy.

For the control group, there was no difference between mass nouns presented as single objects and mass nouns presented as multiple objects in any of the tasks.

RAP showed no difference in target noun accuracy between single mass and multiple mass nouns for either the *‘a’ versus ‘enough’* or the *‘that’ versus ‘those’* picture naming tasks. However, in the *‘this’ versus ‘these’* picture naming task*,* RAP produced accurate target nouns more often when naming pictures of single mass nouns than of multiple mass nouns. This difference arose because RAP pluralised some of the mass nouns which were presented as multiple objects. A comparison between the number of correctly named pictures for single mass nouns and multiple mass nouns independent of their number inflection revealed no significant difference (Wilcoxon matched pairs: $p = 1.00$ (two-tailed)).

Determiner accuracy.

The performance of the control group is predominantly at ceiling which made it impossible to use the RSDT (Crawford & Garthwaite, 2005) to analyse whether the difference in determiner accuracy and in the number of substitution errors between mass and count noun phrases is greater for RAP than for the control group. However, the control group did not show a significant difference between determiners of single mass nouns compared to multiple mass nouns for any of the three picture naming tasks. As expected, in the picture naming task with the determiners *‘a’ versus ‘enough’*, RAP made more determiner errors for single mass nouns compared to multiple mass nouns. He substituted the determiner ‘enough’ more often with the countability incongruent determiner ‘a’ for single mass nouns compared to multiple mass nouns.

Consistent with our predictions for the picture naming tasks with the determiners *‘this’ versus ‘these’ and ‘that’ versus ‘those’*, RAP made significantly more determiner errors for multiple mass nouns compared to single mass nouns. RAP substituted the determiners ‘this’ and ‘that’ significantly more often for the countability incongruent determiners ‘these’ and ‘those’ for multiple mass nouns than for single mass nouns.

Discussion

Comparing depictions of single mass nouns with multiple mass nouns, confirmed that RAPs mass specific difficulties with determiners become apparent when the visual and conceptual-semantic information from mass noun pictures does not match the conceptual-semantic information of the target mass determiner: mass nouns presented as single objects do not activate the concept MULTIPLE for determiners such as ‘some’ and ‘enough’; mass nouns presented as multiple objects do not activate the concept SINGLE for determiners such as ‘this’ and ‘that’.

In a final experiment we carried out four determiner judgement tasks with mass and count noun pictures to investigate whether the proposed lexical-syntactic impairment is modality-neutral by using a comprehension task: if RAP has an impairment of the lexical-syntactic attribute [mass], we would expect similar results on determiner judgement tasks as the picture naming tasks with noun phrases.

For the four determiner judgement tasks, we used the same determiner pairs as in Experiments 4 and 5. According to our hypothesis we would expect

RAP to be better with mass nouns which share the visual and conceptual-semantic information of the critical mass/count noun determiner (e.g., mass nouns presented as multiple objects share the concept MULTIPLE with the target determiner ‘some’) than with mass nouns which do not share this information (e.g., mass nouns presented as single objects do not share the concept MULTIPLE with the target determiner ‘some’). Thus, we compare single mass nouns with multiple mass nouns to confirm the effect of visual and conceptual-semantic information on RAP’s performance on mass noun phrases. Furthermore, we examine count noun phrases and mass noun phrases which share the same determiner to ensure that his difficulties affect not only different kinds of determiners in mass noun phrases, but also spares the same determiners in count noun phrases.

Experiment 6: Determiner judgement and determiner number congruency

Design & Procedure

The stimuli were identical to those used in Experiments 4 and 5. In each trial the participant was presented with a picture and the two critical determiners written on cards. RAP was asked to look at the picture and point to the determiner that matched the picture.

Results

The results are presented in Table 7.

Table 7 *Proportion of Correct Responses in the Determiner Judgement Tasks with Noun Phrases.*

	RAP						Control Mean (Standard Deviation)						RAP - Controls		
Tasks	Singular Count[a]	Plural Count[a]	Mass single[a]	Mass multiple[a]	Mass vs. Count (pvalue)[b]	Mass single vs. Mass multiple (pvalue)[c]	Singular Count[a]	Plural Count[a]	Mass single[a]	Mass multiple[a]	Mass vs. Count (pvalue)[a,d]	Mass single vs. Mass multiple (pvalue)[d]	T-Test (pvalue)[e]	Mass vs. Count RSDT (pvalue)[a,f]	Mass single vs. Mass multiple RSDT (pvalue)[f]
Determiner judgement noun phrases															
‘a' vs. 'some'	1	1	0.63	0.94	.026*	.037	0.98 (0.02)	0.99 (0.02)	0.89 (0.09)	0.99 (0.02)	.009*	.013*	.008*	.017*	.879
‘a' vs. 'enough'	1	1	0.5	1	.005*	.006*	0.97 (0.03)	0.98 (0.02)	0.90 (0.08)	0.98 (0.04)	.012*	.020*	.005*	.004*	.010*
‘this' vs. 'these'	1	1	0.88	0	.001*	.001*	0.99 (0.02)	0.95 (0.05)	0.93 (0.06)	0.83 (0.14)	.019*	.041*	.001*	.002*	.006*
‘that' vs. 'those'	1	1	0.38	0			1 (0)	0.98 (0.03)	0.87 (0.15)	0.79 (0.14)	.009*	.068	.001*		

[a] Plural count nouns were compared with single mass nouns in the determiner judgement tasks with the determiners ‘a’ versus ‘some’ and ‘a’ versus ‘enough’. Singular count nouns were compared with multiple mass nouns in the picture naming tasks with ‘this’ versus ‘these’, and ‘that’ versus ‘those’.
[b] The Wilcoxon two-sample test was used to compare mass with count nouns for RAP.
[c] The Wilcoxon matched pairs test was used to compare single mass with multiple mass nouns for RAP.
[d] The Wilcoxon matched pairs test was used to compare mass with count nouns, and single mass with multiple mass nouns for the control group.
[e] The modified t-tests compared RAP’s general naming performance on combined critical count nouns (singular or plural) and mass nouns (single and multiple) with the control group (Crawford & Garthwaite, 2002; Crawford & Howell, 1998)).
[f] The Revised Standardised Difference Test, RSDT (Crawford, & Garthwaite, 2005)) analysed whether the difference between count and mass nouns, or single mass nouns and multiple mass nouns was significantly greater than any difference between the conditions shown by the controls.
* significant results:p<0.05

We compare plural count nouns with singly depicted mass nouns, and single mass nouns with multiply depicted mass nouns for the two determiner judgement tasks with ‘a’ versus ‘some’, and ‘a’ versus ‘enough’. For the two determiner judgement tasks with the determiners ‘this’ versus ‘these’ and ‘that’ versus ‘those’, we compare singular count nouns with multiple mass nouns, and single mass nouns with multiple mass nouns. The predictions are the same as for the picture naming tasks with noun phrases.

Overall, RAP had difficulties in all four determiner judgement tasks compared to the control group. His performance was above chance in all tasks (Binomial Test: $p > .05$), except for the determiner judgement task with ‘that’ versus ‘those’ where he performed at chance. Given this, it is hard to interpret his performance on this task and no further analysis is reported.

A separate analysis of each noun category revealed that he was better than chance in judging determiners for singular and plural count nouns in all four tasks (same result for singular and plural count nouns in all four tasks (Binomial Test: $p < .001$(two-tailed))). As expected for multiple mass nouns he was above chance in the determiner judgement tasks with ‘a’ versus ‘some’ (Binomial Test: $p < .001$ (two-tailed)) and ‘a’ versus ‘enough’ (Binomial Test: $p < .001$ (two-tailed)) and below chance in the determiner judgement tasks with ‘this’ versus ‘these’ (Binomial Test: $p < .001$ (two-tailed)). As predicted RAP’s performance for mass nouns presented as single objects was at chance for the determiner judgement tasks ‘a’ versus ‘some’ (Binomial Test: $p = .455$), ‘a’ versus ‘enough’ (Binomial Test: $p = 1.00$ (two-tailed)) and above chance for the task with the determiners ‘this’ versus ‘these’ (Binomial Test: $p = .004$ (two-tailed)).

For the judgement tasks with ‘a’ versus ‘some’ and ‘a’ versus ‘enough’, multiple mass nouns are congruent in number with the (plural) determiner ‘some’ and ‘enough’. In this task, as predicted, both RAP and the control group were worse in determiner judgement for single mass nouns compared to plural count nouns and multiple mass nouns. The difference was, in general, significantly greater for RAP compared to the control group.

For the tasks with ‘this’ versus ‘these’, single mass nouns are congruent in number with the (singular) determiner ‘this’. Here, RAP and the control group, as predicted, had more difficulties with judging determiners of multiple mass nouns compared to singular count nouns, and compared to single mass nouns. In all comparisons, the difference between multiple mass nouns compared to singular count nouns, and multiple mass nouns compared to single mass nouns was significantly greater for RAP than for the control group.

Discussion

The outcome of the four determiner judgement tasks confirmed our predictions that RAP has more difficulties with selecting determiners for mass nouns than with determiners for count nouns even though both noun groups required the same determiner. He made more determiner errors for single mass nouns than for plural count nouns in the determiner judgement tasks with ‘a’ versus ‘enough’ and ‘a’ versus ‘some’. His determiner accuracy was worse for multiple mass nouns compared to singular count nouns in the determiner judgement task with ‘this’ versus ‘these’.

The results of the comparison of singly depicted mass nouns with multiply depicted mass nouns, confirmed that his mass specific difficulties with determiners became apparent when he was presented with visual and conceptual-semantic information in mass noun pictures which did not match the conceptual-semantic number information of the target mass determiner. Therefore, RAP had more difficulties with the comprehension of the determiners ‘some’ and ‘enough’ when he was presented with pictures of single mass nouns compared to pictures of multiple mass nouns. Whereas, he had more problems with the determiner ‘this’ when he was presented with pictures of multiple mass nouns compared to pictures of single mass nouns. Even though the control group made also more determiner errors for mass nouns than for count nouns in the determiner judgement tasks, RAP’s difficulties were significantly worse compared to the control group.

Importantly, it is not the case that RAP's determiner choice is entirely based on the visual information from the picture as he is above chance both overall and within mass nouns alone. However, RAP did have particular difficulties with the determiner ‘that’ with performance at chance for mass nouns. He did not once choose ‘that’ for multiple mass nouns and rarely for single mass nouns despite accurately selecting the correct determiner for singular (that) and plural (those) count nouns. We found the same difficulties in the picture naming task with ‘that’ versus ‘those’. As in the determiner judgement task, RAP’s determiner accuracy for ‘that’ was very low in mass noun phrases with a high rate of substitutions by a countability incongruent determiner not only for mass nouns presented as multiple but also for mass nouns presented as single objects.

What could have caused RAP’s specific difficulties with the determiner ‘that’? While the determiners ‘this’, ‘these’ and ‘those’ are demonstrative determiners with only one meaning, ‘that’ is not only used as demonstrative pronoun but serves also several other grammatical purposes and therefore comprises other meanings. For example, ‘that’ can be used as an adverb (e.g., The night was not that long.), a conjunction of a subordinate clause (e.g., She hoped that the night would never end.) or a relative pronoun in a relative clause (e.g., She went out in the night that felt like it was never ending.) (Quirk & Greenbaum, 1974). Unlike ‘that’, ‘this’, ‘these’ and ‘those’ only refer to an entity that has been introduced earlier in a conversation or another context. The different grammatical and semantic applications of ‘that’ could have a negative impact on RAP’s processing of 'that' as a demonstrative determiner for mass nouns.

Returning to the determiner judgement task in general, how can we explain and incorporate RAP’s results for this task within the architecture we have been developing based on Levelt et al.’s (1999) theory (Figures 6a and 6b, above)? The presentation of a picture will lead to the activation of a noun concept (e.g., GARLIC) and of a conceptual node referring to conceptual number, such as SINGLE or MULTIPLE depending on the visual presentation of the depicted noun (e.g., ‘garlic’ presented as a single object will activate the concept SINGLE). The noun concept (GARLIC) activates its noun lemma which subsequently leads to the activation of the attribute [mass] or [count] and of countability congruent determiner lemmas at the lexical-syntactic level (e.g., the noun lemma ‘garlic’ activates the [mass] node and subsequently determiners such as ‘some’, ‘that’). The conceptual nodes SINGLE/MULTIPLE also activate conceptually congruent determiner lemmas (e.g., SINGLE activates the conceptually congruent determiner ‘a’). Even though conceptual-semantic information exerts an influence on determiner processing at the lexical-syntactic level, the selection of the determiner is predominantly determined by lexical-syntactic information (if unimpaired). At the same time as the picture is presented, the participant is presented with two written determiners (e.g., some versus a). The orthographic representation of each determiner activates their determiner lemma. The most highly activated determiner lemma of the two will be chosen for response. For example, when the picture represents a single bulb of GARLIC, in the unimpaired system, the determiner lemma ‘some’ will be the most highly activated, as ‘some’ has received strong activation via the [mass] node, whereas the determiner lemma ‘a’ has only received activation from the conceptual-semantic level. Consequently, the determiner ‘some’ is selected.

However, for RAP, we have proposed that the [mass] node is impaired, hence the determiner judgement process lacks the dominant influence of the lexical-syntactic [mass] node and therefore the appropriate determiner will receive less activation. In this scenario, similar to the picture naming tasks, conceptual-semantic information can exert more influence on the determiner judgement process (e.g., SINGLE activates the determiner lemma ‘a’). Consequently, the determiner lemmas activated by the conceptual-semantic information are more highly activated than those which received activation via the impaired mass node (e.g., the determiner lemma ‘a’ is more highly activated than the determiner lemma ‘some’). Hence, of the two orthographically presented determiners, the most highly activated lemma is the one activated via conceptual-semantic information (e.g., the determiner ‘a’). This explains RAP’s problems with choosing determiners for mass nouns when the visual representation (e.g., mass nouns presented as single objects) does not match the conceptual-semantic representation of the target determiner (e.g., some).

General Discussion

This is the first study to investigate in detail a lexical-syntactic impairment of countability in English. We have presented data from RAP, a man with aphasia who had impairments in word finding and grammatical processing. Background testing indicated that RAP had a mild semantic impairment, and impairments of lexical-syntax and the phonological output buffer. Further testing in this study found that his lexical-syntactic impairment was manifested in problems producing noun phrases containing mass nouns. Critically, accuracy of noun phrase production was influenced by the depiction of the mass noun as single or multiple exemplars. We will first discuss RAP’s impairment and then turn to the theoretical implications of these results.

RAP showed mass noun specific impairments in noun phrases, both in production (picture naming with noun phrases (Experiment 2, 3, 4, 5)) and comprehension (determiner judgment (Experiment 6)). Specifically, he showed severe difficulties with mass noun determiners (e.g., much, enough, this) compared to count noun determiners (e.g., a, many, those, these), while he showed no specific impairment with mass nouns in reading aloud or repetition of noun phrases (Experiment 2) or in bare noun production (Experiment 1).

We tested two hypotheses based on the literature 1) that RAP’s impairment was due to a determiner impairment (Herbert & Best, 2010); and 2) that RAP’s impairment was due to a lexical-syntactic impairment of a [mass] node (Semenza et al., 1997). Experiment 3 refuted the first hypothesis: RAP was able to produce the same determiner for count nouns that he was unable to for mass nouns (e.g. some apples vs. some garlic). Hence, an impairment for specific determiners is implausible, as is any account based on determiner frequency (as clearly the determiner is of the same frequency whether used with a mass noun or a count noun). A frequency account becomes even less plausible as half of the mass noun determiners (‘this’ and ‘that’) used in the picture naming and determiner judgement tasks were substituted by less frequent (spoken and written) determiner forms (‘these’ and ‘those’). We, therefore, concluded that RAP had a lexical-syntactic impairment of the modality neutral mass node.

One piece of data appeared inconsistent with this hypothesis: RAP showed no countability effect in a grammaticality judgement task (Experiment 2). We demonstrated that in fact this result was due to the lack of biasing visual information in this task. In the first experiments of their kind we showed that RAP’s determiner accuracy varied depending on whether mass nouns were depicted as single or multiple entities (Experiments 3, 4, 5). Mass noun determiners that were also singular count noun determiners were produced more accurately when mass nouns were depicted as single entities (e.g. this). Conversely, mass noun determiners that were also plural count noun determiners were produced more accurately when mass nouns were depicted as multiple entities (e.g. some). We suggest visual information to activate conceptual nodes representing SINGLE and MULTIPLE entities (cf Levelt et al., 1999), which in turn activate determiner lemma nodes. When the determiner lemma activated by this route is congruent with the determiner activated by the lexical-syntactic [mass] node (via the mass noun lemma), the correct determiner is produced. However, due to the mass node impairment, when the determiner activated by the lexical-concept is incongruent with the mass noun determiner, this competitor determiner may be selected rather than the partially activated target mass noun determiners at the lexical-syntactic level.

We have been discussing RAP’s impairment as an impairment of the lexical-syntactic attribute (or node) [mass]. However, there are a number of alternative accounts that cannot be excluded. First, rather than an impairment of the node itself, an impairment of activation of the node by the noun lemma would be equivalent in its effects - as is often the case in cognitive neuropsychology, it is virtually impossible to distinguish between impairments of activation of a component with impairment of that component itself.

Second, it is possible that RAP has a general lexical-syntactic impairment rather than a specific lexical-syntactic impairment restricted to the mass node. How might this impairment account for the data? A general lexical-syntactic impairment would predict the pattern shown for grammaticality judgements - generally poor performance but no specific impairment for mass nouns. At first sight this impairment seems inconsistent with the mass impairment for noun phrase production. However, once again the importance of visual and conceptual-semantic information comes to the fore. For mass nouns the number of the depiction can be incongruent with the number of the determiner (e.g. a single mass noun picture and plural determiner ‘some’). However, for count nouns the depiction is *always* congruent with the determiner number (plural count nouns can only be depicted as multiple objects). Hence, even with a general lexical-syntactic impairment, an apparently specific mass noun phrase deficit can occur.

In sum, RAP may have a specific impairment to the lexical syntactic attribute [mass] or activation of this attribute from the noun lemma. Alternatively, he may have a general lexical-syntactic impairment which impairs activation of determiner lemmas via lexical syntactic attributes. All these accounts are consistent with the data, but perhaps the latter is more plausible computationally, as it could be conceived of a general lowering of connection strength rather than a lesion restricted to only a small part of the processing system. We now turn to the theoretical implications of RAP’s case.

The architecture we have developed here has been derived from that of Levelt et al. (1999). However, this theory, in common with every other psycholinguistic theory, does not specify how countability might be represented. We therefore suggested that countability could be represented in the same way as grammatical gender - as an intrinsic fixed grammatical property. This is supported by the fact that whether a noun is mass or count is not predictable from its meaning. However, critically, we have here demonstrated that nonetheless there is a role for conceptual semantics in the lexical-syntax of mass and count nouns. Specifically, that determiner selection for mass and count nouns is rather a convergence of conceptual-semantics and lexical-syntax. This convergence might also explain how speakers can refer to mass nouns as count nouns and vice versa in certain contexts (e.g., The supermarket sold so many different mascaras., After the accident there was cat all over the road.). For example, a speaker’s intention to emphasize count noun characteristics in a mass noun (e.g., individuated, countable) could lead to the activation of count noun specific concepts at the conceptual-semantic level which further activate count noun syntax at the lexical-syntactic level (e.g., count noun determiners, lexical-syntactic feature plural). This leads to the selection of the intended count noun determiner after competition with the grammatically congruent mass noun determiner. In other words, the highly activated count noun syntax overrules mass noun syntax (see Figure 8). The same process could occur for count nouns if the speaker wants to stress a characteristic which is more ‘mass like’ (e.g., unindividuated, substance), by direct activation of the mass node by the concepts UNINDIVIDUATED and SUBSTANCE. Thus, countability appears to have features of both intrinsic fixed syntactic properties (like gender) and extrinsic variable semantic features (like number) at the lexical syntactic level – a hybrid lexical-syntactic attribute. This may not be unusual, other syntactic attributes that are generally thought to be intrinsic and fixed may be influenced by conceptual features. For example, Schiller, Münte, Horemans, and Jansma (2003) showed that gender decisions in German could be influenced by the biological sex of a noun referent.

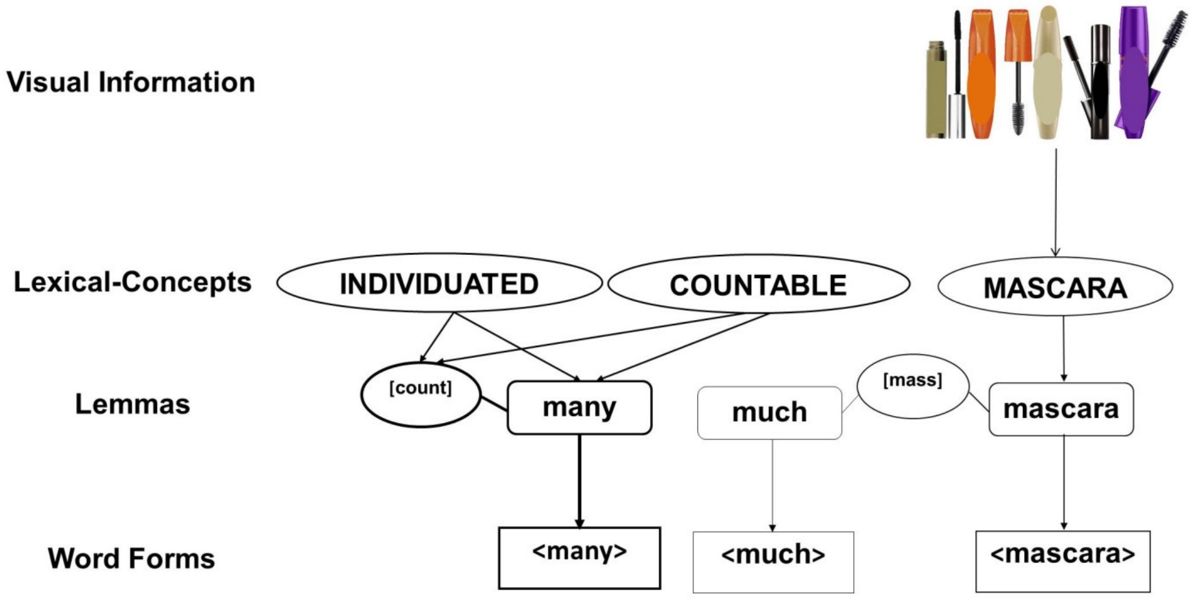

Figure 8. Conversion of a mass noun (and its syntax) into a count noun through the speaker’s intention.

