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The interpretation of the mass-count distinction across languages and populations: Introduction

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In this special collection we bring together experimental studies on the semantic and cognitive correlates of the syntactic mass-count distinction in different (learner) populations and typologically diverse languages. Although the theoretical distinction between mass and count has been investigated extensively in many different adult languages, experimental research on how this distinction is interpreted by different types of learners and speakers is far rarer. The aim of the current special collection is thus to provide a unique set of highly controlled cross-linguistic and cross-population data that helps us further examine various theories of the syntactic mass-count distinction and the interactions between language, cognition and the world.

1 Two types of distinctions and the non-isomorphic mapping

In this special collection we bring together experimental studies on the semantic and cognitive correlates of the syntactic mass-count distinction in different (learner) populations and typologically diverse languages. Although the theoretical distinction between mass and count has been investigated extensively in many different adult languages, experimental research on how this distinction is interpreted by different types of learners and speakers is far rarer. The aim of the current special collection is thus to provide a unique set of highly controlled cross-linguistic and cross-population data that helps us further examine various theories of the syntactic mass-count distinction and the interactions between language, cognition and the world.

But what exactly do we mean when we talk about the syntactic mass-count distinction? Let us start with ontology. In the world surrounding us, entities are categorized according to their *countability*. *Countable* entities such as BALL refer to individual objects with clear boundaries, whereas *uncountable* entities such as DOUGH refer to substance, which do not seem to have clear boundaries (Quine 1960; Jackendoff 1993). This ontological, cognitive distinction between countable and uncountable entities is not only relevant to our conceptualisation of the world but is also expressed in the language we speak, roughly, as count nouns versus mass nouns. In particular, it is realized in the syntax. However, the syntactic distinction between mass and count nouns is expressed differently in different languages. For example, in Dutch or English, count nouns (*bal* – 'ball'), but crucially not mass nouns (*deeg* – 'dough'), can be accompanied by an indefinite article (*een bal* – 'a ball', **een deeg* – '*a dough'), a plural marker (*ballen* – 'balls', **degen* – '*doughs'), and can be directly modified by numerals (*twee ballen* – 'two balls', **twee degen* – '*two doughs'). In contrast, languages such as Mandarin Chinese have no articles; and plural morphology is

only possible with human-denoting nouns (Li & Thompson 1981). This is why some scholars argue that Mandarin Chinese does not show a syntactic mass-count distinction (Allan 1980; Chierchia 1994; 1998a; Krifka 1995; see also Grimm 2012 for a recent discussion). Nevertheless, according to Cheng & Sybesma (1998; 1999; 2012), Doetjes (1997; 2012), and Cheng (2012), the ontological, cognitive distinction between countable and uncountable entities is visible in Mandarin Chinese at the level of numeral classifiers. This means that Mandarin distinguishes mass and count nouns by using different types of numeral classifiers, although they are not always obligatory (Cheng 2012).

Interestingly, when we try to map the ontological distinction between individual- and substance-referring entities to syntactic count and mass nouns, respectively, this mapping is not entirely transparent, or one-to-one. For example, a noun such as *furniture* is syntactically mass (**a furniture*; **three furnitures*; *a piece of furniture*), but refers to a collection of individual, countable entities. Furthermore, it is possible to use countable entities in mass syntax (*You get a lot of table for your money at IKEA.*), or use uncountable entities in count syntax (*territorial waters*). This non-isomorphic mapping between syntax and cognition raises the fascinating question as to how language learners acquire the different types of distinctions and their mappings.