Finally, coming back to the previous case studies of Herbert & Best (2010) and Semenza et al. (1997), how can we explain MH and FA’s different mass specific impairments based on our new theoretical architecture derived from RAP’s results? Herbert and Best accounted for MH’s determiner deficit by an impairment of specific determiner lemma nodes and/or their links. In the introduction, we suggested that her additional bare mass noun deficit could be the result of an impairment of bidirectional links between lexical-syntactic attributes and their noun lemmas on whose feedback the noun lemma selection relies on, or alternatively of an impairment of mass specific concepts/features (e.g., UNINDIVIDUATED, UNCOUNTABLE) at the conceptual-semantic level. Within our revised framework, an alternative account for MH’s mass specific bare noun problem could be a general impairment of the conceptual-semantic level and/or their links to the lexical-syntactic level. Within this theory, activation from mass and count specific concepts (e.g., UNINDIVIDUATED, UNCOUNTABLE) contributes to the selection of noun lemmas and their determiners. The relative rareness of mass nouns compared to count nouns[25] could be expressed by different weightings on links between mass/count concepts and mass/count noun lemmas as well as their determiner lemmas (see Nickels, Biedermann, Schiller & Fieder (submitted) for similar assumption regarding different weightings between the concepts SINGLE and MULTIPLE for singular and plural dominant nouns). Weaker links between mass concepts and their noun and determiner lemmas in comparison to count concepts could make mass nouns more vulnerable to an impairment (see Figure 9). The latter account is more compatible with FA and RAP’s mass specific

[25] Celex has 31549 count noun entries and 13135 mass (uncountable) noun entries when taking only head nouns into account (e.g., singular noun forms, but not the plural noun forms).

impairment which affected only mass noun determiners but spared mass nouns. Based on the similarities between RAP and FA’s impairment, FA’s deficit could not only be accounted for by a specific impairment of the mass node and/or its links but also by a general impairment of the lexical-syntactic level.

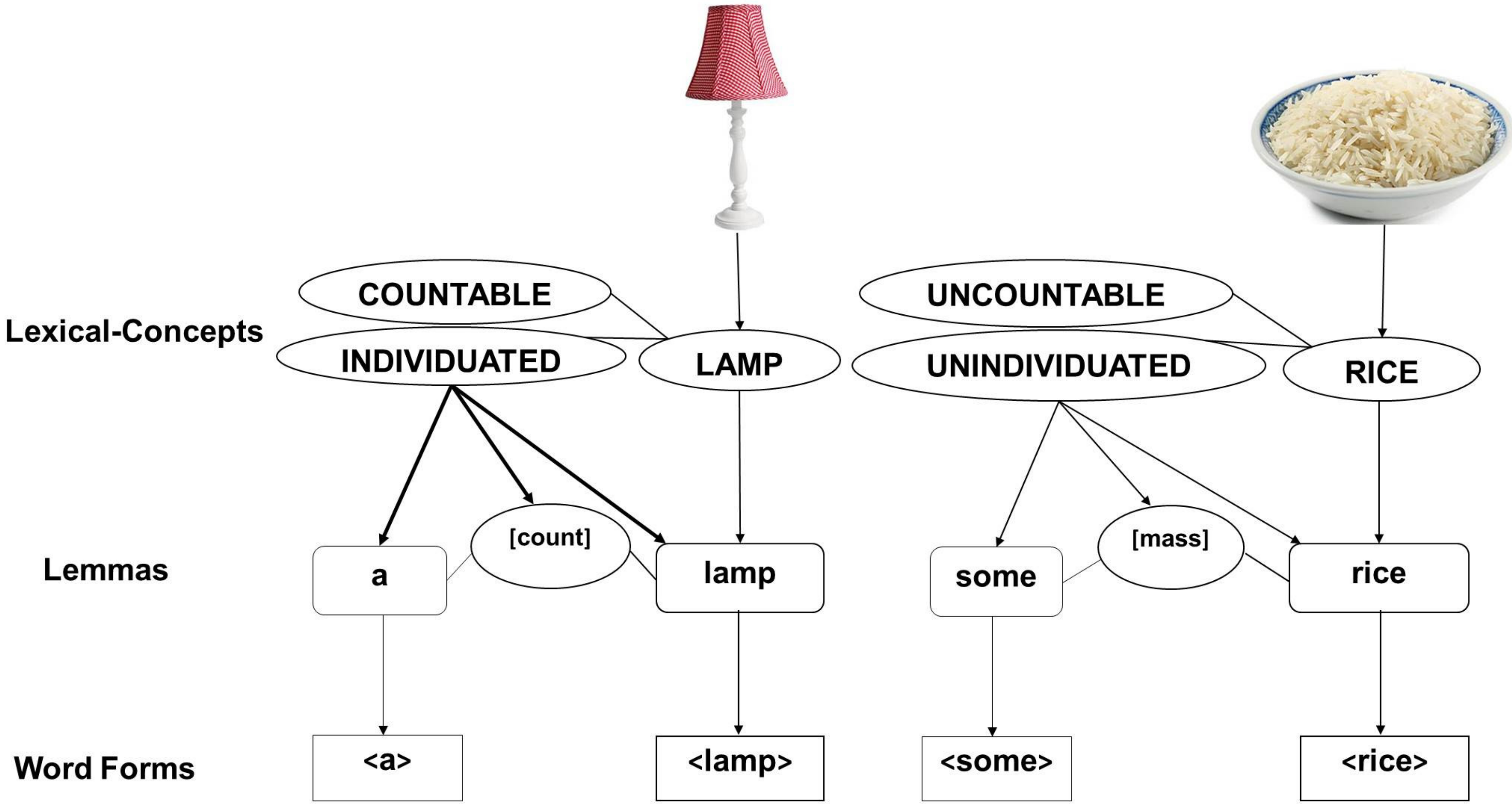

Figure 9. Influence of mass/count concepts on the selection of mass and count noun and determiner lemmas.

In sum, we have provided clear evidence that lexical-syntactic processing of countability can be directly influenced by conceptual-semantic information, a factor which has been largely overlooked to date.

For future research on countability, we recommend inclusion of mass nouns and both singular <u>and</u> plural count nouns. Only by including both singular and plural counts nouns is it possible to distinguish between countability specific impairments and determiner impairments. In addition, we suggest research on possible effects of visual and conceptual-semantic information, such as MULTIPLE and SINGLE on mass and count noun/phrase processing. Finally, further research should examine not only those nouns that are clearly mass or count nouns but also those 'dual' nouns (e.g. cable, cake) in order to identify in how far conceptual-semantic information other than SINGLE and MULTIPLE influences processing.

Conclusions

The aim of this study was to investigate the representation of countability information at the lexical-syntactic level and its impairment in aphasia. We presented experimental evidence of a lexical-syntactic impairment in aphasia which affected processing of mass noun grammar, and specifically the production of noun phrases with mass nouns. In addition, we provided clear evidence that conceptual-semantic information influenced the selection of mass noun determiners.

We used these results to extend the architecture of Levelt et al's (1999) theory to include a syntactic node [mass] which activates appropriate determiners. We also concluded that, mass/count information is represented in the form of a hybrid lexical-syntactic attribute. Mass/count congruent determiners are mostly derived via lexical-syntactic information of the noun lemmas but their selection can also be semantically influenced via the intention of the speaker or pictures.

References

Alario, F.-X., Ayora, P., Costa, A. & Melinger, A. (2008). Grammatical and Nongrammatical Contributions to Closed-Class Word Selection. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(4), 960-981.

Alario, F.-X. & Caramazza, A. (2002). The production of determiners: evidence from French. *Cognition*, 82, 179-223.

Alario, F.-X., Matos, R.E. & Segui, J. (2004). Gender congruency effects in picture naming. *Acta Psychologica*, 117, 185-204.

Baayen, R. H., Burani, C. & Schreuder, R. *(*1996*).* Effects of semantic markedness in the processing of regular nominal singulars and plurals in Italian, *chapter 3, pp. 13-35,* In G. E. Booij and J. van Marle (Eds.), *Yearbook of morphology 1996.* Dordrecht: Kluwer Academic.

Baayen, R. H., Levelt, W.M.J, Schreuder, R. & Ernestus, M. (2008). Paradigmatic structure in speech production. *Chicago Linguistics Society* 43, 1, 1-29.

Baayen, R. H., Piepenbrock, R. & Gulikers, L. (1995). *The CELEX lexical database (CD-ROM).* Philadelphia, PA: Linguistic Data Consortium. University of Pensylvania.

Baayen, R. H., Piepenbrock, R. & van Rijn, H. (1993). *The CELEX Lexical Database (Release 1) [CD-ROM].* Philadelphia: PA: Linguistic Data Consortium. University of Pensylvania.

Baayen, R. H., Schreuder, R. & Sproat, R. (1998). A non-interactive activation model for morphological segmentation. In F. van Eynde, D. Gibbon, & I. Shuurman (Eds.), *Lexicon development for speech and language processing.* Dordrecht: Kluwer Academic.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B. & Treiman, R. (2007). The English Lexicon Project. Behavior Research Methods, 39, 445-459.

Best, W., Schröder, A. & Herbert, R. (2006). An investigation of a relative impairment in naming non-living items: theoretical and methodological implications. *Journal of Neurolinguistics*, 19, 96-123.

Biedermann, B., Nickels, L.A. & Beyersmann, E. (2009). Organisation of 'number' information in the lexicon: Insights from aphasic plural errors. In Otsu, Y. (Ed.), *The Proceedings of the 10th Tokyo Conference on Psycholinguistics* (pp. 27-42). Japan: Hituzi Syobo Publishing.

Biedermann, B., Lorenz, A., Beyersmann, E. & Nickels, L. (In Press). The influence of plural dominance in aphasic word production. *Aphasiology*.

Biran, M. & Friedmann, N. (2012). The representation of lexical-syntactic information: Evidence from syntactic and lexical retrieval impairments in aphasia, *Cortex*, 48(9), 1103-1127.

Bishop, D.V.M. (2003b). Test for Reception of grammar (version 2). London: Psychological Corporation.

Bonin, P., Chalard, M., Méot, A. & Fayol, M. (2002). The determinants of spoken and written picture naming latencies. *British Journal of Psychology*, 93, 89-114.

Bordag, D. & Pechmann, T. (2008). Grammatical Gender in Speech Production: Evidence from Czech. *Journal of Psycholinguistic Research*, 37, 69-85.

Bordag, D. & Pechmann, T. (2009). Externality, Internality, and (In)Dispensability of Grammatical Features in Speech Production: Evidence from Czech Declension and Conjugation. *Journal of Experimental Psychology:*

Learning, Memory, and Cognition, 35(2), 446-465.

Caramazza, A. (1997). How many levels of processing are there in lexical access. Cognitive Neuropsychology, 14, 177-208.

Caramazza, A. & Miozzo, M. (1998). More is not always better: a response to Roelofs, meyer, & Levelt. Cognition, 69, 231-241.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Database,* 33, 497-505.

Costa, A., Kovacic, D., Fedorenko, E. & Caramazza, A. (2003). The Gender Congruency Effect and the Selection of Freestanding and Bound Morphemes: Evidence From Croatian. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(6), 1270-1282.

Crawford, J.R. & Howell, D.C.(1998). Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist, 12*, 482–486.

Crawford, J.R. & Garthwaite, P.H. (2002). Investigation of the single case in neuropsychology: Confidence limits on the abnormality of test scores and test score differences. Neuropsychologia, 40, 1196-1208.

Crawford, J.R. & Garthwaite, P. H. (2005). Testing for suspected impairments and dissociations in single-case studies in neuropsychology: Evaluation of alternatives using Monte Carlo simulations and revised tests for dissociations. *Neuropsychology*, 19, 318-331.

Garrard, P., Carroll, E., Vinson, D. & Vigliocco, G. (2004). Dissociation of Lexical Syntax and Semantics: Evidence from Focal Cortical Degeneration. *Neurocase,*10(5), 353-362.

Glaser, W. R. & Glaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, 118, 13-42.

Gillon, B.S., Kehayia, E. & Taler, V. (1999). The mass/count distinction: Evidence from online psycholinguistic performance. *Brain and Language*, *68*, 205-211.

Gregory, E., Varley, R. & Herbert, R. (2012). Determiner Primes as Facilitators of Lexical Retrieval in English. *Journal of Psycholinguistic Research*, 41, 439-453.

Hemera (1997-2000).*Photo-Objects 50,000. Premium Image Collection.*Hull-Quebec, Canada.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex*, 46(3), 329-342.

Howard, D. & Patterson, K. E. (1992). *Pyramids and Palm Trees.* Bury, St. Edmunds, UK: Thames Valley Test Company.

Jacobson, T. (1999). Effects of grammatical gender on picture and word naming: Evidence from German. *Journal of Psycholinguistic Research*, 28, 499-514.

Janssen, N. & Caramazza, A. (2003). The selection of closed-class words in noun phrase production: The case of Dutch determiners. *Journal of Memory and Language*, 48, 635-652.

Jescheniak, J. D. & Levelt, W. J. M. (1994). Word Frequency Effects in Speech Production: Retrieval of Syntactic Information and of Phonological Form. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20(4), 824-843.

Jescheniak, J.D. (1999). Gender priming in picture naming. Modality and baseline effects. *Journal of Psycholinguistic Research*, 28, 729-737.

Kaplan, E., Goodglass, H. & Weintraub, S. (1978). *The Boston Naming Test.Boston:* E. Kaplan and H. Goodglass.

Kay, J., Lesser, R. & Coltheart, M. (1992). *PALPA: Psycholinguistic assessments of language processing in aphasia*. Hove, England: Erlbaum.

Klein, G. (1964). Semantic power measured through the interference of words with color-naming. *American Journal of Psychology*, 77, 576-588.

La Heij, W., Mak, P., Sander, J. & Willeboordse, E. (1998). The gender-congruency effect in picture-word tasks. *Psychological Research*, 61, 209-219.

Lamers, M.J.M., Roelofs, A. & Rabeling-Keus, I.M. (2010). Selective attention and response set in the Stroop task. *Memory and Cognition*, 38(7), 893-904.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences*, *22*, 1-75.

Luzzatti, C., Mondini, S. & Semenza, C. (2001). Lexical representation and processing of morphologically complex words: Evidence from the reading performance of an Italian agrammatic patient. *Brain and Language*, *79,* 345–359.

Miceli, G., Laudanna, A. & Burani, C. (1994). *Batteria per l’analisi dei deficit afasici del linguaggio*. Universita Cattolica, Roma.

Middleton, E.L., Wisniewski, E.J., Trindel, K.A. & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language*, *50*, 371-394.

Middleton, E.L. (2008). Mass Matters. *Dissertation Abstracts International*, 70(02), (UMI No. 3347451).

Mondini, S., Kehayia, E., Gillon, B., Arcara, G. & Jarema, G. (2009). Lexical access of mass and count nouns. How word recognition reaction times correlate with lexical and morpho-syntactic processing. *Mental Lexicon*, 4(3), 354-379.

Nickels, L. & Cole-Virtue, J. (2004).Reading tasks from PALPA: How do controls perform on visual lexical decision, homophony, rhyme, and synonym judgments? *Aphasiology,18(2),*103-126.

Nickels, L., Biedermann, B., Fieder, N. & Schiller, N.O. (submitted) The Lexical syntactic representation of number. *Language and Cognitive Processes,* invited paper.

Proctor, R. (1978). Sources of color-word interference in the Stroop color-naming task. *Perception & Psychophysics*, 23, 413-419.

Quirk, R. & Greenbaum, S. (1974). *A University Grammar of English*. London, UK: Longman.

Schiller, N. O. & Caramazza, A. (2002). The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German. *Brain and Language,* 81, 342-357.

Schiller, N. O. & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. *Journal of Memory and Language,* 48, 169-194.

Schiller, N. O. & Caramazza, A. (2006). Grammatical gender selection and the representation of morphemes: The production of Dutch diminutives. *Language and Cognitive Processes,* 21(7-8), 945-973.

Schiller, N. O., Münte, T. F., Horemans, I. & Jansma, B. M. (2003). The influence of semantic and phonological factors on syntactic decisions: An event-related brain potential study. *Psychophysiology*, 40, 869-877.

Schriefers, H. (1993). Syntactic Processes in the Production of Noun Phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19(4), 841-850.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2002). Determiner Selection in Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 28(5), 941-950.

Schriefers, H., Jescheniak, J.D. & Hantsch, A. (2005). Selection of Gender-Marked Morphemes in Speech Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 31(1), 159-168.

Schriefers, H. & Teruel, E. (2000). Grammatical Gender in Noun Phrase Production: The Gender Interference Effect in German. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 26(6), 1368-1377.

Semenza, C., Mondini, S. & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Semenza, C., Mondini, S. & Marinelli, K. (2000). Count and Mass Nouns: Semantics and Syntax in Aphasia and Alzheimer`s disease. *Brain and Language, 74*, 395-431.

Shapiro, L.P., Zurif, E., Carey, S. & Grossman, M. (1989). Comprehension of lexical subcategory distinctions by aphasic patients: proper/common and mass/count nouns. *Journal of Speech and Hearing Research*, *32*, 481-488.

Sonnenstuhl, I. & Huth, A. (2002). Processing and Representation of German –n Plurals: A Dual Mechanism Approach. *Brain and Language*, 81, 276-290.

Steinhauer, K., Pancheva, R., Newman, A.J., Gennari, S. & Ullman, M.T. (2001).

How the mass counts: An electrophysiological approach to the processing of lexical features. *Cognitive Neuroscience and Neuropsychology*, 12(5), 999-1005.

Taler, V. & Jarema, G. (2007). Lexical access in younger and older adults: The case of the mass/count distinction. *Canadian Journal of Experimental Psychology*, *61*, 21-34.

Van Berkum, J. J. A. (1997). Syntactic processes in speech production: the retrieval of grammatical gender. *Cognition,* 64, 115-152.

Vigliocco, G., Vinson, D.P., Martin, R.C. & Garrett, M.F. (1999). Is “Count” and “Mass” Information Available When the Noun Is Not? An Investigation of Tip of the Tongue States and Anomia. *Journal of Memory and Language,* 40, 534-558.

Wierzbicka, A. (1988). *The semantics of grammar*. Amsterdam: John Benjamins.

Wisniewski, E.J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and cognitive processes*, 18(5/6), 583-624.

Worrall, L.E., Yiu, E.M-L., Hickson, L.M.H. & Barnett, H.M. (1995). Normative data for the boston naming test for Australian elderly. *Aphasiology*, 9(6), 541-551.

Author Note

During the preparation of this paper, Nora Fieder was funded by a Macquarie University Research Excellence (MQRES) scholarship, Lyndsey Nickels was funded by an Australian Research Council Future Fellowship and Britta Biedermann by a Macquarie University Research Fellowship (MQRF), and an ARC Australian Post-Doctoral Fellowship. We would like to thank Naama Friedmann for helpful discussion.