The experimental studies in this special collection take the syntactic mass-count distinction as a starting point, and investigate both children's and adult's cognitive correlates of this syntactic mass-count distinction by using Barner & Snedeker's (2005) Quantity Judgment Task. As such, the data these studies yield easily and directly allow comparisons across languages and populations, providing novel and important insights into different linguistic theories of the mass-count distinction, as well as into the (development of the) language-cognition interface. The special collection includes studies reporting the interpretation of the mass-count distinction in a number of typologically diverse languages, namely, Dutch (van Witteloostuijn & Schaeffer), Korean (MacDonald & Carroll), Mandarin Chinese (Lin & Schaeffer), and Yudja (Lima), in which different learner populations are investigated, varying from monolinguals (Lima; Lin & Schaeffer; van Witteloostuijn & Schaeffer), bilinguals (Lima; Yin & O'Brien), and adult second language learners (MacDonald & Carroll), to children with Specific Language Impairment (van Witteloostuijn & Schaeffer). The special collection is concluded by a discussion of a broad, in-depth, discussion of the cross-linguistic empirical study of the mass-count distinction; the progress made over the years as well as the challenges it faces by Alan Bale & David Barner, and a study by Jeffrey Lidz and colleagues, who employ novel experiments to go beyond Barner & Snedeker's paradigm and explore the interface between count and mass nouns on the one hand, and non-linguistic cognitive systems on the other.

2 The Original Quantity Judgment task: Barner and Snedeker (2005)

As noted above, the current special collection is rooted in the seminal study of Barner & Snedeker (2005), who developed a Quantity Judgment Task using various types of count and mass nouns to test English-acquiring children's knowledge of the syntactic mass-count distinction and its mapping to semantics.

Barner & Snedeker (2005) conducted three experiments using the Quantity Judgment Task. Their first experiment tested the interpretation of object-mass nouns such as *furniture*, count nouns such as *shoes*, and substance-mass nouns such as *toothpaste*. The question they investigated by means of this experiment was whether children and adults treat object-mass nouns as count nouns and thus quantify over individuals, or whether interpretations of such nouns pattern instead with substance-mass nouns and hence, quantity judgments are determined by overall volume.

Adult participants were presented with pictures of two characters having the same object X of either different numbers of individual items or different overall volume. The pictures were accompanied by the critical question *Who has more X(s)?*, which was provided by the experimenter. Child participants received the same stimuli, but in the form of the actual scenes as the ones depicted in the pictures. Crucially, one character was presented as having more individual items, i.e., more in terms of number, while the other character had more in terms of overall volume, i.e., a higher amount of substance. For example, in the experimental item that tested the count noun *shoes*, one character had three small shoes whereas the other character was shown to have one large shoe, as illustrated in the middle picture in Figure 1. Importantly, the one large object comprised more in terms of overall material and surface area than the sum of the three small items of the same kind. Figure 1 presents examples of the tested items in Barner & Snedeker's first experiment.

A total of 16 monolingual English-speaking children aged 4;1–4;6 (mean 4;3) and 16 adult speakers of English participated in the first experiment. The results show that the adult participants relied almost exclusively on number-based judgments when presented with count nouns such as *shoes* and object-mass nouns such as *silverware* (100% and 97%, respectively). When presented with substance-mass nouns such as *toothpaste*, however, they only gave volume-based judgments (no number-based judgments were attested). The child participants showed adultlike interpretational patterns in all three conditions: in the count, object-mass, and classical substance-mass conditions, child judgments were number-based 89%, 95%, and 9% of the time, respectively. These results clearly indicate that both the English-speaking children and the adults treated object-mass nouns as count nouns in terms of quantification over individuals. As argued by Barner & Snedeker, this provides evidence for the linguistic non-specification view of mass and count nouns (Gillon 1996), according to which whether mass nouns (either substance-mass or object-mass) denote individuals is not part of their lexical semantics; instead, it is specified by world knowledge. Similarly, Barner & Snedeker further argue that their results provide support for Chierchia's (1998a) Inherent Plurality Hypothesis, which maintains that *all* nouns refer to sets of individuals.

Nevertheless, Barner & Snedeker themselves formulated two major possible objections to their first experiment. First, the participants could have interpreted an object-mass noun such as *silverware* (see first picture in Figure 1) as *knives*, a count noun representing individual objects, rendering pseudo-number-based judgements. Barner & Snedeker therefore carried out a second experiment, in which they revised the test by presenting the participants with multiple kinds (e.g., *knives* and *forks*) of the corresponding object-mass noun, namely *silverware*. Accordingly, all count and substance-mass nouns were manipulated as having multiple individual items, as shown in Figure 2.