Appendix A

Connected Speech: excerpt of the Cinderella recount

“Cinderella is ah .... ah Cinderella is ah three daughters you know a ugly one (laughs) ah the ugly one and the ah ... tall you know and Cinderella is beautiful you know and Cinderella is a the mother of the three girls is a ah two of the oldest ones you know and spoil them you know and Cinderella is a sweeping up or the make the beds you know and Cinderella was ah ah the .. animals you know is a birds and a mice and .. and ah ah Cinderella is a the ... is ... the songs you know and the . ah mice and the birds and cats and all that ah ah ah sing the songs you know and ah ah Cinderella .. ah ... the prince on the prince on the the bʌ bʌ the king and the prince is ah prince is a ... twenty-first birthday or something and mhm .... the prince is ah ah prince is ah ... ah the town is a beautiful kɜ:ls you know is a tance route thing you know and the ugly sisters and the mother is ah the prince at the balb room you know and the Cinderella is stopping at home you know and ah .. ah the the Cinderella is the birds and the cats and all that”

Appendix B

Set A		Set B		
mass nouns	singular count nouns	mass nouns	singular count nouns	plural count nouns
asparagus	bag	asparagus	apple	bricks
broccoli	basket	butter	basket	cameras
butter	cave	celery	bucket	cats
celery	chef	cream	ghost	horses
chess	cloud	garlic	lantern	fists
cinnamon	cucumber	hay	nun	kings
cream	dragon	honey	pearl	lions
dough	eagle	ink	razor	masks
garlic	elephant	jelly	shadow	pegs
cinnamon	ghost	milk	skull	prams
gold	harp	mustard	spoon	ships
graffiti	horse	rust	table	skirts
grass	king	soccer	elephant	trays
hay	lamp	steam	truck	turtles
honey	lantern	sugar	trumpet	violins
ink	lion	water	whip	wheels
jelly	mattress			
mascara	moth			
milk	nose			
money	nun			
mud	oven			
mustard	pedal			
rain	razor			
rice	shadow			
rust	skull			
soccer	tray			
soup	umbrella			
steam	vase			
tennis	violin			
water	wallet			

Appendix C

Stimuli characteristics averaged by category Set A (singular count nouns, mass nouns).

	singular count nouns	mass nouns	t(29)	p
Log (written frequency)	1.15	1.22	-0.57	0.58
Log (spoken frequency)	0.64	0.8	-1.01	0.32
Log (written stem frequency)	2.48	2.41	0.43	0.67
Log (spoken stem frequency)	0.79	0.88	-0.53	0.60
Bigram frequency	7298	8838	-1.19	0.24
Number of syllables	1.63	1.77	-0.64	0.53
Number of phonemes	4.33	4.6	-0.65	0.52
Number of graphemes	5.13	5.37	-0.62	0.54
Phon. neighbourhood density	1.72	1.7	0.12	0.91
Orth. neighbourhood density	1.96	2.02	-0.30	0.76
Imageability	598	591	0.74	0.47
Concept familiarity	4.47	4.55	-0.97	0.34
Age of acquisition	2.87	3.03	-0.70	0.49
Visual complexity	3.16	3.26	-0.45	0.66
Image agreement	4.34	4.28	0.50	0.62
Naming agreement	96.17	97.17	-1.00	0.33

Appendix D

Stimuli characteristics averaged by category Set B (plural count nouns, mass nouns).

	plural count nouns	mass nouns	t(15)
Log (written frequency)	1.00	1.22	-1.16
Log (spoken frequency)	0.68	0.81	-0.71
Log (written stem frequency)	2.68	2.43	1.18
Log (spoken stem frequency)	1.16	0.89	1.27
Bigram frequency	1552	1688	-0.33
Number of syllables	1.44	1.81	-1.31
Number of phonemes	4.88	4.69	0.43
Number of graphemes	5.50	5.25	0.59
Phon. neighbourhood density	1.74	1.73	0.05
Orth. Neighbourhood density	1.89	1.96	-0.28
Imageability	590	5.88	0.16
Age of acquisition	2.89	2.94	-0.18
Naming agreement	93.63	95.31	-1.16

Chapter 5

How ‘some garlic’ becomes ‘a garlic’ or ‘some onion’: Mass and count processing in aphasia.

Nora Fieder[a], Lyndsey Nickels[a], Britta Biedermann[a] & Wendy Best[b]

[a] *ARC Centre of Excellence in Cognition and its Disorders(CCD) and NHMRC Centre of Excellence in Aphasia Rehabilitation,*

Department of Cognitive Science

Macquarie University, Sydney, Australia

[b]*Department of Human Communication Science*

University College London, London, UK

ABSTRACT

This paper investigates the underlying causes of mass/count specific impairments in aphasia in two aphasic individuals with a grammatical impairment, DEH and GEC. DEH and GEC were both tested with a series of tasks to comprehensively investigate the factors influencing the production of mass and count nouns and noun phrases. The results showed that DEH frequently substituted mass specific determiners with count noun determiners leading to ungrammatical noun phrases. In contrast, GEC’s impairment predominantly affected naming of mass nouns, which resulted in the production of semantic paraphasias and no responses. DEH’s results replicated and supported previous findings about the lexical-syntactic representation of countability information (Fieder, Nickels, Biedermann & Best, submitted). GEC’s mass noun difficulties extend these findings by suggesting that, in addition to lexical-syntactic representation, there is a conceptual-semantic aspect to the representation of countability (e.g., INDIVIDUATED, COUNTABLE for count nouns, UNINDIVIDUATED, UNCOUNTABLE for mass nouns) which contributes to the selection of mass and count nouns.

INTRODUCTION

“The greater part of the world's troubles are due to questions of grammar.”

Michel de Montaigne, *The Complete Essays*

Aphasia often causes problems in spoken word production which can be attributed to an impairment at one or more levels of the language system. There have been many reports of individuals with impairments at the semantic level (e.g., Butterworth, Howard & McLoughlin, 1984; Coughlan & Warrington, 1981; Hillis, Rapp, Romani & Caramazza, 1990; Howard & Orchard-Lisle, 1984; Huff, Mack, Mahlmann & Greenberg, 1988; Warrington, 1975) and/or the word form level (e.g., Howard, 1995; Kay & Ellis, 1987). However, breakdown at the lexical-syntactic level has received far less attention (e.g., Herbert & Best, 2010). Lexical-syntactic information specifies words grammatically, for example regarding word category (e.g., noun, verb, and adjective), number (singular versus plural), countabilty (mass versus count) and, in gender-marking languages, grammatical gender (e.g., masculine, neuter, feminine). This information differentiates between homophonous words (e.g. a box; to box) and generates congruency between associated parts of a sentence to facilitate its comprehension (Chan, 2005; Seyboth, Blanken, Ehrmann, Schwarz & Bormann, 2011).

There are some descriptions of aphasic individuals with lexical-syntactic impairments affecting grammatical gender (Biran & Friedmann, 2011; Seyboth et al., 2011), number (Biedermann, Lorenz, Beyersmann & Nickels, 2012; Biedermann, Beyersmann, Mason & Nickels, 2013; Luzzatti, Mondini & Semenza, 2001) or countability (Fieder, Nickels, Biedermann & Best, submitted; Herbert & Best, 2010; Semenza, Mondini & Cappelletti, 1997; Semenza, Mondini & Marinelli, 2000). In this study, we focus on countability. First we will briefly describe some of the characteristics of mass and count nouns, before reviewing the literature on mass and count noun impairments in aphasia.

Countability information is a type of lexical-syntactic information that classifies nouns into mass (e.g. garlic, water) or count (e.g. onion, ocean). In English, countability defines the appropriate determiner and whether nouns can be morphologically marked for number. Count nouns can be combined with quantifiers that denumerate and therefore express their countability semantically, such as ‘a’ which stands for one, or ‘many’ and ‘few’ which refer to a larger or smaller number of multiple objects and with numerals, such as ‘two’ or ‘three’. Count nouns can also form a plural. In comparison, mass nouns cannot be pluralised nor be combined with numerals. Instead, they can only occur with quantifiers that do not denumerate and hence refer to their quantity as a substance, such as ‘much’ and ‘little’. The only way to precisely express the amount of such a substance is by a unit of measurement (‘a loaf of bread’, ‘three kilos of butter’). For many nouns, the grammatical division into mass versus count has been argued to be derived from the noun’s semantics (Middleton, 2008; Middleton, Wisniewski, Trindel & Imai, 2004; Wierzbicka, 1988; Wisniewski, Lamb & Middleton, 2003). Nouns which refer semantically to individual, countable objects with clear boundaries tend to be grammatically treated as count nouns. Nouns which refer to substances and aggregates with no clear boundaries are uncountable and therefore grammatically categorised as mass nouns. However, a multitude of exceptions exist which have an arbitrary relationship between semantics and grammar. These include, for example, aggregates which are count nouns, such as lentils and peas and mass nouns which represent entities, such as garlic, bacon and bread. Moreover, countability grammar can be flexibly used depending on the speaker’s intention to refer to mass or count noun like attributes of an object. For example, mass nouns can be used with count noun grammar to emphasize variety or individuality of an object (e.g., The bakery displayed so many breads but I bought only one.) and count nouns can be used with mass noun grammar to emphasize a substance-like state of an object (e.g., The baby had banana all over its face.).

There have been only four case studies to date that have investigated lexical, semantic and grammatical processing of mass and count nouns in people with aphasia (Fieder et al., submitted; Herbert & Best, 2010; Semenza et al., 1997; Semenza et al., 2000). Three of the aphasic individuals showed a dissociation between mass and count nouns with mass noun grammar being more impaired than count noun grammar whereas only one individual had more difficulties with bare count nouns compared to mass nouns. In the following section, we briefly summarise these studies as their findings provide evidence for the grammatical specification of nouns for countability. They also reveal how countability information could be represented and processed not only at the lexical-syntactic but also at the conceptual-semantic level (Fieder et al., submitted). Subsequently, we interpret these findings within an adaptation of Levelt, Roelofs and Meyer’s (1999) theory of language production.

We recently investigated mass and count processing in the case of RAP, a man with aphasia including word finding difficulties and a grammatical impairment (Fieder et al., submitted). A first series of tasks tested RAP’s performance on processing single mass and count nouns in reading and repetition, written and spoken picture naming and further comprehension and production of mass and count noun phrases in reading and repetition, grammaticality judgments, and picture naming. The results revealed that RAP had greater difficulties naming pictures with mass noun phrases than count noun phrases but no difference between mass and count was found in the production of nouns in isolation (so called ‘bare’ nouns). RAP frequently substituted mass noun determiners (some, much) by count noun determiners (a, many) which resulted in ungrammatical noun phrases (e.g., *a mustard, *many butter). A series of follow-up tests consisting of picture naming and determiner judgement tasks with noun phrases revealed that RAP’s difficulties affected determiners when they were used with mass nouns but spared the same determiners when they were used with count nouns (e.g., some garlic vs. some onions) in both language production and comprehension. From these results it was concluded that RAP suffered from a lexical-syntactic impairment which affected mass specific grammar rather than specific determiner forms. Moreover, it was found that conceptual-semantic information influenced determiner accuracy for mass nouns. In a final set of experiments, the same mass nouns were presented once as single objects and once as multiple objects: RAP only showed difficulties with mass noun determiners when the visual presentation did not match the conceptual-semantic information of the target determiner. For example, when a mass noun was depicted as single object RAP had no difficulty with determiners ‘that’ or ‘this’, that are also used with singular count nouns, in other words determiners which are conceptually singular. However, he had difficulty producing conceptually multiple determiners such as ‘some’ or ‘enough’. When mass nouns were presented as multiple objects, the reverse pattern was found.

MH, an earlier case reported by Herbert and Best (2010), had difficulties with mass nouns compared to singular count nouns. However, unlike RAP, MH’s difficulties affected not only determiners for mass nouns but also determiners for plural count nouns. MH was also impaired in the production of bare mass nouns. However, this impairment of bare mass noun production vanished when she was given determiner cues. Herbert and Best proposed that MH’s difficulties with mass nouns and the determiners of mass nouns and plural count nouns could be either attributed to an impairment of specific determiners at the lexical-syntactic level or to an impairment of the links between lexical-syntactic attributes (e.g., attribute [mass]) and determiners.

In an Italian case study, Semenza et al. (1997) investigated FA, a woman with mild anomia and grammatical difficulties in language production. The results revealed only mass specific difficulties in the grammatical tasks which led to pluralisation of mass nouns and substitutions of mass noun determiners by count noun determiners. FA’s mass specific impairment was localised at the lexical-syntactic level.

Finally, to our knowledge there has been only one case study (Semenza et al., 2000) that has reported a dissociation between mass and count nouns with singular count nouns being more impaired than mass nouns. CN, a woman with fluent aphasia, was worse at naming count nouns than mass nouns but she did not show this difference in grammatical and semantic tasks. Semenza et al. suggested that her count noun specific difficulties could be explained by impaired word form retrieval.

Based on the results of these case studies, Fieder et al. (submitted) proposed an account which incorporates the representation of countability into a theory derived from Levelt et al.’s (1999) theory. In accordance with Levelt et al.’s theory, nouns are represented at three major levels, the meaning of a noun is represented in the form of a concept at the conceptual-semantic[26] level, its lexical-syntax is represented at the lexical-syntactic (lemma) level, and its word form is represented at the word form level. Pure grammatical attributes, such as grammatical gender, which represent an intrinsic unchanging property of a noun, are only represented at the lexical-syntactic level in the form of attribute nodes (e.g., one node for each gender). Their activation occurs solely from the noun’s lemma node. Variable, extrinsic lexical-syntactic features, such as number, are a second form of grammatical attributes, these are exclusively derived conceptually from the intention of the speaker. In addition to their lexical-syntactic representation, extrinsic features have a representation at the conceptual-semantic level in the form of a concept node (e.g., MULTIPLE for plural, SINGLE for singular). Activation of the extrinsic lexical-syntactic feature (e.g., plural) can only occur with activation of its conceptual equivalent (e.g., MULTIPLE). Based on RAP’s results, Fieder et al. (submitted) considered countability information to be a grammatical attribute which shares characteristics of both intrinsic and extrinsic attributes. According to their theory, nouns are specified for mass/count in the form of a hybrid lexical-syntactic attribute which, like intrinsic features, is specified for each noun at the lexical-syntactic level, but, like extrinsic features can also be influenced by conceptual-semantic information. Fieder et al.’s results supported the influence of concepts relating to SINGLE and MULTIPLE entities on the

[26] Levelt et al. (1999) refer to this level as lexical-conceptual level. We prefer the term conceptual-semantic level as it indicates more directly its function as semantic memory.

selection of mass/count noun specific determiners. The influence of conceptual-semantic information also allows the speaker to use mass/count noun grammar more flexibly if they want to emphasize characteristics of an object/ entity which belong to the other noun’s category. As described earlier, for example, to refer to count nouns as mass nouns in order to emphasize a substance-like state (e.g., The toddler smeared avocado all over the floor.).

This study aims to replicate and extend the single case study on countability specific impairments by Fieder et al. (submitted) by adding empirical evidence from two single case studies, to find further evidence for the representation of countability specific information at the lexical-syntactic level. In addition, we further investigate the underlying causes of mass-specific impairments in aphasia through the different patterns shown by the two cases.

In this study we describe two individuals with aphasia, GEC and DEH who showed different countability-specific deficits. We conducted three experiments in order to localise the underlying impairment of their countability-specific deficit and to draw further conclusions about the representation and processing of mass/count information at the lexical-syntactic and conceptual-semantic level. Prior to the countability-specific tasks, we describe a number of background language assessments conducted to identify the different levels of breakdown in GEC’s and DEH’s language systems. We follow this with a description of the stimuli, general design, procedure and the analysis for the different countability-specific tasks. Subsequently, we report and discuss the results of the mass/count-specific tasks: reading and repetition of bare nouns and noun phrases (Experiment 1), picture naming with bare nouns (Experiment 2) and picture naming with noun phrases (Experiment 3).

CASE DESCRIPTION

Participants

GEC was a 67 year-old retired investment adviser who suffered a left cerebrovascular infarct in the frontoparietal region 3 years prior to the current investigation. GEC’s spontaneous speech was slow and non-fluent due to frequent word finding difficulties and mild apraxia of speech. He communicated in short sentences which were often well-formed (see Appendix A for a connected speech sample).

DEH was a 65 year old man who suffered an infarct in the territory of the left Middle Cerebral Artery secondary to infective endocarditis. DEH worked as a typesetter prior to his stroke. At the time of testing, DEH’s spontaneous speech was non-fluent with long hesitations due to severe word finding difficulties (see Appendix B for a sample of his connected speech) and the presence of stereotypical productions such as ‘you know’, fillers such as ‘ahm’, ‘yes’, and ‘and’, as well as a few neologisms.

Both participants were right-handed and had normal or corrected-to-normal vision and normal hearing.

Background language assessment

A number of background assessments were carried out to determine the general nature of GEC and DEH’s language processing impairments. The results are summarised in Table 1.

Table 1 *Background Assessments for DEH & GEC.*

Task	N of items	% Cut-off[a]	DEH % correct	GEC % correct
Conceptual semantic processing				
PPT[b] 3 pictures	52	94	100	90*
Comprehension				
Spoken comprehension				
PPT[b] 1 word 2 pictures	52	94	96	92*
PALPA[c] spoken word picture matching	40	95	97.5	100
NC-VF[d] spoken word picture verification	264	-	100	96
PALPA[c] Auditory synonym judgement	60	-	88	82
High imageability	30	-	90	97
Low imageability	30	-	87	67
Written comprehension				
PPT[b] 1 word 2 pictures	52	94	98	90*
PALPA[c] written word picture matching	40	95	97.5	95
PALPA[c] Written synonym judgement	60	87	93	80*
High imageability	30	91	93	80*
Low imageability	30	82	90	80*
Sentence comprehension				
TROG2[e]	80 (20 blocks)	18 blocks	64* (8 blocks)	64* (8 blocks)
Production				
Spoken picture naming				
NC-VF[d] spoken picture naming	132	-	79	83
Boston naming test[f]	60	75	42*	65*
Written picture naming				
NC-VF[d] written picture naming	132	-	87	22
Reading				
NC-VF[d] word reading	132	-	83	87
NC-VF[d] nonword reading	47	-	2	28
Repetition				
NC-VF[d] word repetition	132	-	86	89
NC-VF[d] nonword repetition	47	-	43	81

[a] Cut-off for normal performance is lower end of normal range. The cut-off is the score two standard deviation below the mean of the performance of healthy controls; percentage at cut-off and below represents impaired performance. The ‘normal range’ is taken from the instruction manuals of the respective tests, or

from the Nickels & Cole-Virtue (2004) norms. Patient scores are marked with an asterisk if score is below normal range.
[b] Pyramids and Palm Trees Battery (PPT) (Howard & Patterson, 1992) assesses the ability to access semantic information from pictures, written words and spoken words.
[c] Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart, 1992) assesses language processing in adults with acquired aphasia within a psycholinguistic framework.
[d] Nickels, Cole-Virtue & Fieder (NC-VF) (unpublished) picture stimulus set consists of 147 items (132 critical word items, 47 nonword items) which are analysed in subgroups that are systematically controlled and manipulated regarding semantic (concreteness, imageability, familiarity, age of acquisition), lexical (age of acquisition, frequency, phonological neighbourhood) and sublexical (length) variables to investigate language processing in adults with acquired aphasia within a psycholinguistic framework.
[e] TROG 2 (Bishop, 2003b) assess the comprehension of different grammatical structures within sentences in children and adults. Each grammatical structure is tested in a block consisting of 4 different sentences. A block counts as correct if all 4 sentences are correct. The cut-off score is 18 fully correct blocks.
[f] Boston Naming Test (BNT) (Kaplan, Goodglass & Weintraub, 1983) assesses picture naming in adults with aphasia. The BNT cut-off score is derived from Australian controls (n=31) in DEH and GEC’s age group (65-69 years) (Worrall, Yiu, Hickson & Barnett, 1995)

GEC had a mild conceptual and lexical-semantic impairment. He showed difficulties in picture naming with written picture naming being more severely impaired than spoken picture naming (McNemar’s test exact: $p < .001$ (two-tailed)). His spoken picture naming was not affected by lexical variables (frequency, age of acquisition, imageability and length), although he showed a small but significant reversed age of acquisition effect in written naming (see Table 2). In spoken picture naming, GEC made predominantly semantic errors followed by no responses and phonological[27] errors. GEC had severe difficulties in written picture naming (see Table 3) with responses frequently consisting of only the first one to three letters of the target word (35% of errors) which suggested a severe impairment of the orthographic output buffer. However, he also produced no responses and some orthographic (fragment) errors which were consistent with the onsets of semantically related words (e.g., target word ‘ring’, response ‘dia’ like diamond; target word ‘skirt’, response ‘dr’ from dress; conservatively classified as ‘unrelated’ in Table 3). Consequently, we would suggest that GEC’s spoken and written picture naming were both impacted by underlying impairments in the route from the conceptual-semantic to the lexical-syntactic level and a mild conceptual-semantic impairment. In addition, there were impairments of both phonological and orthographic output buffers. GEC’s word reading and word repetition were equally impaired (NC-VF picture stimulus set) ((McNemar’s test exact (two-tailed: GEC: $p = .678$). Even though no effect of word length or other variables was found (see Table 2), the predominance of phonological errors and lack of semantic errors in

[27] Phonological/orthographic errors included phonological/orthographic word errors, phonological/orthographic nonword errors.and false starts (target: flag, response: ff flag) where responses shared 50% of their phonemes/graphemes with the target word or vice versa.

reading and repetition (see Table 3) further confirmed an impairment of the phonological output buffer.

At the level of sentence processing, GEC showed a syntactic impairment (e.g., centre-embedded sentences, relative clauses, sentences with post-modified subject) but also impaired morphological processing (e.g., singular/plural inflections) suggesting an impairment at the lexical-syntactic level.

In contrast to GEC, DEH’s conceptual and lexical-semantic processing remained intact. He had difficulties in spoken and written word naming with written naming being slightly but not significantly better than spoken naming (McNemar’s test exact: $p = .071$ (two-tailed)). He showed no effects of frequency, age of acquisition, imageability or length in written word naming but showed a length effect in spoken picture naming (see Table 2). In spoken naming, DEH’s errors were predominantly phonological and semantic, while he produced mostly orthographic errors and no responses in written naming (see Table 3). As DEH’s semantic comprehension was intact, his naming errors suggested an impairment of the route from lexical-syntax to the phonological output lexicon (resulting in semantic errors in spoken naming) and an impairment of the orthographic output lexicon and the phonological and orthographic buffers. Like GEC, DEH's word reading and word repetition were equally impaired (NC-VF picture stimulus set) ((McNemar’s test exact (two-tailed: DEH: $p = .473$) and not influenced by lexical variables (see Table 2). However, while DEH made predominantly phonological and semantic errors in word reading, only phonological and unrelated (predominantly fragments/false start) errors were found in repetition (NC-VF stimulus set) (see Table 3). DEH’s semantic errors in word reading and his particularly poor nonword reading performance (1/47 nonwords correct) compared to nonword repetition (McNemar’s test (two-tailed): $p < .001$) was consistent with a pattern of deep dyslexia. Further testing of his reading impairment was carried out. He performed a lexical decision and reading aloud task with stimuli which manipulated imageability and frequency (PALPA subtest 25, n = 120; subtest 31, n = 80). While he showed normal performance on the visual lexical decision task (subtest 25: 98% correct, controls 98%), his performance on reading aloud was impaired (64% correct, controls 99%). In reading aloud, DEH showed a strong and significant imageability effect (High Imageabilty 80%; Low Imageability 48%, Fisher exact: $p = .005$ (two-tailed)) but no effect of frequency (High Frequency 68%; Low Frequency 63%). DEH’s semantic errors in word reading and picture naming suggested an impaired link between the lexical-syntactic level and the phonological output lexicon as the impairment underlying deep dyslexia. Finally, DEH had an impairment at the lexical-syntactic level resulting in difficulties with syntactic and morphological processing.

In summary, background testing suggested that both DEH and GEC had impairments at the level of the phonological and orthographic buffers, the sublexical reading route and the lexical-syntactic level. In addition, GEC showed an impairment of the semantic system and the route from semantics to the lexical-syntactic level. DEH had an additional impairment of the orthographic output lexicon and the route from lexical-syntax to the phonological output lexicon.

Table 2 *Effects of Psycholinguistic Variables in Nickels & Cole-Virtue’s (2004) Background Assessment for DEH & GEC.*

Variables	frequency			aoa			phonemes			imageability		
Tasks	N of items	**DEH** % correct	**GEC** % correct	N of items	**DEH** % correct	**GEC** % correct	N of items	**DEH** % correct	**GEC** % correct	N of items	**DEH** % correct	**GEC** % correct
Spoken naming												
High (Long)	38	82	87	40	80	80	38	76	89	49	80	88
Low (Short)	38	79	92	40	85	85	38	95	84	49	73	82
Fisher exact p =		*1.00*	*.71*	_	*.77*	*1.00*		*.05**	*.74*		*.64*	*.58*
Written naming												
High (Long)	38	89	18	40	85	10	38	84	11	49	88	24
Low (Short)	38	79	21	40	90	30	38	92	26	49	86	22
Fisher exact p=		*.35*	*.65*	_	*.74*	*.05**		*.48*	*.14*		*1.00*	*1.00*
Reading												
High (Long)	38	84	87	40	78	85	38	84	89	49	80	92
Low (Short)	38	87	84	40	88	90	38	82	92	49	82	86
Fisher exact p =		*1.00*	*1.00*	_	*.38*	*.74*		*1.00*	*1.00*		*1.00*	*.52*
Repetition												
High (Long)	38	92	87	40	88	93	38	84	87	49	94	90
Low (Short)	38	80	95	40	80	85	38	84	89	49	84	84
Fisher exact p =		*.19*	*.43*	_	*.55*	*.48*		*1.00*	*1.00*		*.20*	*.55*

Table 3 *Proportion of different error types in spoken and written picture naming, word reading and repetition for GEC and DEH on the Nickels, Cole-Virtue & Fieder (unpublished) set of 147 items.*

	Spoken picture naming		Written picture naming		Reading		Repetition	
Error Types	GEC	DEH	GEC	DEH	GEC	DEH	GEC	DEH
semantic	0.35	0.37	0	0.12	0	0.41	0	0
phonological/orthographic	0.22	0.37	0.79	0.53	0.71	0.45	0.71	0.94
unrelated	0.17	0.04	0.08	0	0.24	0	0.29	0.06
no responses	0.26	0.22	0.14	0.35	0.06	0.14	0	0
Number of Errors	23	27	103	17	17	22	14	18

EXPERIMENTAL INVESTIGATIONS OF COUNTABILITY

We developed a series of tasks to experimentally investigate countability. Experiment 1 examined whether there were countability specific deficits arising from the word form level and/or post-lexical levels. These tasks comprised reading and repetition of bare mass and count (singular & plural) nouns and noun phrases.

In Experiments 2 & 3 conceptual-semantic and lexical-syntactic processing of the critical stimuli was tested in a set of picture naming tasks with bare mass and count nouns and noun phrases. To exclude a determiner specific deficit as underlying cause of any noun phrase problems, the determiners were manipulated so that the determiner forms were the same for mass noun phrases as for either singular or plural count noun phrases (e.g., ‘some’ for both plural count and mass noun phrases; 'this' for both singular count and mass) Furthermore, the visual presentation of mass nouns was systematically manipulated with mass nouns being presented as single and multiple objects to investigate effects of visual/conceptual-semantic information (SINGLE versus MULTIPLE) on lexical-syntactic processing as we had found to be the case in a previous case (Fieder et al., submitted).

General Design & Procedure

All of the mass and count noun tasks described in this study were the same as those which were used in Fieder et al. (submitted). In all tasks items were presented in a fixed pseudorandomised order and the participant’s first response was scored.

Experimental Stimuli

The stimulus set comprised picturable singular count nouns (n=16), plural count nouns (n=16) and mass nouns (n=16). For each stimulus item we obtained a colour photograph from Hemera Photo Objects Collection I & II (1997-2000), Herbert and Best (2010) or from Google Images. The stimulus set was controlled for name agreement (above 85% for 20 unimpaired adults aged 19-35).

All nouns were morphologically simple and count nouns were singular-dominant (singular forms were more frequent than their corresponding plural forms). Sets were matched listwise for log transformed written and spoken surface and stem frequency from the CELEX database (Baayen, Piepenbrock & van Rijn, 1993; Baayen, Piepenbrock & Guliker, 1995), number of syllables, phonemes and graphemes using the MRC Psycholinguistic database (Coltheart, 1981), phonological and orthographic neighbourhood density from the English lexicon project (Balota et al., 2007), and for imageability, age of acquisition, and name agreement (data collected by the authors) (see Appendix C).

All tasks used the same 48 critical items mentioned above. While for some tasks, such as reading and repetition of bare nouns no filler items were required, other tasks (picture naming with bare nouns and noun phrases, reading and repetition of noun phrases) required fillers (of differing numbers). In picture naming with bare nouns and noun phrases, the same mass nouns were presented once depicted as a single object and once as multiple objects (32 mass noun pictures in total). For picture naming with bare nouns, we included a further 16 singular and 16 plural count noun fillers to counterbalance the number of nouns presented across each category (32 singular count nouns, 32 plural count nouns, 32 mass nouns). In tasks which required the production of noun phrases, filler items were included to counterbalance the number of phrases starting with the same determiner. For example, in reading and repetition of noun phrases with the determiners ‘a/some’ or in a different task ‘a/enough’, the same determiner ‘some’ (or ‘enough’) would be used for noun phrases with plural count nouns (16) and noun phrases with mass nouns (16). Therefore, we added an additional 16 singular count noun fillers to the critical 16 singular count noun items to counterbalance the number of phrases starting with the same determiner (e.g., 32 noun phrases starting with ‘a’ and 32 noun phrases starting with ‘some’). The same was done for noun phrases which started either with the determiner ‘this/these’, or in a different task with ‘that/those’. Only this time, singular count nouns and mass nouns shared the same determiner either ‘this’ or ‘that’, hence 16 plural count noun fillers were additionally included. For the picture naming task with noun phrases, items were counterbalanced regarding the number of phrases starting with the same determiner. We used a subset of the material from an earlier study (Fieder et al., submitted). Nouns of both item groups partly overlapped. The material for the picture naming tasks with the determiners ‘a/some’ and ‘a/enough’ consisted of 16 plural count noun pictures and 32 mass noun pictures as critical items and 55 singular count noun pictures and 7 plural count noun pictures as fillers[28]. The material for the two picture naming tasks with ‘this/these’ and ‘that/those’ consisted of 16 singular count noun pictures and 32

[28] In the earlier study (Fieder et al., submitted), 23 plural count noun pictures and 32 mass noun pictures formed the set of critical items, while the 55 singular count noun pictures served as fillers.

mass noun pictures as critical items and 32 singular count noun and 80 plural count noun pictures as fillers[29].

Analysis

DEH and GEC’s performance was compared to a control group of 10 undergraduate students using a modified t-test (Crawford & Garthwaite, 2002) to check which tasks and hence language functions were preserved or impaired. In order to claim that DEH and GEC had a dissociation in their performance for mass and count nouns we required the following: first that there was a significant difference between accuracy of mass and count conditions (Wilcoxon two-sample), and, second, that this difference was significantly greater than any difference between the conditions shown by the controls (Revised Standardised Difference Test, RSDT; Crawford & Garthwaite, 2005). However, the RSDT could not be applied when the control group performed close to or at ceiling.

In the picture naming tasks with bare nouns and noun phrases we first compared the results of singular and plural count nouns combined (as singular and plural stimuli consisted of different items) with those of mass nouns presented as single and as multiple objects averaged (as both stimuli sets consisted of the same items) to look for an overall difference between count and mass noun, noun phrase or determiner accuracy (Wilcoxon two-sample). We also compared the results for mass nouns presented as single objects with mass nouns presented as multiple objects (Wilcoxon matched pairs) as visual and/or conceptual-semantic information has been shown to influence noun

[29] In the earlier study (Fieder et al., submitted), 48 singular count noun pictures, 32 mass noun pictures formed the set of critical items while 80 plural count noun pictures served as fillers.

phrase accuracy when a participant has a lexical-syntactic impairment (Fieder et al., submitted).

Experiment 1: Reading & Repetition of Bare Nouns and Noun Phrases

Design & Procedure

Depending on the tasks, the participants were either requested to read aloud single words/noun phrases that were presented in written form on a computer screen or to repeat auditorily presented words/noun phrases. The reading and repetition tasks with noun phrases involved a series of tasks which required the production of mass and count nouns in combination with four different determiner pairs: a/some, a/enough, this/these, that/those. Both tests were preceded by practice items to familiarise participants with the procedure.

Results

The results of the reading and repetition tasks are presented in Table 4.

Table 4 *Reading and repetition of bare nouns and noun phrases.*

	GEC				DEH			
Tasks	Singular Count n=16	Plural Count n=16	Mass n=16	Count vs. Mass (Wilcoxon two-sample)[a]	Singular Count n=16	Plural Count n=16	Mass n=16	Count vs. Mass (Wilcoxon two-sample)[a]
Reading[b]								
bare nouns	0.94	0.75	0.81	1.00	0.94	0.75	0.81	1.00
a' vs. 'some'	0.88	0.94	0.94	1.00	0.31	0.69	0.69	.360
a' vs. 'enough'	0.94	0.75	0.88	1.00	0	0.88	0.5	.919
this' vs. 'these'	0.75	1	0.88	1.00	0.06	0.81	0.19	.170
that' vs. 'those'	0.63	0.81	0.75	1.00	0	0	0	1.00
Repetition[b]								
bare nouns	0.88	0.63	0.94	.244	0.94	0.75	.94	.647
a' vs. 'some'	0.69	1	0.94	.647	0.56	0.38	0.56	.762
a' vs. 'enough'	0.94	0.94	0.88	.855	0.81	0.94	0.88	1.00
this' vs. 'these'	0.75	0.63	0.88	.294	0.69	0.94	0.63	.294
that' vs. 'those'	0.81	0.88	0.88	1.00	0.56	0.94	0.69	.91

[a] We compared singular and plural count nouns combined with the average of single and multiple mass nouns with the Wilcoxon two-sample test.
[b] The control group performed at ceiling in reading and repetition of bare nouns. Control participants performed at or close to ceiling on similar reading and repetition tasks with noun phrases (Fieder, Nickels, Biedermann & Best, submitted).

The control group performed at ceiling for reading and repetition of bare nouns. Neither the control group, nor GEC and DEH showed a difference between mass and count nouns in reading and repetition of bare nouns (see Table 4). GEC also showed no difference in accuracy of mass and count noun phrases in reading and repetition. As GEC, DEH showed no countability specific effect in either the reading or the repetition tasks with noun phrases. However, as he performed poorly on the reading task we further investigated the nature of his errors: It was apparent that he had severe difficulty reading noun phrases containing some specific determiners (see Table 5). Even though no difference was found in the general comparison between mass and count nouns (singular plus plural), DEH had particular problems with the determiners ‘a’, ‘this’, ‘that’ and ‘those’. In the ‘a/some’ and ‘a/enough’ reading tasks, he was worse in reading singular count noun phrases (requiring ‘a’) compared to plural count noun phrases and mass noun phrases (requiring ‘some’ or ‘enough’; Wilcoxon two-sample (two-tailed): singular count vs. plural count: ‘a’ vs. ‘some’: $p = .082$; ‘a’ vs. ‘enough’: $p < .001$; , singular count vs. mass: ‘a’ vs. ‘some’: $p = .082$; ‘a’ vs. ‘enough’: $p = .005$). In both tasks, he predominantly substituted the determiner ‘a’ either by the determiner ‘enough’ (100%) or ‘some’ (31%) depending on the task. He had further difficulties with the determiner ‘this’ in the ‘this/these’ reading task leading to differences between plural count noun phrases compared to singular count and mass noun phrases ((Wilcoxon two-sample (two-tailed): singular count vs. plural count: $p < .001$; singular count vs. mass: $p = .002$). Once again, his errors were predominantly determiner substitution of ‘this’ by ‘these’ (70%). Furthermore in the ‘that/those’ reading task, DEH substituted all of the two target determiners ‘that’ and ‘those’ by the countability neutral determiner ‘the’. In addition to determiner errors, DEH frequently made number errors, pluralising singular count and mass nouns and omitting plural –s in plural count nouns (see Table 5).

Table 5 DEH: *Error Proportions in reading of noun phrases.*

	Reading Noun Phrases											
	‘a' vs. 'some'			‘a' versus 'enough'			‘this' versus 'these'			‘that' versus 'those'		
	CSG	CPL	M	CSG	CPL	M	CSG	CPL	M	CSG	CPL	M
Total error proportion	*0.69*	*0.31*	*0.31*	*1.00*	*0.13*	*0.50*	*0.94*	*0.13*	*0.88*	*1.00*	*1.00*	*1.00*
Noun errors (proportion of total errors)	*0.55*	*0.80*	*0.80*	*0.81*	*1.00*	*1.00*	*0.33*	*1.00*	*0.29*	*0.69*	*0.44*	*0.38*
phonological errors	0.09	0.20	0.60	0.19	0.50	0.13	0.07	0.00	0.00	0.00	0.06	0.00
semantic errors	0.09	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
number errors	0.27	0.40	0.00	0.19	0.00	0.13	0.13	0.00	0.14	0.25	0.00	0.06
unrelated errors	0.09	0.20	0.00	0.25	0.50	0.50	0.13	1.00	0.14	0.25	0.25	0.25
no responses	0.00	0.00	0.20	0.19	0.00	0.00	0.00	0.00	0.00	0.19	0.13	0.06
Determiner errors (proportion of total errors)[a]	*0.45*	*0.20*	*0.20*	*0.19*	*0.00*	*0.00*	*0.67*	*0.00*	*0.71*	*0.31*	*0.56*	*0.63*
countability neutral substitution	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.21	0.31	0.56	0.63
countability incongruent substitution	0.18	0.20	0.00	0.19	0.00	0.00	0.47	0.00	0.50	0.00	0.00	0.00
others	0.27	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a] Determiner errors were only calculated for noun phrases with the correct target noun (i.e. items with noun errors may also have incorrect determiners)

We further investigated DEH’s difficulties in reading determiners with a reading comprehension and a reading production task in order to localise the level of his reading impairment and to confirm our earlier diagnosis of deep dyslexia and thus his severe difficulties in reading (abstract) function words. In the reading comprehension task, DEH was presented with a spoken target determiner and two written determiners and was asked to choose the matching written target determiner. Each determiner of the four different determiner pairs ‘a/some’, ‘a/enough’, ‘this/these’, ‘that/those’ was presented twice as a spoken target determiner in a fixed, pseudorandomised order. Each written determiner pair was presented four times in alternated order (e.g., twice ‘a’ versus ‘some’, twice ‘some’ versus ‘a’). DEH performed at ceiling on this task (100% correct). In the reading production task, DEH was asked to read the eight determiners aloud (in a pseudorandom order) and his first response was scored. In contrast to the comprehension task, DEH had severe difficulties in reading the determiners aloud (29% correct). The only determiners he was able to read correctly were ‘some’ (100% correct) and ‘enough’ (100% correct).

Discussion

Neither GEC nor DEH showed a countability specific effect in reading and repetition of bare nouns or noun phrases. DEH was found to have severe difficulties in reading noun phrases with the determiners ‘a’, ‘this’, ‘that’ and ‘those’, while the determiners ‘some’, ‘enough’ and ‘these’ were relatively spared. The follow-up tasks on reading showed that DEH could match the auditory determiners to their written form but suffered severe difficulties in reading the same determiners aloud. DEH’s pattern of results suggests that his determiner specific reading impairment can be localised in the link between the lexical-syntactic and the phonological word form levels. Such an impairment is consistent with the results of the background assessments and with a pattern of deep dyslexia, where reading of function words is often more impaired (etc., determiners, prepositions) than reading of content words (nouns, verbs) due to function words being more abstract (Marshall & Newcombe, 1973; Patterson, 1979; Saffran & Marin, 1977).

However, it was clear that neither GEC nor DEH had an impairment specific to mass or count nouns that affects post-lexical level processing as tapped by these tasks. In the next set of experiments (Experiments 2 & 3), we investigated the participants’ picture naming performance with bare nouns and noun phrases to examine effects of countability at the lexical-syntactic and/or conceptual-semantic levels.

Experiment 2: Spoken Picture Naming with Bare Nouns

Two blocks of pictures were presented for naming on separate days. Each block contained half of the mass and half of the count nouns.

Results

GEC’s and DEH’s picture naming was impaired compared to the control group (modified t-test (two-tailed) (Crawford & Garthwaite, 2002): GEC: $t = -5.232$, $p = .001$; DEH: $t = -5.721$, $p < .001$). Neither the control group nor DEH showed a difference in naming accuracy between count nouns and mass nouns. However, GEC was significantly better in naming count nouns compared to mass nouns. The difference between count and mass noun naming accuracy was significantly greater for GEC than for the control group (see Table 6). The control group was significantly better in naming pictures of single mass nouns than multiple mass nouns while DEH and GEC did not show a difference.

Table 6 *Spoken picture naming with bare nouns.*

	Accuracy (proportion)				Statistical significance (p value)			
	Singular Count	Plural Count	Single Mass	Multiple Mass	Count vs. Mass[a,b,c]	Single Mass vs. Multiple Mass[b,c]	Count vs. Mass cf controls[a,d]	Single Mass vs. Multiple Mass cf controls[d]
GEC	0.81	0.81	0.56	0.44	.013*	.424	.001*	n/a
DEH	0.75	0.62	0.81	0.56	.574	.227	n/a	n/a
CONTROLS	0.96	0.89	0.97	0.93	.289	.048*	-	-

[a] Singular and plural count nouns combined (as both noun groups consisted of different items) were compared with the average of single and multiple mass nouns (as both noun groups consisted of the same items).
[b] For DEH and GEC, the Wilcoxon two-sample test was used to compare count nouns with mass nouns and the Wilcoxon matched pairs test was used for the comparison of single mass with multiple mass nouns.
[c] For control participants, the Wilcoxon matched pairs test was used for the comparison between count and mass nouns and between single mass and multiple mass nouns.
[d] The Revised Standardised Difference Test, RSDT (Crawford, & Garthwaite, 2005)) analysed whether the difference between count and mass nouns or between single and multiple mass nouns was significantly greater for DEH and GEC than for the controls.
[*] Significant result, p<0.05 (two-tailed).
n/a - not applicable: RSDT was not used as GEC/DEH did not show a significant difference between conditions.

Experiment 3: Picture Naming with Noun Phrases

Design & Procedure

Participants were required to name pictures with noun phrases (determiner plus noun) in four different tasks using four different determiner pairs: ‘a/some’, ‘a/enough’, ‘this/these’, ‘that/those’. Determiners for mass noun phrases were the same as for singular count noun phrases in half of the tasks (‘this’, ‘that’) and the same as for plural count noun phrases in the other half (‘some’, ‘enough’) in order to exclude that mass/count effects are due to determiner specific impairments. In each trial of each task, participants were presented simultaneously with a target noun picture and the beginning of a sentence in written and auditory form: ‘a/some’: I see _ _., ‘a/enough’: Have you seen _ _?, ‘this/these’ & ‘that/those’: I can see_ _.. Subsequently, participants were asked to complete the sentence by using the appropriate choice of determiner and the noun depicted in the picture. Prior to testing, participants underwent a training phase where they were given determiner cards to practice naming pictures (different to the pictures in the test phase) with noun phrases with the appropriate determiner. Each task consisted of two blocks in which half of the mass nouns were presented as single and half as multiple objects. Each block was presented on separate days.

Results

The results for GEC, DEH and the control group are presented in Table 7.