(Who has more silverware?) *(Who has more shoes?)* *(Who has more toothpaste?)*
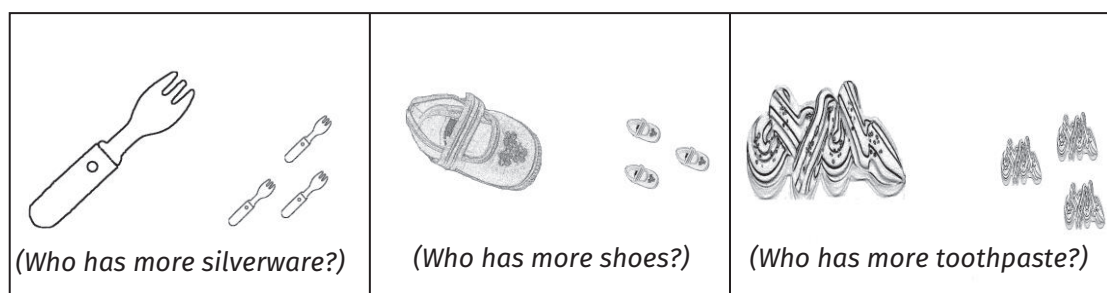
Figure 1: Illustration of experimental items in Experiment 1 (Barner & Snedeker 2005: Figure 1).

Figure 2: Illustration of experimental items in Experiment 2 (Barner & Snedeker 2005: Figure 3).
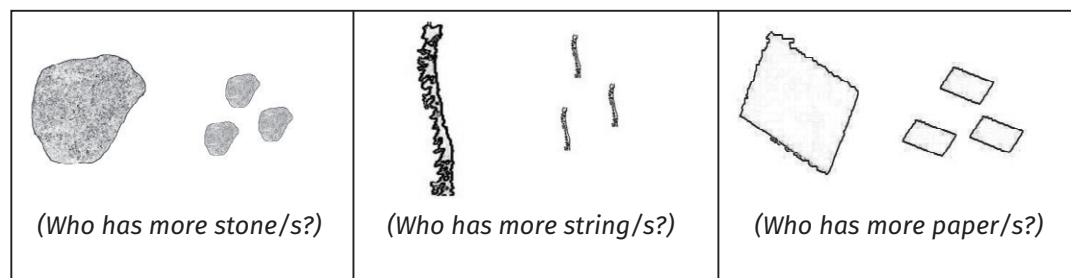
Figure 3: Illustration of experimental items in Experiment 3 (Barner & Snedeker 2005: Figure 4).

A group of 12 monolingual English-speaking children aged 4;0–4;6 (mean 4;3) and 16 monolingual adults were tested. The data revealed that with count nouns such as *shoes* and object-mass nouns such as *furniture*, adults almost always based their judgments on number (93.8% and 97.9% respectively). Conversely, number-based judgments were not attested with substance-mass nouns such as *toothpaste*. Child results revealed adultlike behavior with the classical count and object-mass items, with number-based judgments at 97.9% and 91.7%, respectively. With substance-mass nouns, the children gave number-based judgment 39.6% of the time. Barner & Snedeker interpreted these results as a confirmation of the conclusion of their first experiment: Both children and adults interpret object-mass nouns as quantifying over individuals, supporting Gillon and Chierchia, and providing evidence against Quine.

Another potential objection to Barner & Snedeker's first experiment concerns the linguistic environments in which the quantity judgment question was posed. It may have been the case that the participants – both children and adults – ignored the linguistic environments of the test questions and followed a quantity judgment *strategy* by always counting individuals, regardless of the noun types. In order to test this possibility, Barner & Snedeker developed their third experiment, in which they focused on so-called flexible nouns such as *string(s)* and *stone(s)*, which appear in both count and mass syntax in English, but with different interpretations. As in the first two experiments, two characters were presented as having certain quantities of the relevant object, as illustrated in Figure 3. The experimental items were manipulated in terms of their mass or count syntax between participants such that each participant was presented with either all the tested nouns in count syntax (i.e., with plural morphology), or in mass syntax (i.e., without plural morphology).