Table 7 *Proportion of Correct Responses for GEC, DEH and the control group in the Picture Naming Tasks with Noun Phrases.*

Tasks	Singular Count n=16	Plural Count n=16	Mass single n=16	Mass multiple n=16	Mass vs. Count (pvalue)[a,b]	Mass single vs. Mass multiple (pvalue)[c]	Mass vs. Count RSDT (pvalue)[a,e]	Mass single vs. Mass multiple RSDT (pvalue)[e]
GEC							GEC cf Controls	
Whole phrase accuracy								
‘a' vs. 'some'	0.81	0.72	0.25	0.44	.003*	.149	.042*	n/a
‘a' vs. 'enough'	0.78	0.66	0.06	0.38	.001*	.037*	.001*	.001*
‘this' vs. 'these'	0.72	0.72	0.44	0.44	.049*	.842	.002*	n/a
‘that' vs. 'those'	0.72	0.81	0.25	0.25	.001*	.637	.577	n/a
Noun accuracy								
‘a' vs. 'some'	0.90	0.88	0.63	0.50	.019*	.424	.013*	n/a
‘a' vs. 'enough'	0.81	0.81	0.25	0.56	.002*	.037*	.001*	.001*
‘this' vs. 'these'	0.81	0.81	0.50	0.50	.021*	.637	.001*	n/a
‘that' vs. 'those'	0.72	0.88	0.50	0.38	.014*	.346	.001*	n/a
Determiner accuracy[f]								
‘a' vs. 'some'	0.97	0.83	0.40	0.88	.005*	.149	/	/
‘a' vs. 'enough'	0.90	0.79	0.25	0.67	.100	.037*	/	/
‘this' vs. 'these'	0.89	0.89	0.88	0.88	1.00	.773	/	/
‘that' vs. 'those'	1	0.93	0.50	0.57	.002*	1.00	/	/
Determiner substitutions[f]								
‘a' vs. 'some'	0.03	0	0.20	0	.824	1.00	/	/
‘a' vs. 'enough'	0.10	0	0	0	.963	1.00	/	/
‘this' vs. 'these'	0	0.04	0	0	1.00	1.00	/	/
‘that' vs. 'those'	0	0	0	0.33	.075	.346	/	/
DEH							DEH cf Controls	
Whole phrase accuracy								
‘a' vs. 'some'	0.84	0.88	0.63	0.94	.193	.073	n/a	.001*
‘a' vs. 'enough'	0.72	0.53	0.19	0.69	.132	.006*	n/a	.001*
‘this' vs. 'these'	0.44	0.91	0.63	0	.006*	.002*	.002*	.567
‘that' vs. 'those'	0.44	0.59	0.63	0.19	.489	.011*	n/a	.001*
Noun accuracy								
‘a' vs. 'some'	0.88	0.88	0.94	0.94	.873	.637	n/a	n/a
‘a' vs. 'enough'	0.78	0.63	0.94	0.81	.109	.346	n/a	n/a
‘this' vs. 'these'	0.50	0.94	0.81	0.56	.951	.072	n/a	.232
‘that' vs. 'those'	0.66	0.78	0.75	0.38	.236	.020*	n/a	.001*
Determiner accuracy[f]								
‘a' vs. 'some'	0.96	0.93	0.67	1	.073	.019*	/	/
‘a' vs. 'enough'	0.93	0.73	0.27	0.86	.009*	.006*	/	/
‘this' vs. 'these'	0.89	0.94	0.79	0	.001*	.002*	/	/
‘that' vs. 'those'	0.70	0.71	0.83	0.38	.523	.073	/	/
Determiner substitutions[f]								
‘a' vs. 'some'	0	0	0.36	0	.048*	.037*	/	/
‘a' vs. 'enough'	0	0.17	0.50	0	.333	.149	/	/
‘this' vs. 'these'	0	0	0.14	1	.001*	.001*	/	/
‘that' vs. 'those'	0.25	0.18	0.17	0.58	.226	.037*	/	/

Table 7 (continued)

Tasks	Singular Count n=16	Plural Count n=16	Mass single n=16	Mass multiple n=16	Mass vs. Count (pvalue)[a,b]	Mass single vs. Mass multiple (pvalue)[c]	Mass vs. Count RSDT (pvalue)[a,e]	Mass single vs. Mass multiple RSDT (pvalue)[e]
Control Mean (Standard Deviation)		-	-	-				-
Whole phrase accuracy								
a' vs. 'some'	0.99 (0.03)	0.98 (0.03)	0.96 (0.05)	0.95 (0.06)	.156	1		
a' vs. 'enough'	0.98 (0.06)	0.96 (0.06)	0.94 (0.08)	0.95 (0.08)	.196	.773		
this' vs. 'these'	0.99 (0.01)	0.99 (0.03)	0.99 (0.03)	0.96 (0.07)	.201	.174		
that' vs. 'those'	0.98 (0.04)	0.99 (0.01)	0.96 (0.07)	0.95 (0.06)	.071	.586		
Noun accuracy								
a' vs. 'some'	0.99 (0.03)	0.98 (0.03)	0.96 (0.05)	0.95 (0.06)	.106	1		
a' vs. 'enough'	0.98 (0.06)	0.96 (0.05)	0.96 (0.07)	0.95 (0.08)	.143	.773		
this' vs. 'these'	0.99 (0.01)	0.99 (0.03)	0.99 (0.03)	0.98 (0.04)	.269	.346		
that' vs. 'those'	0.98 (0.03)	0.99 (0.01)	0.96 (0.07)	0.96 (0.06)	.203	.637		
Determiner accuracy[f]								
a' vs. 'some'	1 (0.00)	0.99 (0.03)	1 (0.00)	0.99 (0.02)	.493	.343		
a' vs. 'enough'	0.98 (0.04)	1 (0.00)	0.98 (0.03)	1 (0.00)	.167	.082		
this' vs. 'these'	1 (0.00)	1 (0.00)	1 (0.00)	0.98 (0.04)	.177	.193		
that' vs. 'those'	0.99 (0.02)	1 (0.00)	1 (0.00)	0.99 (0.04)	.502	.343		
Determiner substitutions[f]								
a' vs. 'some'	0 (0.00)	0 (0.00)	0 (0.00)	0.01 (0.02)	.343	.343		
a' vs. 'enough'	0 (0.00)	0 (0.00)	0.01 (0.02)	0 (0.00)	.632	.343		
this' vs. 'these'	0 (0.00)	0 (0.00)	0 (0.00)	0.11 (0.31)	1	.312		
that' vs. 'those'	0.01 (0.02)	0 (0.00)	0 (0.00)	0.01 (0.02)	.69	.343		

[a] Singular and Plural count nouns combined (as both noun groups consisted of different items) were compared with the average of single mass nouns and multiple mass nouns (as both noun groups consisted of the same items) in the count and mass comparison for all of the picture naming tasks.
[b]The Wilcoxon two-sample test was used to compare the accuracy of noun phrases, nouns and determiners between mass and count nouns for GEC and

DEH. The Wilcoxon two-sample test was also used to compare the number of correct and countability neutral determiners with the number of countability incongruent determiners between mass and count noun phrases.

[c] The Wilcoxon matched pairs test was used to compare the accuracy of noun phrases, nouns and determiners between single mass and multiple mass nouns for GEC and DEH. The Wilcoxon two-sample test was also used to compare the number of correct and countability neutral determiners with the number of countability incongruent determiners between single mass and multiple mass noun phrases.

[d] The Wilcoxon matched pairs test was used to compare the accuracy of noun phrases and nouns between mass and count nouns, and single mass and multiple mass nouns for the control group. The related t-test was used to compare the accuracy of determiners and the number of determiner substitutions between mass and count nouns, and single mass and multiple mass nouns for the control group.

[e] The Revised Standarised Difference Test, RSDT (Crawford, & Garthwaite, 2005)) analysed whether the difference between count and mass nouns, or single mass nouns and multiple mass nouns was significantly greater than any difference between the conditions shown by the controls.

[f] Determiner accuracy and determiner substitutions are calculated for noun phrases with the target noun independent of the target noun’s number (for example when mass nouns were pluralised

[*] Significant result, p<.05 (two-tailed)

/: RSDT could not be used as the control group was at or close to ceiling.

n/a: not applicable: RSDT was not used as GEC/DEH did not show a significant difference between conditions.

Overall, GEC and DEH were impaired in all four picture naming tasks compared to the control group (modified t-test (Crawford & Garthwaite, 2002) (two-tailed): ‘a/some’: GEC: $t = -11.622$, $p < .001$; DEH: $t = -10.304$, $p < .001$; ‘a/enough’: GEC: $t = -7.365$, $p < .001$; DEH: $t = -8.664$, $p < .001$; ‘this/these’: GEC: $t = -14.179$, $p < .001$; DEH: $t = -16.045$, $p < .001$; ‘that/those’: GEC: $t = -11.239$, $p < .001$; DEH: $t = -12.055$, $p < .001$).

Whole Phrase

Count versus Mass

The control group showed no difference between count and mass noun phrases in any of the tasks, although performance was marginally better on count noun phrases in the task with ‘that/those’.

GEC was significantly more accurate in producing count noun phrases compared to mass noun phrases in all four tasks. This difference was greater for GEC than for the control group in all but the ‘that/those’ task.

DEH showed no countability effect in all but in the picture naming task with ‘this/these’, where he was better with count compared to mass noun phrases. This effect reached significance when compared to the control group.

Single versus Multiple Depictions of Mass Nouns

For the control group, no difference in accuracy of noun phrase production was found between single and multiple mass noun depictions in any tasks.

GEC showed no difference between single and multiple mass noun phrases, except for the ‘a/enough’ task, where he was better with multiple than with single mass noun phrases. This difference was significantly larger for GEC than the control group.

DEH showed a significant difference in accuracy between single and multiple mass noun depictions in all but the ‘a/some’ task, where the effect was marginally significant. However, critically, the direction of the effect changed across tasks: he was better with multiple than single mass noun phrases in the ‘a/some’ and ‘a/enough’ tasks, whereas the reverse effect was found for the ‘this/these’ and ‘that/those’ tasks. This difference was greater for DEH than for the control group in all but the ‘this/these’ task.

However, an analysis of noun phrase accuracy can be inconclusive as both incorrect determiners and incorrect nouns lead to noun phrase errors. Phrases with noun errors are counted as incorrect even though they may include the correct determiner (e.g., picture of mass noun 'broccoli': (a) response 'a carrot' is labelled as mass noun phrase error; (b) response 'a broccoli' is also labelled as mass noun phrase error). We therefore followed-up the analysis of noun phrases by looking at nouns and determiners separately in order to specify the location and nature of DEH and GEC’s impairments. We included two different determiner analyses. The first determiner analysis examined determiner accuracy in noun phrases where the correct target noun (independent of the target noun’s number) was produced. The second analysis compared the number of correct determiners including as correct determiners which were substituted by a countability neutral determiner (e.g., ‘the’ can be used for mass and count nouns) with the number of determiners which were substituted by a countability incongruent determiner (e.g., count noun determiner ‘a’ was substituted by mass noun determiner ‘much’) for mass and count nouns. For all analyses which compared count with mass nouns, single and multiple mass noun depictions were averaged (as both noun groups consisted of the same items) and singular and plural count nouns were combined (as both noun groups consisted of different items).

Target Noun

Count versus Mass

The control group showed no difference in accuracy of noun production between count and mass nouns in any tasks. GEC was significantly better in naming pictures with count nouns compared to mass nouns in each of the four picture naming tasks. This difference was greater for GEC than for the control group in all tasks. Unlike GEC, DEH showed no difference between count and mass nouns.

Single versus Multiple Depictions of Mass Nouns

The control group showed no difference in noun accuracy between single and multiple depictions of mass nouns. Similarly, GEC showed no difference in accuracy of noun production within the noun phrase between single and multiple depictions of mass nouns in all but the ‘a/enough’ picture naming task, where he was better with multiple compared to single mass nouns. This difference was greater for GEC than for the control group. While no difference was found for the tasks ‘a/some’ and ‘a/enough’, DEH was significantly better with single mass nouns compared to multiple mass nouns in the ‘that/those’ task and marginally significantly better in the ‘this/these’ task. This difference was only greater for DEH than for the control group in the ‘that/those’ task. However, most of the noun errors were pluralisation of the target mass nouns, when they were presented as multiple objects (for multiple mass nouns: ‘this/these’: 5/7 noun errors were number errors; ‘that/those’: 7/10 noun errors were number errors) (see Table 8 for the proportion of noun errors including and excluding number errors). A comparison of single mass nouns with multiple mass nouns independent of the noun’s number revealed no difference (Wilcoxon matched pairs: ‘this/these’: $p = .637$ (two-tailed); ‘that/those’: $p = 1.00$ (two-tailed)).

Target Determiner

Count versus Mass

The analysis of determiner accuracy and substitutions showed no countability effect for the control group. However, the existence of a countability effect cannot be ruled out completely as the performance of the control group was either at, or close to ceiling which could obscure a difference between mass and count noun determiners (for further discussion see Best, Schröder & Herbert, 2006). The ceiling effect made it impossible to use RSDT (Crawford & Garthwaite, 2005) in order to analyse whether the difference in determiner accuracy and in the number of substitution errors between mass and count noun phrases is greater for DEH or GEC than for the control group.

GEC showed a countability effect on accuracy of determiner production which was significant for the ‘a/some’ task and ‘that/those’ tasks. GEC’s determiner errors were predominantly omissions of mass noun determiners leading to grammatically correct sentences (e.g. I can see broccoli; see Table 8). The number of determiners which were substituted by countability incongruent determiners did not differ across mass and count noun phrases although in the ‘that/those’ task the difference was close to significant (see Table 7).

DEH made more errors for mass than for count noun determiners in the ‘a/enough’ and ‘this/these’ tasks and marginally significantly more errors in the ‘a/some’ task while no difference was found for the ‘that/those’ task. He substituted significantly more often mass noun determiners by countability incongruent determiners than count noun determiners in the ‘a/some’ and ‘this/these’ tasks, while no difference was found in the ‘a/enough’ and ‘that/those’ tasks (see Table 7). In two of the four tasks, countability incongruent determiner substitutions accounted for the majority of his determiner errors in mass noun phrases (see Table 8).

Single versus Multiple Depictions of Mass Nouns

For both the control group and GEC, no difference in determiner accuracy and determiner substitutions was found between single and multiple mass nouns in any task, except for the ‘a/enough’ task, where determiner accuracy was marginally better for multiple compared to single depictions of mass nouns (see Table 7).

However, DEH’s determiner accuracy was significantly different for single and multiple mass noun depictions in three of the tasks and close to significant in the ‘that/those’ task. He made fewer determiner errors for multiple mass noun depictions in the picture naming tasks with ‘a/some’ and ‘a/enough’, whereas he showed the opposite effect for the ‘this/these’ and ‘that/those’ tasks (see Table 7). The same significant effects were found for the analysis of determiner substitutions in all but the ‘a/enough’ task, where the difference did not reach significance. DEH more often substituted determiners of single mass nouns by a countability incongruent determiner than determiners of multiple mass nouns in the ‘a/some’ task, whereas the opposite pattern was found for the ‘this/these’ and ‘that/those’ tasks (see Table 7).

Table 8 *Proportion of Noun Error Types and Determiner Error Types for single plus multiple mass nouns (N = 32) and singular plus plural count nouns (N = 32) for GEC and DEH in Picture Naming Tasks with Noun Phrases.*

	GEC								DEH							
	mass nouns				count nouns				mass nouns				count nouns			
Tasks	‘a' vs. 'some'	‘a' vs. 'enough'	‘this' vs. 'these'	‘that' vs. 'those'	‘a' vs. 'some'	‘a' vs. 'enough'	‘this' vs. 'these'	‘that' vs. 'those'	‘a' vs. 'some'	‘a' vs. 'enough'	‘this' vs. 'these'	‘that' vs. 'those'	‘a' vs. 'some'	‘a' vs. 'enough'	‘this' vs. 'these'	‘that' vs. 'those'
Types of Noun Errors																
total proportion of errors that are noun errors including number errors	0.44	0.59	0.50	0.56	0.14	0.19	0.19	0.20	0.06	0.13	0.31	0.44	0.13	0.30	0.28	0.28
proportion of noun errors excluding number errors[a]	0.44	0.59	0.50	0.53	0.14	0.16	0.19	0.20	0.06	0.09	0.13	0.22	0.09	0.16	0.16	0.17
phonological errors[b]	0.06	0.16	0.13	0.13	0.05	0.03	0.05	0.05	0.03	0	0	0.09	0.03	0.08	0.06	0.03
semantic errors	0.16	0.16	0.19	0.19	0.08	0.09	0.09	0.13	0.03	0.03	0.03	0.06	0.06	0.06	0.08	0.05
unrelated errors[c]	0.06	0.06	0.06	0.09	0	0	0.03	0.02	0	0.03	0.03	0.03	0	0.02	0.02	0.03
no responses	0.16	0.22	0.13	0.13	0.02	0.03	0.02	0.02	0	0.03	0.06	0.03	0	0	0	0.05
Types of Determiner Errors																
proportion of determiner errors[d]	0.39	0.46	0.13	0.47	0.11	0.12	0.12	0.04	0.17	0.45	0.57	0.40	0.02	0.20	0.04	0.28
countability neutral substitution[e]	0.06	0.08	0	0.13	0.02	0.04	0.08	0.02	0	0.03	0.04	0	0	0.02	0.04	0.06
countability incongruent substitution[f]	0.06	0	0	0.13	0.02	0.02	0.02	0	0.17	0.14	0.54	0.36	0	0.07	0	0.19
countability congruent substitution[g]	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0
omissions	0.28	0.38	0.13	0.19	0.07	0.06	0	0.02	0	0.28	0	0.04	0.02	0.11	0	0.04

[a] Number errors are pluralisations of a target mass or singular count noun and omission of the –s for plural count nouns.

[b] Phonological errors include phonological word errors, phonological nonword errors and false starts (target: flag, response: ff flag) which share 50% phonemes with the target noun.
[c] Unrelated errors are words and nonwords which are not phonologically or semantically related to the target word.
[d] Proportion of determiner errors was analysed only for noun phrases which were produced with the target noun.
[e] Countability neutral substitutions refer to substitutions by a determiner which can be used for mass and count nouns (e.g., the).
[f] Countability incongruent substitutions refer to substitutions by a count noun determiner for target mass nouns and a mass noun determiner for target count nouns (e.g., for mass nouns: a, those; for count nouns: much) which lead to a grammatically incorrect noun phrase (e.g., for mass nouns: *a rice, *those rice; for count nouns: *much cat).
[g] Countability congruent substitutions refer to substitutions by a count noun determiner for count nouns and mass noun determiner for mass nouns which are not the target determiner (e.g., for mass nouns: target determiner ‘some’, response: much; for count nouns: target determiner ‘a’, response: this) but lead to a grammatically correct noun phrase (e.g., for mass nouns: much rice, for count nouns: this cat).

Discussion (Experiments 2 & 3)

Both GEC and DEH are generally impaired in spoken picture naming with bare nouns and noun phrases (Experiments 2 & 3). DEH and GEC were found to have a mass specific deficit. However, the nature of this deficit differed: DEH only showed a mass deficit in the picture naming tasks with noun phrases but not in the picture naming task with bare nouns. In the picture naming tasks with noun phrases, he frequently substituted mass noun determiners (e.g., some, this) with count noun determiners (e.g., a, these). These substitution errors led to the production of ungrammatical mass noun phrases, such as ‘a tennis’ instead of ‘some tennis’, ‘a hay’ instead of ‘enough hay’, and ‘these steams’ instead of ‘this steam’. DEH’s determiner impairment for mass nouns became particularly apparent when he was presented with depictions of mass nouns in which visual and conceptual-semantic representation did not match the grammatical number of the target determiner. For example, in the picture naming task requiring the determiners ‘a/some’, the mass noun determiner is the same as the plural count noun determiner. In this task, DEH made more mass noun determiner errors when mass nouns were presented as one single object rather than as multiple objects. Similarly, an effect of conceptual number on determiner accuracy for mass noun phrases was found with ‘this/these’ and ‘that/those’. However, in this case singular count nouns and mass nouns share the same determiner and DEH produced determiners more accurately for mass nouns which were depicted as one single object as opposed to multiple objects. This pattern of performance is similar to that shown by RAP (Fieder et al., submitted).

DEH’s lexical-syntactic impairment also affected number marking of mass nouns and count nouns. Even though mass nouns are not grammatically marked for number, DEH often pluralised mass nouns which were depicted as multiple objects in the picture naming tasks with noun phrases (e.g., ‘these butters’ instead of ‘this butter’; ‘enough creams’ instead of ‘enough cream’). The co-occurrence of determiner substitutions with grammatically incongruent determiners and number errors indicate that DEH’s apparently mass specific problem is grammatical in nature and therefore located at the lexical-syntactic level.

At first sight, GEC’s difficulties with mass noun phrases in the picture naming tasks look similar to those of DEH. However, unlike DEH, GEC’s impairment predominantly affected the production of mass nouns rather than mass noun determiners. GEC had more difficulties in naming mass nouns compared to count nouns. Unlike DEH, GEC’s noun errors were not lexical-syntactic as GEC only once pluralised a mass noun in all the experimental tasks. Instead, most of his noun errors were semantic errors followed by no responses and phonological errors (see Table 8). GEC made more semantic errors for mass than for count nouns in naming tasks with noun phrases[30] (Wilcoxon two-sample (two-tailed): ‘a/some’: $p = .048$; a/enough: $p = .028$; ‘this/these’: $p = .100$; ‘that/those’: $p = .050$). Even though GEC predominantly substituted target mass nouns with count nouns (see Table 9), a comparison of the substituting mass (29%) and count nouns (71%) for target mass nouns revealed that their frequency reflected the normal mass and count noun

[30] The number of correct responses including phonological errors and the number of semantic errors and no responses was compared for single plus multiple mass nouns with singular plus plural count nouns.

distribution in English (according to CELEX, Baayen et al., 1995) (Binomial Test (two-tailed): ‘a/some’: $p = .180$; ‘a/enough’: $p = .702$; ‘this/these’: $p = .129$; that/those: $p = 1.00$).

Table 9 *Proportion of Noun Errors which resulted in nonwords and words (mass and count) for GEC in the picture naming tasks with noun phrases.*

	Mass nouns				Count nouns			
Noun Errors	‘a' vs. 'some' n=16	‘a' vs. 'enough' n=16	‘this' vs. 'these' n=16	‘that' vs. 'those' n=16	‘a' vs. 'some' n=16	‘a' vs. 'enough' n=16	‘this' vs. 'these' n=16	‘that' vs. 'those' n=16
total proportion of errors that are noun errors	0.44	0.59	0.50	0.56	0.14	0.16	0.19	0.20
proportion of noun errors excluding errors that result in nonwords or no responses	0.22	0.22	0.25	0.28	0.08	0.13	0.16	0.13
- substitutions by a mass noun	0	0.03	0	0.09	0	0	0	0
- substitutions by a count noun	0.22	0.19	0.25	0.19	0.08	0.13	0.16	0.13

GEC showed similar mass noun difficulties and error types in the picture naming task with bare nouns: He produced more semantic errors for bare mass than for bare count nouns (Wilcoxon two-sample (two-tailed): $p = .032$). In addition to noun errors, GEC also produced determiner errors, but in general there was no significant countability effect. Unlike DEH’s determiner substitution errors, most of GEC’s determiner errors were omissions.

From the reading and repetition tasks, we can exclude post-lexical processing as a locus for GEC’s mass specific noun impairment. In addition, GEC’s impairment did not result in violations of the grammatical structure of mass noun phrases. Therefore, we would suggest the locus of GEC’s mass specific impairment is at the conceptual-semantic level and the link between conceptual-semantic and lexical-syntactic level rather than the lexical-syntactic level itself. GEC’s mass specific noun impairment will be further discussed and embedded into a theoretical framework in the General Discussion.

GENERAL DISCUSSION

The aim of this study was to investigate countability specific impairments in aphasia in order to test and extend our knowledge about the representation and processing of mass/count information. We reported countability specific impairments in two individuals with word finding difficulties and conceptual-semantic and/or lexical-syntactic impairments. We assessed the processing of mass and (singular and plural) count nouns and their determiners at different levels of the language system to investigate patterns of influence of countability on performance and to identify the locus of impairment.

In a previous study (Fieder et al., submitted), we used the same tasks to systematically identify and investigate the mass specific difficulties of another man with aphasia, RAP. Like DEH and GEC, RAP suffered from a lexical-syntactic impairment and word finding difficulties. He frequently substituted mass noun determiners with count noun determiners in language production and comprehension as an outcome of an impaired lexical-syntactic mass node and/or a general lexical-syntactic impairment. Moreover, RAP’s lexical-syntactic impairment resulted in conceptual-semantic information influencing his determiner choice for mass nouns: RAP selected determiners which matched the conceptual-semantic number of the depicted mass nouns. For example, mass nouns depicted as single objects (a single bulb of garlic) evoke the concept SINGLE which is consistent with the determiner ‘a’. RAP’s pattern of results led us to conclude that nouns and noun determiners are specified for countability at the lexical-syntactic level, for example through attributes, such as [mass] and [count]. In addition, we proposed that countability was not only derived lexical-syntactically but was also influenced by conceptual-semantic information (e.g., SINGLE and MULTIPLE for singular and plural count noun phrases). It was therefore suggested that countability is represented in the form of a hybrid attribute opposed to an intrinsic lexical-syntactic property (like grammatical gender) which is purely derived by lexical-syntax or an extrinsic lexical-syntactic feature (like number) which is derived by conceptual-semantic information.

How does DEH and GEC’s mass specific impairment relate to that of RAP? Like RAP, DEH showed no mass specific impairment in reading, repetition or picture naming with bare nouns (Experiments 1 & 2), nor in reading and repetition of noun phrases (Experiment 1) excluding a post-lexical locus for the effect of countability. Even though DEH had severe difficulties in reading specific determiners, there was no effect of countability. His poor performance was a result of more general difficulties in reading abstract words such as determiners. His general determiner problems in reading did not occur in the picture naming tasks. We can therefore confidently conclude that reading determiners aloud engages different processes to producing determiners in a picture naming task with noun phrases. DEH’s deep dyslexic symptoms suggested that he read via the semantic route. Hence, in order to read a noun phrase (e.g., a lamp), the orthographic form of the determiner and noun must activate their lemma nodes and subsequently semantically related concepts (e.g., determiner ‘a’ activates concepts INDEFINITE and SINGLE, noun ‘lamp’ activates concept LAMP) before activation is sent back to their lemma nodes and then phonological word forms. DEH’s impairment at the lexical-syntactic level and of the link between lexical-syntactic and word form level is likely to result in an overall decrease in the activation of word forms. As abstract words, determiners are particularly affected by this impairment because their semantic representation is qualitatively weaker in the first place (see Plaut & Shallice (1993) who argued that abstract words are represented by fewer semantic features compared to concrete words). Consequently, lemmas and word forms of determiners receive less conceptual-semantic activation compared to nouns. It is unlikely that nouns exert an influence (conceptual-semantic or lexical-syntactic) on determiner processing during reading, for DEH, due to the sequential order (nouns appear after determiners).

Why is DEH generally better at producing determiners in picture naming with noun phrases compared to reading? Compared to reading, in picture naming with noun phrases, determiners are not presented orthographically to the participant. Instead determiners have to be lexical-syntactically derived, which means their selection relies on activation from the depicted target noun. Depicted nouns in this task are semantically concrete and therefore sufficient activation can be forwarded from noun concepts to noun lemmas and subsequently to determiner lemmas. Moreover, in picture naming, the impaired lexical-syntactic level is only accessed once while reading via the semantic route requires accessing it twice. Overall, this could result in fewer errors when determiner word forms are accessed in picture naming compared to reading.

Most importantly, the results of Experiment 3 revealed that DEH had mass specific difficulties in naming pictures with mass noun phrases. DEH substituted mass noun determiners with count noun determiners while mass nouns themselves remained relatively unaffected. Like RAP, DEH’s choice of determiners was affected by the conceptual-semantic information evoked by the depiction of the mass nouns (whether they were depicted as single or multiple objects). DEH frequently made number errors for both mass and count nouns. From these results we can infer that DEH’s deficit was grammatical in nature – it affected all of the tested determiners for mass nouns. Therefore, we suggest that DEH suffered from either a general lexical-syntactic impairment and/or a specific impairment of the attribute [mass] at the lexical-syntactic level. From DEH’s ability to occasionally produce mass noun determiners correctly, we can further conclude that his impairment was only partial. Hence, occasionally lexical-syntactic mass noun determiner representations received enough activation to be selected correctly. In the case of congruency between the conceptual-semantic number information of a depicted mass noun and its determiner, we propose that the determiner received an extra jolt of activation from concepts (e.g., SINGLE or

MULTIPLE) which led to the selection of the correct mass noun determiner. However, if the conceptual-semantic number information of a depicted mass noun and its determiner was incongruent, target mass noun determiners would not receive extra activation. Instead, incongruency would lead to the activation of competitor determiners congruent with the conceptual-semantic information of the mass noun depiction, such as certain count noun determiners. For DEH, this often resulted in the selection of a competitor (count noun) determiner rather than the partially activated target mass noun determiner. Unlike mass nouns, the conceptual-semantic number information for count nouns and their determiners is always congruent as singular count nouns must be depicted as single objects and require a singular determiner (e.g., a) and plural count nouns must be depicted as multiple objects and require a plural determiner (e.g., some). Hence, even in case of a general lexical-syntactic rather than a a specific mass node impairment, count noun determiner representations (lemmas) would still have a processing advantage by receiving an extra jolt of activation from their conceptual-semantic congruent concepts (SINGLE or MULTIPLE). In contrast, lexical-syntactic mass noun determiner representations (lemmas) remain more vulnerable to the effects of an impairment when the depiction of the mass noun and its target determiner are number incongruent.

Turning to GEC, he showed no countability specific effect in reading and repetition of bare nouns and noun phrases (Experiment 1) excluding a post-lexical locus for his mass specific impairment. In Experiment 2, picture naming with bare nouns, he was better in naming pictures of singular and plural count nouns compared to mass nouns. The same mass noun specific difficulties were observed in picture naming tasks with noun phrases (Experiment 3). In contrast to DEH, GEC’s mass noun errors were not pluralisations but mainly semantic paraphasias and no responses. Even though GEC produced some determiner errors, unlike DEH’s errors, they consisted predominantly of omissions. Therefore, we concluded that the impairment(s) underlying GEC’s mass noun specific difficulties was likely to be localised at the conceptual-semantic level and/or the link between the conceptual-semantic and lexical-syntactic level. As noted in the Introduction, many theories assume that nouns are semantically specified for countability either through one or a set of concepts/features, such as UNINDIVIDUATED, UNDEFINITE, INDIVISIBLE, NON-DISTINCT or UNCOUNTABLE for mass nouns and/or INDIVIDUATED/ATOMIC, DEFINITE, DIVISIBLE, DISTINCT and COUNTABLE for count nouns (Barner & Snedeker, 2005, 2006; Bloom, 1994, 1999; Gordon, 1985; Macnamara, 1986; Quine, 1960; Wisniewski, Imai & Casey, 1996). Activation of these concepts could contribute to or even be required for the selection of mass/count nouns and their determiner nodes at the lexical-syntactic level. Similar assumptions have been made for the concepts SINGLE and MULTIPLE (Fieder et al., submitted; Nickels, Biedermann, Fieder & Schiller, submitted). Since English has many more count than mass nouns (see footnote 7, earlier) (Brown & Berko, 1960; Iwasaki, Vinson & Vigliocco, 2010, Baayen, Piepenbrock & Gulikers, 1995), count specific concepts (e.g., INDIVIDUATED, COUNTABLE) are more often activated than mass concepts. This can be expressed with different weightings in the links (Dell, Schwartz, Martin, Saffran & Gagnon, 1997) which connect mass and count concepts with their noun and determiner lemma representations. Thus, count concepts would have stronger connections and consequently send more activation to count noun and determiner lemma nodes compared to mass concepts (see Figure 1). Weaker connections would make mass nouns more vulnerable to impairment than count nouns because their lemma representations receive less activation from the mass concepts. The same explanation was used by Fieder et al. (submitted) to account for MH’s (Herbert & Best, 2010) mass noun impairment. However, GEC’s mass noun deficit could also be explained by a mass specific impairment of one or several mass concepts/features (e.g., UNINDIVIDUATED, UNCOUNTABLE) at the conceptual-semantic level.

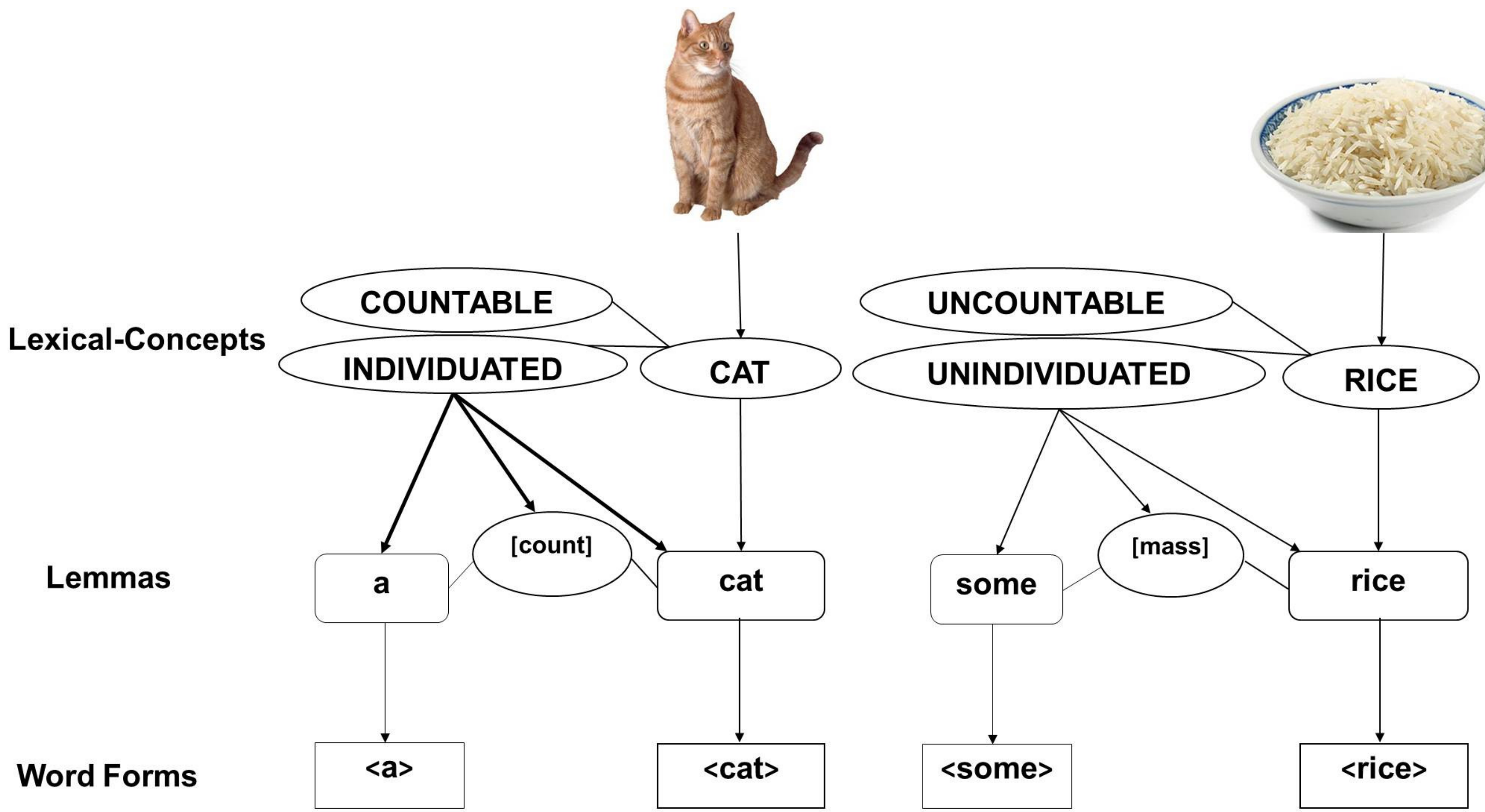

Figure 1. Conceptual-semantic and lexical-syntactic representation of mass and count nouns.

An alternative explanation for GEC’s mass noun deficit could be that mass nouns were necessarily depicted as individuated entities with clear boundaries (e.g., bulb of garlic, bowl of rice, a jar of honey) with other words mass nouns were visually similar to count nouns. This could have resulted in a decrease of activation from the visual representation of the mass noun to mass specific concepts (e.g., UNINDIVIDUATED) and then to mass noun lemmas. In both cases, GEC’s impairments at the conceptual-semantic level and the connection between the conceptual-semantic and lexical-syntactic level (see results of background language assessment) would result in a mass noun specific deficit. The conceptual-semantic impairment can account for GEC’s increased number of semantic errors for mass nouns compared to count nouns and omissions of mass noun determiners in picture naming. Further support for a general impairment rather than a mass specific impairment at the conceptual-semantic level (e.g., impairment of one or more mass concepts) comes from the fact that GEC’s noun substitutions followed the frequency distribution of mass and count nouns in English (Baayen et al., 1995).

CONCLUSION

This study replicated and extended a previous single case study with RAP, an aphasic individual with a mass specific deficit attributed to either a general impairment at the lexical-syntactic level or a specific impairment of the lexical-syntactic attribute [mass] (Fieder et al., submitted). We have presented data from two more aphasic individuals, DEH and GEC, who both suffered from an apparent mass specific deficit. DEH’s mass specific deficit had the same features as those of RAP and was also ascribed to an impairment at the lexical-syntactic level. In contrast to DEH and RAP's difficulties with mass noun determiners, GEC’s mass specific difficulties affected mass nouns. We concluded that his difficulties were likely to be the result of a general impairment at the conceptual-semantic level and of the link between the conceptual-semantic and the lexical-syntactic level. In order to explain the mass noun specific effect we proposed that countability is represented in the form of mass and count specific concepts which are connected to their lexical-syntactic representations (e.g., noun lemmas). We suggested further that connection strength of mass versus count concepts varies depending on their frequency with the result that connections are weaker for mass than for count concepts.

In sum, DEH’s results support the findings of our earlier study (Fieder et al., submitted) and therefore provide further evidence for the lexical-syntactic specification of countability which is particularly crucial for the selection of mass noun determiners. GEC’s results describe a different form of mass specific impairment which can be best explained with a conceptual-semantic representation of countability.

REFERENCES

Baayen, R. H., Piepenbrock, R. & Gulikers, L. (1995). *The CELEX lexical database (CD-ROM).* Philadelphia, PA: Linguistic Data Consortium. University of Pensylvania.

Baayen, R. H., Piepenbrock, R. & van Rijn, H. (1993). *The CELEX Lexical Database (Release 1) [CD-ROM].* Philadelphia: PA: Linguistic Data Consortium. University of Pensylvania.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B. & Treiman, R. (2007). The English Lexicon Project. Behavior Research Methods, 39, 445-459.

Barner, D. & Snedeker, J. (2005). Quantity judgements and individuation: evidence that mass nouns count. *Cognition*, 97, 41-66.

Barner, D. & Snedeker, J. (2006). Children’s Early Understanding of Mass-Count Syntax: Individuation, Lexical Content, and the Number Asymmetry Hypothesis. *Language Learning And Development*, 2(3), 163-194.

Best, W., Schröder, A. & Herbert, R. (2006). An investigation of a relative impairment in naming non-living items: theoretical and methodological implications. *Journal of Neurolinguistics*, 19, 96-123.

Biedermann, B., Lorenz, A., Beyersmann, E. & Nickels, L. (2012). The influence of plural dominance in aphasic word production. *Aphasiology*. 26(8), 985-1004.

Biedermann, B., Beyersmann, E., Mason, C. & Nickels, L. (2013). Does plural dominance play a role in spoken picture naming? A comparison of unimpaired and impaired speakers. *Journal of Neurolinguistics*, 26(6), 712-736.

Biran, M. & Friedmann, N. (2012). The representation of lexical-syntactic information: Evidence from syntactic and lexical retrieval impairments in aphasia, *Cortex*, 48(9), 1103-1127.

Bishop, D.V.M. (2003b). Test for Reception of grammar (version 2). London: Psychological Corporation.

Bloom, P. (1999). The role of semantics in solving the bootstrapping problem. In R. Jackendoff, P. Bloom & K. Wynn (Eds.). *Language, logic, and concepts: Essays in memory of John Macnamara*. Cambridge, MA: MIT Press.

Bloom, P. & Keleman, D. (1995). Syntactic cues in the acquisition of collective nouns. *Cognition*, 56, 1–30.Brown, R., & Berko, J. (1960). Word Association and the Acquisition of Grammar. *Child Development*, 31(1), 1-15.

Butterworth, B, Howard, D. & McLoughlin, P. (1984). The semantic deficit in aphasia: the relationship between semantic errors in auditory comprehension and picture naming. *Neuropsychologia*, 22(4), 409-426.

Brown, R. & Berko, J. (1960). Word Association and the acquisition of Grammar. *Child Development*, 31(1), 1-14.

Chan, S.-M. (2005). *Genusintegration. Eine systematische Untersuchung zur Genuszuweisung englischer Entlehnungen in der deutschen Sprache*

[Gender intergration. A systematic investigation of gender assignment for English loanwords in German]. Munich, Germany: Iudicium.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Database,* 33, 497-505.

Coughlan, A. K. & Warrington, E. K. (1981). The impairment of verbal semantic memory: a single case study. *Journal of Neurology, Neurosurgery, and Psychiatry*, 44, 1079-1083.

Crawford, J.R. & Garthwaite, P.H. (2002). Investigation of the single case in neuropsychology: Confidence limits on the abnormality of test scores and test score differences. Neuropsychologia, 40, 1196-1208.

Crawford, J.R. & Garthwaite, P. H. (2005). Testing for suspected impairments and dissociations in single-case studies in neuropsychology: Evaluation of alternatives using Monte Carlo simulations and revised tests for dissociations. *Neuropsychology*, 19, 318-331.

Dell, G.S., Schwartz, M.F., Martin, N., Saffran, E.M. & Gagnon, D.A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, 104(4), 801-838.

Fieder, N., Nickels, L., Biedermann, B. & Best, W. (submitted). From ‘much butter’ to ‘many butter’: An investigation of mass and count processing in aphasia. *Cognitive Neuropsychology*.

Gordon, P. (1985). Evaluating the semantic categories hypothesis: The case of the mass/count distinction. *Cognition*, 20, 209–242.

Hemera (1997-2000). *Photo-Objects 50,000. Premium Image Collection.*Hull-Quebec, Canada.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex*, 46(3), 329-342.

Hillis, A E., Rapp, B., Romani, C. & Caramazza, A. (1990). Selective impairment of semantics in lexical processing. *Cognitive Neuropsychology*, 7(3), 191-243.

Howard, D. (1995). Lexical anomia: or the case of the missing lexical entries. *The Quarterly Journal of Experimental Psychology*, 48a(41), 999-1023.

Howard, D. & Orchard-Lisle, V. (1984). On the origin of semantic errors in naming: evidence form the case of a global aphasic. *Cognitive Neuropsychology*, 1(2), 163-190.

Howard, D. & Patterson, K. E. (1992). *Pyramids and Palm Trees.* Bury, St. Edmunds, UK: Thames Valley Test Company.

Huff, J. F., Mack, L., Mahlmann, J. & Greenberg, S. (1988). A comparison of lexical-semantic impairments in left hemisphere stroke and Alzheimer’s disease. *Brain and Language,* 34, 262-278.

Iwasaki, N. Vinson, D.P. & Vigliocco, G. (2010). Does the grammatical count/mass distinction affect semantic representations? Evidence from experiments in English and Japanese. *Language and Cognitive Processes*, 25(2), 189-223.

Kaplan, E., Goodglass, H. & Weintraub, S. (1978). *The Boston Naming Test.* Philadelphia: Lea & Febiger.

Kay, J. & Ellis, A. (1987). A cognitive neuropsychological case study of anomia. Implications for psychological models of word retrieval. *Brain*, 110, 613-629.

Kay, J., Lesser, R. & Coltheart, M. (1992). *PALPA: Psycholinguistic assessments of language processing in aphasia*. Hove, England: Erlbaum.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences*, *22*, 1-75.

Luzzatti, C., Mondini, S. & Semenza, C. (2001). Lexical representation and processing of morphologically complex words: Evidence from the reading performance of an Italian agrammatic patient. *Brain and Language*, *79,* 345–359.

Macnamara, J. (1986). *A border dispute: The place of logic in psychology*. Cambridge, MA: MIT Press.

Marshall, J. C. & Newcombe, F. (1973). Patterns of paralexia: A psycholinguistic approach. *Journal of Psycholinguistic Research,* 2,175-199.

Middleton, E.L., Wisniewski, E.J., Trindel, K.A. & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language*, *50*, 371-394.

Middleton, E.L. (2008). Mass Matters. *Dissertation Abstracts International*, 70(02), (UMI No. 3347451).

Nickels, L., Biedermann, B., Fieder, N. & Schiller, N.O. (submitted) The Lexical syntactic representation of number. *Language and Cognitive Processes*.

Nickels, L. & Cole-Virtue, J. (2004).Reading tasks from PALPA: How do controls perform on visual lexical decision, homophony, rhyme, and synonym judgments? *Aphasiology,18(2),*103-126.

Patterson, K.E. (1979). What is Right with “Deep” Dyslexic Patients?. *Brain and Language*, 8, 111-129.

Plaut, D.C. & Shallice, T. (1993). Deep dyslexia: A case study of connectionist neuropsychology. *Cognitive Neuropsychology*, 10(5), 377-5.

Quine, W.V.O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Saffran, E. M. & Marin, 0.S.M. (1977). Reading without phonology: Evidence from aphasia. *Quarterly Journal of Experimental Psychology*, 29, 515-525.

Semenza, C., Mondini, S. & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Semenza, C., Mondini, S. & Marinelli, K. (2000). Count and Mass Nouns: Semantics and Syntax in Aphasia and Alzheimer`s disease. *Brain and Language, 74*, 395-431.

Seyboth, M., Blanken, G., Ehmann, D., Schwarz, F. & Bormann, T. (2011). Selective impairment of masculine gender processing: Evidence from a German aphasic. *Cognitive Neuropsychology*, 28(8), 564-588.

Warrington, E. K. (1975). The selective impairment of semantic memory. *Quarterly Journal of Psychology*, 27, 635-657.

Wierzbicka, A. (1988). *The semantics of grammar*. Amsterdam: John Benjamins.

Wisniewski, E.J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and cognitive processes*, 18(5/6), 583-624.

Wisniewski, E. J., Imai, M. & Casey, L. (1996). On the equivalence of superordinate concepts. *Cognition*, 60, 269–298.

Worral, L. E., Yiu, E. M-L., Hickson, L. M. H. & Barnett, H. M. (1995). Normative data for the Boston Namong Test for Australian elderly. *Aphasiology*, 9(6), 541-551.

Author Note

During the preparation of this paper, Nora Fieder was funded by a Macquarie University Research Excellence (MQRES) scholarship, Lyndsey Nickels was funded by an Australian Research Council Future Fellowship and Britta Biedermann by a Macquarie University Research Fellowship (MQRF), and an ARC Australian Post-Doctoral Research Fellowship.

APPENDIX A

Connected Speech: excerpt of the Cinderella story for GEC

“It’s a story of Cinderella and...she has...a stepmother and two sisters...and the stepmother and the sisters beat her and...not very good but not very good either he-he...and the...sisters are...being taken to a ball at the princess place.....and... Cinderella is not asked to come…...but it.is.okay to.come...in the evening....eight o’clock is the time.and....have a good time with the horses and pumpkin and..............pumpkin...mm...sorry I don’t know what is the matter would be...but I have got to very mice in my /teɪlspɪn/ and it is mm... [t: okay just go on if you can so].I...no..the very.mhm.....mhm mhm…when you go out onto the floor you have very good idea for Cinderella when she has..a.....very fine young men with her..it is the prince.and prince is…...holding her...tightly..and the thing is...twelve o’clock and she must flee...she goes across the.concourse and it is...very much like..it..too............sh no I’m going sorry I am ahh it I don’t have words to say but afterwards the prince arrives and takes out the boot and tried it on for both sister’s feet but it was way too large...and then...he...espied the other little girl and...when he asked......her…...what were you doing last night...and he..had the word...my prince I was dancing with you...and he got the slipper out and...it is true...what she was saying and they lived happily ever after he-he”

APPENDIX B

Connected Speech DEH: excerpt of the Cinderella story

“Ah Cinderella and one two three ah no good at all and the … Cinderella ahm invite . to this the ah peak house in the yes and … and ah doormat no ah door no ahm …………….ok ahm .. ok one two three ahm sisters and ahm ……ahm /θrə/ ahm beautiful you know one two three and ………. dormas no …. ah ok. a pillow no ah a pumpkins and oh you know ah ….. ahm pumpkin boom beautiful ah ….. ok. and …….. and beautiful ah ok. yeah and …. and … Cinderella … and her prince and boom boom and one no one two three four five six seven eighth nine ten eleven twelve o’clock .. boom oh yeah her racing away and ahm the ahm …… ahm .... her shoes one two no one and they ah ……… ahm her guards man [-] and you know ahm ahm . ok. the Cinderella . ah yes no one no two three no oh no ah common Cinderella oh beautiful and the story goes along ah a well end wedding pace and beautiful.”

APPENDIX C

	singular count nouns (sg)	plural count nouns (pl)	mass nouns	sg count vs. mass t(15)	sg count vs. mass p	pl count vs. mass t(15)	pl count vs. mass p	sg count vs. pl count t(15)	sg count vs. pl count p
Log (written frequency)	1.15	1.00	1.22	-0.42	0.68	-1.16	0.26	-0.92	0.37
Log (spoken frequency)	0.68	0.68	0.81	-0.72	0.48	-0.71	0.49	-0.01	1.00
Log (written stem frequency)	2.51	2.68	2.43	0.39	0.70	1.18	0.26	1.05	0.31
Log (spoken stem frequency)	0.89	1.16	0.89	-0.01	1.00	1.27	0.23	1.35	0.20
Number of syllables	1.63	1.44	1.81	-0.90	0.38	-1.31	0.21	-0.76	0.46
Number of phonemes	4.56	4.88	4.69	-0.23	0.83	0.43	0.68	0.74	0.47
Number of graphemes	5.38	5.50	5.25	0.32	0.76	0.59	0.56	0.31	0.76
Phon. neighbourhood density	1.79	1.74	1.73	0.22	0.83	0.05	0.96	-0.23	0.83
Orth. neighbourhood density	1.90	1.89	1.96	-0.26	0.80	-0.28	0.79	-0.06	0.95
Imageability	601	590	588	1.04	0.32	0.16	0.88	-0.79	0.44
Age of acquisition	2.89	2.89	2.94	-0.15	0.88	-0.18	0.86	0.02	0.98
Naming agreement	95.31	93.63	95.31	0.00	1.00	-1.16	0.26	-1.14	0.27

Chapter 6

Summary and Conclusions

Nora Fieder, Lyndsey Nickels & Britta Biedermann

ARC Centre of Excellence for Cognition and its Disorders (CCD)

Department of Cognitive Science

Macquarie University, Sydney, Australia

The research presented in this thesis aimed to investigate the representation and processing of countability information at the lexical-syntactic level in language production. The lexical-syntactic level is still a relatively unexplored component of the language system where comparably little research has focussed on countability. Countability is a particularly interesting grammatical attribute of nouns as its nature is still controversial (see e.g., Middleton, 2008) and less clear compared to grammatical number which is semantically derived or grammatical gender which is lexical-syntactically derived. While countability has been argued by some to be derived through conceptual-semantics, like number (Cheng, 1973; Grandy, 1973; Middleton, Wisniewski, Trindel & Imai, 2004; Wierzbicka, 1988; Wisniewski, Lamb & Middleton, 2003), others have argued that it is a fixed lexical-syntactic attribute similar to grammatical gender (e.g., Garrard, Carroll, Vinson & Vigliocco, 2004; Middleton, 2008; Shapiro, Zurif, Carey & Grossman, 1989; Vigliocco, Vinson, Martin & Garrett, 1999). The research in this thesis has contributed to this debate by drawing inferences regarding the representation of mass/count information from experimental manipulations of countability. Countability processing was investigated in language unimpaired and language impaired speakers using different methods. Paper Two is the first reported study to use a picture-word interference paradigm to investigate countability processing. Papers Three and Four report single case studies which used a series of different tasks (including some novel tasks) to gain further insights about countability processing by examining mass specific breakdown in language impaired (aphasic) speakers.

The findings of this research regarding countability processing and their implications for countability representation are summarised and discussed in the following sections.

Paper One

Paper One discussed current theories of the representation of countability information at the lexical-syntactic and conceptual-semantic level with consideration of empirical findings from previous mass/count noun studies with language unimpaired and impaired speakers in language comprehension and production (Tip-of-the-Tongue studies, lexical decision studies, a semantic categorisation study, a grammatical judgement study, event related potential (ERP) studies, case studies of language impaired individuals).

Three theoretical accounts of countability representation were introduced and discussed which differed in their assumptions regarding lexical-syntactic and/or conceptual-semantic markedness for mass and count: The Count And Mass Marked hypothesis (based on Levelt, Roelofs & Meyer's (1999) representation for grammatical gender), the Count UnSpecified Mass Marked hypothesis (derived from Taler and Jarema (2006)), and the Mass UnSpecified Count Marked hypothesis (derived from Barner & Snedeker, 2005, 2006).

Most of the empirical evidence from Tip-of-the-Tongue (TOT) studies and single case studies with aphasic individuals supported the Count and Mass Marked hypothesis in which both mass and count nouns are lexical-syntactically specified for countability. TOT studies found that mass **and** count information is more often available when participants were in TOT state than when they were not in a TOT state. Single case studies with aphasic individuals found mass **and** count specific impairments which affected either processing of bare nouns and/or grammatical units (e.g., noun phrases, sentences) (e.g., Herbert & Best, 2010; Semenza, Mondini & Cappelletti, 1997). However, some lexical decision studies (Gillon, Kehayia & Taler, 1999; Mondini et al., 2009; Taler & Jarema, 2007) supported the Count Unspecified Mass Marked account with results showing longer processing times for mass than for count nouns. Taler and Jarema (2007) suggested that differences in their conceptual-semantic representation, rather than in their lexical-syntactic markedness could have led to the countability effect in the lexical decision studies. Further support for a semantic distinction between mass and count nouns was found in a semantic categorisation task (Bisiacchi, Mondini, Angrilli, Marinelli & Semenza, 2005) and ERP studies (Bisiacchi et al., 2005; Mondini, Angrilli, Bisiacchi, Spironelli, Marinelli & Semenza, 2008) which showed different processing times or patterns of early automatic (N150) activation between mass and count nouns. We proposed therefore that count nouns, which are often described as more concrete (Mondini et al, 2008) have a richer conceptual-semantic representation in the form of a larger number of conceptual-semantic features compared to mass nouns. The larger number of semantic features for count nouns makes semantic categorisation easier. Moreover, word recognition of count nouns in lexical decision is facilitated through increased feedback from semantic features to the word form (see Pexman, Lupker & Hino, 2002).

Paper Two

In Paper Two, two picture-word interference studies were used. The first study investigated whether countability is processed in a similar way to variable extrinsic lexical-syntactic features, such as number (e.g., [singular], [plural]), or to fixed intrinsic lexical-syntactic properties, such as grammatical gender (e.g., [masculine, [neuter]). The methodology was derived from earlier studies on grammatical gender and number (e.g., Schiller & Caramazza, 2002, 2003) which revealed gender congruency effects but no number congruency effects. The results of Experiment 1 revealed a countability congruency effect on noun phrase production, similar to previous gender congruency effects: there were longer naming latencies for countability incongruent compared to countability congruent target-distractor pairs. Moreover, no number congruency effect was found which replicated in English findings of previous studies on number in German, Dutch and French (Alario, Ayora, Costa & Melinger, 2008; Schiller & Caramazza, 2002, 2003).

Experiment 2 was a picture-word interference study similar to Experiment 1, but with determiners as distractors, rather than nouns. This experiment examined whether the countability congruency effect resulted from competition between either lexical-syntactic [mass] and [count] attributes (e.g., see Schriefers, 1993), or mass and count specific determiners (e.g., see Miozzo & Caramazza, 1999). The results showed a reversed countability congruency effect with longer naming latencies for countability congruent determiner distractors compared to countability incongruent determiner distractors. The reversed countability congruency effect conflicts with an account which proposes competition between lexical-syntactic [mass] and [count] attributes. However, the effect is consistent with a determiner competition account where lexical-syntactically more similar, thus countability congruent determiners compete more strongly with the target determiner than less similar, thus countability incongruent determiners (Alario et al., 2008).

Papers Three and Four

Papers Three and Four used a neuropsychological approach. The papers presented single case studies of three aphasic individuals RAP (Paper Three), DEH (Paper Four) and GEC (Paper Four) who each suffered from a mass specific impairment. In order to draw inferences about countability representation, the underlying causes of their mass specific breakdown was investigated through their different mass/count specific error patterns. A series of tasks was conducted to test countability processing at the different levels of the language system. Paper Three addressed the same questions as Paper Two on whether nouns are specified for mass/count at the lexical-syntactic level and whether the activation of this information is syntactically or semantically driven. The study was further concerned with the question of under what circumstances selection of lexical-syntactic countability information is required. The results of the countability specific tasks showed that RAP had difficulties in the production and comprehension of mass specific determiners in noun phrases while bare mass nouns remained relatively unaffected. RAP's determiner errors were substitutions of mass noun determiners by count noun determiners which led to grammatically incorrect noun phrases (e.g., *many butter, *a jelly). The same determiners were spared when they were used in count noun phrases. Moreover, it was found that visual and/or conceptual-semantic information influenced RAP's performance for mass noun determiners in picture naming and determiner judgement. RAP's selection of mass noun determiners improved when conceptual-semantic number information between mass noun depictions (e.g., MULTIPLE) and target determiners (e.g., some) was congruent compared to incongruent (target determiner 'this'). RAP was argued to suffer either from a specific impairment of the lexical-syntactic attribute

[mass] or alternatively from a general lexical-syntactic impairment (for further discussion see the section below: Mass specific versus general lexical-syntactic/conceptual-semantic impairment).

Paper Four was a replication of Paper Three which aimed to provide additional empirical evidence regarding the representation of countability through two further single case studies, DEH and GEC. DEH was found to have a lexical-syntactic impairment similar to RAP which predominantly affected the production of mass noun determiners but spared bare mass and count nouns and count noun determiners. DEH showed also the same influence of conceptual-semantic number information on the production of mass noun determiners that RAP had shown. DEH also produced number errors for mass and count nouns which is consistent with a lexical-syntactic impairment.

In contrast to RAP and DEH, GEC's mass noun determiner errors were relatively sparse and consisted predominantly of determiner omissions resulting in grammatically correct noun phrases. GEC's mass specific difficulties affected the production of bare mass nouns resulting in semantic paraphasias and no responses. His mass noun deficit was argued to be caused by either an impairment of mass specific concepts (e.g., UNINDIVIDUATED, UNCOUNTABLE) or a general impairment of the conceptual-semantic level and the link between conceptual-semantic and lexical-syntactic level (for further discussion see the section below: Mass specific versus general lexical-syntactic/conceptual-semantic impairment).

Evidence for a lexical-syntactic representation of countability

The main aim of this thesis was to investigate the representation of countability information at the lexical-syntactic level. What are the conclusions about countability representation which can be drawn from the results of the picture-word interference (Paper Two) and single case studies (Papers Three & Four)?

The countability congruency effect found in the first picture-word interference study with nouns as distractors strongly indicates that lexical-syntactic mass/count information has psychological reality. This congruency effect was similar to effects found for grammatical gender suggesting that countability is represented in the form of fixed intrinsic lexical-syntactic properties opposed to variable extrinsic lexical-syntactic features like number. The symmetrical patterns of the effect for mass and count noun targets imply that both are specified for countability, for example in the form of a [mass] property for mass nouns and a [count] property for count nouns. These properties are activated and allow for the selection of countability specific determiners to produce mass/count noun phrases. The precise representation of countability information will be discussed further in the next section under consideration of conceptual-semantic information. The reversed countability congruency effect found in the second picture-word interference study showed that it is not activation/selection of [mass] and [count] attributes but of their different determiners that is competitive in nature.

Further support for a lexical-syntactic representation of countability comes from the two single case studies with RAP and DEH: their lexical-syntactic impairment was mass specific and not constrained to specific determiner forms.

Moreover RAP and DEH's determiner substitution errors for mass nouns showed that countabiity information is essential for the selection of grammatically correct determiners. In comparison, the selection of lexical-syntactic mass/count information does not seem to be required for the selection of bare mass/count nouns as RAP and DEH's production of mass nouns remained relatively unaffected.

Evidence for a conceptual-semantic representation of countability

One of the major findings from the single case studies with RAP and DEH was the influence of the conceptual-semantic information SINGLE and MULTIPLE on the selection of mass noun determiners. Even though this information was not countability but number specific it facilitated the selection of determiners when the conceptual-semantic number information of the depicted noun (e.g., MULTIPLE) was congruent with the grammatical number information of the target determiner (e.g., some, enough). Hence, not only lexical-syntactic mass/count but also specific conceptual-semantic information can contribute to the selection of determiners for mass and count nouns. Since this effect was not found in language unimpaired control participants, we would propose that a lexical-syntactic impairment can lead to an increased influence of conceptual-semantic information on lexical-syntactic processing.

Such a conceptual-semantic influence could be taken as evidence against countability being purely lexical-syntactically derived. This is consistent with the idea that conceptual-semantic information can influence the activation of [mass] and [count] attributes directly. For example, in cases where speakers refer to mass nouns as count nouns (e.g., The supermarket sold so many different mascaras.) in order to emphasise count noun characteristics in a mass noun, or mass noun characteristics in a count noun (e.g., After the accident there was cat all over the road.). In these cases, mass syntax changes to count syntax so that mass nouns can be pluralised and combined with count noun determiners. Consequently, we suggested that countability is represented in the form of a hybrid attribute instead of a pure lexical-syntactic property. Such hybrid lexical-syntactic [mass] and [count] attributes would receive most of their activation from representations at the lexical-syntactic level (e.g., nouns and determiners), but can also receive some activation from the conceptual-semantic level. Further evidence for the existence of hybrid attributes comes from a German study with grammatical gender (Schiller, Münte, Horemans & Jansma, 2003), an attribute which was thought to be purely lexical-syntactically derived. The results showed that gender decisions were influenced by the biological sex of a noun referent.

But what kind of conceptual-semantic information other than MULTIPLE and SINGLE could influence activation/selection of determiners for mass and count nouns and/or [mass] and [count] attributes? Typical semantic characteristics which are countability specific are: unindividuated, undefinite, indivisable, non-distinct or uncountable for mass nouns and individuated/atomic, definite, divisable, distinct and countable for count nouns (Barner & Snedeker, 2005, 2006; Bloom, 1999; Gordon, 1985; Macnamara, 1986; Quine, 1960; Wisniewski, Imai & Casey, 1996). Hence any or all of these semantic characteristics could be represented as concepts at the conceptual-semantic level and contribute to the selection of determiners and [mass]/[count] attributes at the lexical-syntactic level.

Evidence for a conceptual-semantic representation of countability was found in the single case study with GEC (Paper Four). GEC's conceptual-semantic impairment affected the production of mass nouns, but relatively spared their related syntax. GEC's mass noun deficit supports an account in which nouns are specified by mass/count specific concepts whose activation is essential for the selection of mass/count noun representations at the lexical-syntactic level. Assumptions about conceptual-semantic representations for countability will be further discussed in the section below: Dual Nouns.

Mass specific versus general lexical-syntactic/conceptual-semantic impairment

What is the most plausible account for RAP, DEH and GEC's mass specific impairment? The mass specific difficulties of all three individuals could be accounted for either by an impairment of a mass specific component at the lexical-syntactic or conceptual-semantic level or alternatively by a more general lexical-syntactic or conceptual-semantic impairment.

For RAP and DEH, the mass specific account was an impairment of the lexical-syntactic attribute [mass] or its links at the lexical-syntactic level. The global account was a general lexical-syntactic impairment which would lead to the same mass specific difficulties because mass noun depictions (e.g., a single mass noun) do not always match the grammatical number of their determiners (e.g., some (plural)) while count nouns always do. A number mismatch could hinder the selection of grammatically correct determiners for mass nouns when the lexical-syntactic level is impaired as the influence of conceptual-semantic information on determiner selection would increase.

GEC's mass noun deficit could also be explained by either a mass specific impairment of one or several mass concepts (e.g., UNINDIVIDUATED, UNCOUNTABLE) or by a general impairment of the conceptual-semantic level and the links between conceptual-semantic and lexical-syntactic level. Mass nouns could be more vulnerable to the effects of a general conceptual-semantic impairment as they are less frequent. The frequency of mass/count concepts could be expressed by different weightings of the links to their lexical-syntactic representations. A conceptual-semantic impairment could lead to a decrease in activation between concepts and noun lemmas which would affect mass nouns more than count nouns.

Both the mass specific and the general account can explain the data equally well. However, we suggest that the general impairment account is more plausible since lesions would seem unlikely to be restricted to only one part of a processing system, such as, the lexical-syntactic [mass] attribute or a mass specific concept (e.g., UNINDIVIDUATED). Moreover, seven aphasic individuals were screened for this research and three showed a mass noun/determiner related impairment. This high prevalence rate makes a very specific impairment seem even more unlikely. A general lexical-syntactic impairment was further supported by DEH's additional difficulties with number marking for mass and count nouns. In case of GEC, a general impairment was supported by the proportion of mass/count noun substitutes (intruders) which correlated with the normal distribution of mass and count nouns in English (Baayen, Piepenbrock & Guliker, 1995).

Implications for Theories of Language Production (Levelt et al., 1999 & Caramazza, 1997; Caramazza & Miozzo, 1997, 1998)

How can the two theories of language production by Levelt et al. (1999) and Caramazza (1997) account for the findings regarding countability processing and representation? Which aspects of the theories need revision in order to fit the data in this thesis? As neither theory explicitly mentions countability, we need to derive predictions about its representation from other lexical-syntactic attributes. Within both theories countability could be either represented as fixed intrinsic lexical-syntactic properties or as variable extrinsic features [mass] and [count]. In Levelt et al.'s theory lexical-syntactic properties receive activation exclusively via noun lemma nodes while lexical-syntactic features are activated by conceptual-semantic representations (e.g., the number feature [singular] is activated by the concept SINGLE). Levelt et al.'s theory would have to be modified to account for hybrid attributes which receive activation from lexical-syntactic **and** conceptual-semantic representations by connecting [mass] and [count] attributes. It seems plausible that there may be stronger links to the lexical-syntactic attributes from noun lemmas and comparatively weaker links from mass/count specific concepts. In the Independent Network theory, the lexical-syntactic level does not mediate between the conceptual-semantic and word form level, hence lexical-syntactic properties are activated by their word forms instead of noun lemmas. Lexical-syntactic features can receive semantic activation but their selection still relies on the activation from their word forms. As lexical-syntactic features are already hybrid attributes in the Independent Network theory, countability could be represented in a similar form. However, conceptual-semantic information would have to be granted more influence on the selection process of lexical-syntactic features in order to account for the influence of conceptual-semantic number on determiner selection as it was the case for RAP and DEH.

Levelt et al.’s theory needs further amendments to account for the influence of countability specific, conceptual-semantic information on bare noun production and processing which was found for GEC (Paper Four), MH (Herbert & Best 2010) and in several lexical decision, semantic categorisation and ERP studies (see Paper One: Bisiacchi et al., 2005; Gillon et al., 1999; Mondini et al., 2008; Mondini et al., 2009; Taler & Jarema, 2007). Levelt et al. hypothesise that word meanings are represented nondecompositionally with a few exceptions for semantic number in the form of SINGLE and MULTIPLE features. Hence the range of semantic features in Levelt et al.’s theory would need to be widened by including mass and count specific features/concepts (e.g., UNINDIVIDUATED, UNCOUNTABLE versus INDIVIDUATED, COUNTABLE) and possibly others which represent the specific meaning of determiners (e.g., INDEFINITE versus DEFINITE for determiners like ‘a’ and ‘the’, LARGE QUANTITY versus SMALL QUANTITY for ‘much’, ‘many’ versus ‘few’, ‘little’) (Nickels, Biedermann, Fieder & Schiller, submitted). Links from the conceptual-semantic to the lexical-syntactic level would have to be weighted differently based on the frequency of concepts with stronger links for count compared to mass concepts. Moreover, as lexical decision is thought to be carried out at the level of the input word form, and this task can be influenced by semantic features/concepts, there must be feedback from the conceptual-semantic level to the (input) word form level.

Unlike in Levelt et al.’s theory, word meanings are represented decompositionally in the form of semantic features In the Independent Network theory. However, similar assumptions about mass and count specific concepts and their weighted links need to be implemented to account for conceptual-semantic mass noun effects. In comparison to Level et al.'s theory, feedback would only be required from the conceptual-semantic to the input word form level to explain semantic effects in lexical decision.

How can both theories account for the different (determiner) countability congruency effects (Paper Two)? Within Levelt et al.'s theory, determiner competition can only occur at the lexical-syntactic level since (a) this is the location of lexical-syntactic attributes and (b) processing between levels is strictly serial leading to the activation of only one determiner at the word form level. In the Independent Network theory, determiner competition would take place at the word form level since (a) lemma node representations for nouns and determiners do not exist and (b) activation cascades between different levels. Hence in the Independent Network theory activation would cascade from noun word forms to their lexical-syntactic attributes and back to congruent determiner word forms.

In **both** theories, longer naming latencies for countability incongruent target-distractor noun pairs (Experiment 1) can be explained by stronger competition due to more similar levels of activation between target and distractor determiners. In the countability incongruent condition, both target and distractor determiners received activation only once, target determiners by target nouns and distractor determiners by distractor nouns. In the congruent condition, target determiners received activation twice, once from target nouns and once from distractor nouns due to their shared mass/count attributes. Hence in the congruent condition, target determiners were more highly activated than distractor determiners which resulted in less competition for the target determiner. The reversed countability congruency effect (Experiment 2) with longer naming latencies for countability congruent determiners can be explained by stronger competition between mass/count congruent determiners. Countability congruent distractor determiners received additional activation from target nouns via their shared mass/count attributes. Hence congruent distractor determiners were more highly activated and could compete more strongly with target noun determiners than in the countability incongruent condition. The Independent Network theory can also account for longer naming latencies for countability incongruent target-distractor noun pairs by inhibition between lexical-syntactic attributes of the same subnetwork ([mass] versus [count]). Countability incongruent target and distractor nouns would activate different lexical-syntactic [mass]/[count] attributes leading to inhibition between them. Inhibition could decrease the levels of activation which is sent to determiner forms and therefore slow down determiner selection. However, this assumption cannot account for the reversed countability congruency effect (Experiment 2) where countability incongruent target-distractor pairs were processed faster than countability congruent target-distractor pairs.

Turning from countability to number, how can the absence of a number congruency effect be explained in each theory? The results of Paper 2 Experiment 1 showed that naming latencies for plural count noun targets with number congruent (plural count noun) and number incongruent (singular count noun) distractors were the same. We discussed two possible accounts for the absent number congruency effect within Levelt et al.'s theory. Firstly, target pictures could activate number concepts and subsequently their lexical-syntactic number features more rapidly than distractor words (Chapnik Smith & Magee, 1980; Glaser & Glaser, 1989). Secondly, written distractor words could bypass the semantic-conceptual level and instead send activation directly via their noun lemma nodes to their lexical-syntactic attributes. As number features must be set by conceptual-semantic activation, lexical-syntactic activation from distractor noun lemmas would have been insufficient for competition with the target's number feature/determiner.

Accounting for the absence of a number congruency effect is much less straightforward within the Independent Network theory. Earlier findings of an absent number congruency effect in bare nouns (Schiller & Caramazza, 2002) were explained by the target noun being produced without the need for selection of lexical-syntactic features: word forms are accessed purely on the basis of activation from the conceptual-semantic level (e.g., the plural suffix –s would be activated by the number concept MULTIPLE). However, the same explanation cannot be used for the production of target noun phrases as the selection of determiners requires activation of their lexical-syntactic attributes (e.g., number and countability).

We find it impossible to account for the absence of a number effect within the Independent Network theory as written distractor nouns (and determiners) would be processed as fast or possibly even faster than target noun depictions (and determiners): Distractor nouns can access their lexical-syntactic number feature directly from the (orthographic) input word form level and subsequently send activation to the appropriate determiner at the phonological (output) word form level. Additionally, distractor nouns could access their conceptual-semantic representation(s) via the (orthographic) input word form level and subsequently send activation to the number feature at the lexical-syntactic level and the determiner at the word form level. Processing of target noun pictures will take as long or even longer than distractor nouns, since the target noun's lexical-syntax and the word form of its determiner are selected only after the target noun's word form has been accessed. In the scenario where number incongruent target and distractor nouns are processed equally fast, number features/determiner word forms would compete with each other resulting in a number congruency effect.

Overall, both theories can account for the different mass specific effects which were found in determiner judgement and/or picture naming for language impaired individuals (see section above: Mass specific versus general lexical-syntactic impairment) and in lexical decision for language unimpaired individuals, if some modifications are taken into consideration. In order to explain mass specific effects the concept frequency account was proposed as an alternative theory to the ‘number of features’ account (Paper One). The ‘number of features’ account seems to be less plausible as at least some count nouns like abstract count nouns (e.g., idea, thought) or count noun aggregates (e.g., lentils, beans) would have to have a similar number of semantic features to mass nouns (e.g., rice, irony) and vice versa. Finally, only Levelt et al.’s theory can account fully for the different (determiner) countability congruency effects and the absent number effect (Paper Two).

Dual Nouns

Our data only allows us to draw conclusions for nouns which are clearly mass or count. However, there are nouns which are frequently used as both mass and count nouns, so called dual nouns. How might these nouns be represented? Straight forward dual nouns such as ‘chicken’ and ‘lamb’ do not only behave syntactically differently but have also a different meaning depending on whether they are mass or count nouns (mass meaning: meat; count meaning: the animal).

Hence, it is plausible that they are represented in a similar way to homophones (or polysemes) with one word form but two lemma nodes at the lexical-syntactic (lemma) level. Each of the two lemma nodes is connected to different lexical-syntactic attributes (e.g., mass or count). Depending on the speaker's intention, one of the two lexical-concepts of a dual noun would be selected and send activation to either the mass or count specific lemma node (see for homophone representation: Biedermann and Nickels, 2008 a,b ; Caramazza, Costa, Miozzo & Bi, 2001; Jescheniak and Levelt, 1994; Miozzo & Caramazza, 2005).

It is also the case that nouns which are almost exclusively used as either mass or count, can nevertheless be flexibly used as mass or count nouns depending on the conceptual/perceptual characteristics to which a speaker intends to refer (Allan, 1980; Wisniewski et al., 2003). As discussed earlier this supports a conceptual-semantic difference in the speakers' understanding of the characteristics a prototype mass or count noun should possess. It is therefore likely that mass and count nouns are not only syntactically but also semantically specified for countability. The semantic specification can be assumed to be more flexibly used by speakers, whereas the lexical-syntactic specification of these nouns remains categorical. Hence, in the case when a speaker wants to emphasize certain mass like characteristics in a count noun, relevant features (e.g., INDIVIDUATED, COUNTABLE) could become activated at the conceptual-semantic level, resulting in an overriding of the standard syntactic specification and the use of a count noun in a mass noun context with mass noun determiners. Eberhard, Bock and Cutting (2005) discuss a parallel issue with respect to grammatical gender. Nouns, such as 'Huhn' (hen) are conceptual-semantically marked regarding their natural gender (feminine), however this specification can be overridden by the grammatical gender of the word ‘Huhn’, which in German is neuter (das Huhn).

Frisson and Frazier (2005) propose a similar theory where, by default, nouns are lexical-syntactically specified for being either mass or count. These default or underived forms are also conceptual-semantically specified with mass nouns denoting a substance and count nouns representing an individuated entity. However, the mass/count status of a word can be changed through the application of lexical rules which results in derived forms. Mass nouns can be turned into count nouns through a proportioning rule (e.g. some beer vs. three beers), and count nouns into mass nouns through a grinding rule (e.g. three pears vs. a small amount of pear). While these accounts provide potential explanations for flexible use of mass and count nouns, they remain hypothetical as our experiment addressed mass and count nouns in their most frequent usage.

Limitations and Future Directions

The single case studies presented in this thesis give evidence for an influence of countability and/or number specific conceptual-semantic information on determiner and bare noun selection at the lexical-syntactic level. However, it remains unclear in how far conceptual-semantic information exerts a direct influence on the activation/selection of lexical-syntactic mass/count attributes. We argued for a hybrid representation of lexical-syntactic [mass]/[count] attributes from speaker’s behaviour of using mass nouns as count nouns and vice versa, and the influence of number concepts on noun phrase production. However, none of our experimental evidence directly supports this assertion rather than an effect on determiner selection. Moreover, our data showed only a conceptual-semantic influence of number/countability information on noun and noun phrase production for language impaired, but not unimpaired individuals. We argued that some of the conceptual-semantic effects which were seen for RAP, DEH and GEC could have been obscured by the ceiling effects for language unimpaired participants (Best, Schröder & Herbert, 2006). Hence it would have been beneficial to collect latency data for the same tasks with language unimpaired participants to have a more sensitive measure of possible effects. Another, unavoidable, limitation of our studies was the depictions of mass nouns as objects with clear boundaries and therefore more count like. As discussed in Paper Four, this could have caused GEC's naming difficulties for mass nouns. Depicting mass nouns as entities could have decreased the activation sent from the visual representation to mass specific concepts (e.g., UNINDIVIDUATED) and eventually to mass noun lemmas and therefore hinder the selection of mass noun lemmas. Nonetheless, depicting mass nouns as substances and aggregates would reduce the name agreement of the stimuli and often have made them indistinguishable from other substances (e.g., the pure substance mascara would have looked like ink, tar or black coffee).

The process of undertaking this research has made it clear that there are several methodological factors which are important for future researchers to consider. First, we recommend countability ratings are undertaken to ensure the mass/count status of the items and therefore to prevent inclusion of dual nouns. Additionally studies which investigate countability should include both singular and plural count nouns in order to be able to draw clear conclusions about countability, such as to distinguish mass/count specific language impairments from determiner specific language impairments. In picture based tasks (e.g., picture naming, determiner judgement), conceptual-semantic number/countability effects of mass and count noun depictions should be considered and if possible controlled and/or manipulated for. Finally, a not inconsiderable number of nouns seem to be used both as mass and count nouns hence research on dual nouns would be beneficial to make more explicit assumptions about their representation.

Final Comments

The research on mass and count nouns presented in this thesis led to different countability effects across experiments from which we could draw conclusions about its representation and processing at the lexical-syntactic and conceptual-semantic level. The extended and partially amended version of Levelt et al.'s (1999) theory and the Independent Network theory (Caramazza, 1997; Caramazza & Miozzo, 1997, 1998) could mostly account for these effects. The research contributes to previous findings, assumptions and discussions about the representation of mass/count information and the conclusions can even be partially applied to the representation of other lexical-syntactic attributes, such as number and grammatical gender. The different countability effects also allowed creation of guidelines for future research on mass, count and, hopefully, dual nouns.

References

Allan, K. (1980). Nouns and Countability. *Language*, *56*, 541-547.

Alario, F.-X., Ayora, P., Costa, A. & Melinger, A. (2008). Grammatical and Nongrammatical Contributions to Closed-Class Word Selection. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(4), 960-981.

Baayen, R. H., Piepenbrock, R. & Gulikers, L. (1995). *The CELEX lexical database (CD-ROM).* Philadelphia, PA: Linguistic Data Consortium. University of Pensylvania.

Barner, D. & Snedeker, J. (2005). Quantity judgements and individuation: evidence that mass nouns count. *Cognition*, 97, 41-66.

Barner, D. & Snedeker, J. (2006). Children's Early Understanding of Mass-Count Syntax: Individuation, Lexical Content, and the Number Asymmetry Hypothesis. *Language Learning And Development*, 2(3), 163-194.

Best, W., Schröder, A. & Herbert, R. (2006). An investigation of a relative impairment in naming non-living items: theoretical and methodological implications. *Journal of Neurolinguistics*, 19, 96-123.

Biedermann, B. & Nickels, L. (2008).The representation of homophones: More evidence from the remediation of anomia. *Cortex*, 44, 276-293.

Biedermann, B. & Nickels, L. (2008). Homographic and heterographic homophones in speech production: Does orthography matter? *Cortex*,44, 683-697.

Bisiacchi, P., Mondini, S., Angrilli, A., Marinelli, K. & Semenza, C. (2005). Mass and count nouns show distinct EEG cortical processes during an explicit semantic task. *Brain and Language*, 95, 98-99.

Bloom, P. (1999). The role of semantics in solving the bootstrapping problem. In R. Jackendoff, P. Bloom, & K. Wynn (Eds.). *Language, logic, and concepts: Essays in memory of John Macnamara*. Cambridge, MA: MIT Press.

Caramazza, A. (1997). How many levels of processing are there in lexical access?. *Cognitive neuropsychology*, *14*(1), 177-208.

Caramazza, A., Costa, A., Miozzo, M. & Bi, Y. (2001). The specific-word frequency effect: Implications for the representation of homophones in speech production. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 27(6), 1430-1450.

Caramazza, A. & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the 'tip-of-the tongue' phenomenon. *Cognition*, 64, 309-364.

Caramazza, A. & Miozzo, M. (1998). More is not always better: a response to Roelofs, Meyer, & Levelt. Cognition, 69, 231-241.

Chapnik Smith, M. & Magee, L.E. (1980). Tracing the Time Course of Picture-Word Processing. *Journal of Experimental Psychology: General*, 109(4), 373-392.

Cheng, C. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Eberhard, K.M., Cutting, J.C. & Bock, K. (2005). Making Syntax of Sense: Number Agreement in Sentence Production. *Psychological Review*, 112(3), 531-559.

Frisson, S. & Frazier, L. (2005). Carving up word meaning: Portioning and grinding. *Journal of Memory and Language*, 53, 277-291.

Garrard, P., Carroll, E., Vinson, D. & Vigliocco, G. (2004). Dissociation of Lexical Syntax and Semantics: Evidence from Focal Cortical Degeneration. *Neurocase,*10(5), 353-362.

Gillon, B.S., Kehayia, E. & Taler, V. (1999). The mass/count distinction: Evidence from online psycholinguistic performance. *Brain and Language*, *68*, 205-211.

Glaser, W.R. & Glaser, M.O. (1989). Context Effects in Stroop-Like Word and Picture Processing. *Journal of Experimental Psychology: General*, 118(1), 13-42.

Gordon, P. (1985). Evaluating the semantic categories hypothesis: The case of the mass/count distinction. *Cognition*, 20, 209–242.

Grandy, R.G. (1973). Comments on Moravcsik's paper. In Hintikka et al. (Eds.), Approaches to natural language (pp. 286-288). Dordrecht: Reidel.

Herbert, R. & Best, W. (2010). The role of noun syntax in spoken word production: Evidence from aphasia. *Cortex*, 46(3), 329-342.

Jescheniak, J.D. & Levelt, W.J.M. (1994). Word Frequency Effects in Speech Production: Retrieval of Syntactic Information and of Phonological Form.

Journal of Experimental Psychology: Learning, Memory, and Cognition, *20*(4), 824-843.

Levelt, W. J. M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences,* 22, 1-75.

Macnamara, J. (1986). *A border dispute: The place of logic in psychology*. Cambridge, MA: MIT Press.

Middleton, E.L. (2008). Mass Matters. *Dissertation Abstracts International*, 70(02), (UMI No. 3347451).

Middleton, E.L., Wisniewski, E.J., Trindel, K.A. & Imai, M. (2004). Separating the chaff from the oats: Evidence for a conceptual distinction between count noun and mass noun aggregates. *Journal of Memory and Language*, *50*, 371-394.

Miozzo, M. & Caramazza, A. (1999). The Selection of Determiners in Noun Phrase Production. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 25(4), 907-922.

Miozzo, M. & Caramazza, A. (2005). The representation of homophones: Evidence from the distractor frequency effect. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 31(6), 1360-1371.

Mondini, S., Angrilli, A., Bisiacchi, P., Spironelli, C., Marinelli, K. & Semenza, C. (2008). Mass and Count nouns activate different brain regions: An ERP study on early components. *Neuroscience Letters* 430, 48-53.

Mondini, S., Kehayia, E., Gillon, B., Arcara, G. & Jarema, G. (2009). Lexical access of mass and count nouns. How word recognition reaction times correlate with lexical and morpho-syntactic processing. *Mental Lexicon*, 4(3), 354-379.

Nickels, L., Biedermann, B., Fieder, N. & Schiller, N.O. (submitted) The Lexical syntactic representation of number. *Language and Cognitive Processes*.

Pexman, P.M., Lupker, S.J. & Hino, Y. (2002). The impact of feedback semantics in visual word recognition: Number-of-features effects in lexical decision and naming tasks. *Psychonomic Bulletin & Review*, ((3), 542-549.

Quine, W. V. O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Schiller, N. O. & Caramazza, A. (2002). The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German. *Brain and Language,* 81, 342-357.

Schiller, N. O. & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. *Journal of Memory and Language,* 48, 169-194.

Schiller, N. O., Münte, T. F., Horemans, I. & Jansma, B. M. (2003). The influence of semantic and phonological factors on syntactic decisions: An event-related brain potential study. *Psychophysiology*, 40, 869-877.

Schriefers, H. (1993). Syntactic Processes in the Production of Noun Phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19(4), 841-850.

Semenza, C., Mondini, S. & Cappelletti, M. (1997). The grammatical properties of mass nouns: An aphasia case study. *Neuropsychologia, 35*(5), 669-675.

Semenza, C., Mondini, S. & Marinelli, K. (2000). Count and Mass Nouns: Semantics and Syntax in Aphasia and Alzheimer`s disease. *Brain and Language, 74*, 395-431.

Shapiro, L.P., Zurif, E., Carey, S. & Grossman, M. (1989). Comprehension of lexical subcategory distinctions by aphasic patients: proper/common and mass/count nouns. *Journal of Speech and Hearing Research*, *32*, 481-488.

Taler, V. & Jarema, G. (2006). On-Line lexical processing in AD and MCI: An early measure of cognitive impairment? *Journal of Neurolinguistics, 19*, 38-55.

Taler, V. & Jarema, G. (2007). Lexical access in younger and older adults: The case of the mass/count distinction. *Canadian Journal of Experimental Psychology*, *61*, 21-34.

Vigliocco, G., Vinson, D.P., Martin, R.C. & Garrett, M.F. (1999). Is “Count” and “Mass” Information Available When the Noun Is Not? An Investigation of Tip of the Tongue States and Anomia. *Journal of Memory and Language,* 40, 534-558.

Wierzbicka, A. (1988). *The semantics of grammar*. Amsterdam: John Benjamins.

Wisniewski, E. J., Imai, M. & Casey, L. (1996). On the equivalence of superordinate concepts. *Cognition*, 60, 269–298.

Wisniewski, E.J., Lamb, C.A. & Middleton, E.L. (2003). On the conceptual basis for the count and mass noun distinction. *Language and cognitive processes*, 18(5/6), 583-624.