Participants were 12 monolingual English children aged 4;0–4;5 (mean 4;2) and 16 monolingual English adults. The results showed that the adults almost always based their judgments on number when the flexible nouns appeared in count syntax (97%) but hardly ever did so when the nouns were presented in mass syntax (3%). The distinction was

also apparent in the child data, with number-based judgments at 95% for flexible nouns appearing in count syntax and 25% for flexible nouns appearing in mass syntax. These results led the authors to conclude that not only adults but also children employ syntactic information in making their quantity judgments. They provide evidence for the hypothesis that individual-item-based and volume-based interpretations are (at least partially) driven by syntax (see also Borer 2004).

Overall, Barner & Snedeker's (2005) study shows that both English-speaking adults and English-acquiring four-year-olds are aware of the syntactic mass-count distinction and its mapping to semantics. Various psycholinguists subsequently employed Barner & Snedeker's experimental paradigm to test knowledge of the mass-count distinction in various learner populations acquiring diverse languages, to examine different theoretical approaches to the syntactic mass-count distinction and its mapping to semantics. It is this experimental paradigm that connects all studies in the current special collection and provides us with a unique set of highly controlled cross-linguistic and cross-population data.

3 The current special collection

Before we introduce each contribution, it is perhaps necessary to provide a brief overview of the terminology used in the various papers so as to avoid confusion. First, different terms are used to distinguish between what we can generally consider countable versus uncountable interpretations. These include "cardinal", "number-based", "bounded" and "numerical", as opposed to "non-cardinal", "volume-based", "unbounded" and "non-numerical", respectively. Each contribution also employs slightly different terms to refer to the various ontological noun types. Specifically, mass nouns may also be referred to as either "classical mass nouns" or "substance-mass nouns"; object-mass nouns are also referred to as "collective nouns" or "fake-mass nouns" (following Chierchia 2010).

Turning now to the particular papers in this special collection, in the first study, Suzi Lima discusses the interpretation of object- and substance-denoting nouns in a language that does not syntactically distinguish between mass and count nouns, namely, Yudja, a Brazilian indigenous language. She tested both child and adult speakers of Yudja, and finds that children accept cardinal (number-based) as well as non-cardinal (volume-based) interpretations for all nouns. In contrast, adults strongly prefer a cardinal interpretation of both object and substance denoting nouns. Lima argues that the adult results confirm that maximal self-connected concrete portions of a kind (as in substance denoting entities) can be considered as atoms and can be counted (Lima 2014) and thus, that counting does not require natural atomicity (Rothstein 2010). The difference between the child and the adult interpretations in Yudja suggests that the definition of atoms for counting does not depend solely on the lexical meaning of a noun (Srinivasan & Barner 2016) but arises from a combination of lexical, syntactic and pragmatic factors. This in turn suggests that pragmatics impact the interpretation of nouns in the same way as other phenomena, such as the acquisition of scalar quantifiers, as proposed in Foppolo et al. (2012). As for the child results, Lima also suggests that there may be influence from Brazilian Portuguese, the language of instruction at school.

Lima's suggestion that the lexical meaning of a noun is not sufficient for its mass or count interpretation is also highlighted in Lin & Schaeffer's study on Mandarin-speaking children and adults. Unlike Yudja, but also very differently from English and Dutch, Mandarin Chinese syntactically realizes the mass-count distinction only by means of numeral classifiers, which are only obligatory in the presence of a numeral. Interestingly, in the Mandarin version of the critical question of the Quantity Judgment Task, namely *Shei de X duo*? ('Whose X is more?'), the presence of a classifier leads to ungrammaticality, rendering a unique opportunity to test the interpretations of nouns of various ontological

types when no syntactic cues for the mass-count distinction is present. Lin & Schaeffer's results show that all types of nouns in Mandarin Chinese allow both number-based and volume-based interpretations, providing evidence for Pelletier's (2012) claim that all nouns are semantically both count and mass in our lexicon, and that it is ultimately syntax that decides on one of the two interpretations. As for the preference for certain interpretations in particular types of nouns, Lin & Schaeffer argue that it is a consequence of what they call "linguistic experience", which is reflected more strongly in adults than in children due to longer exposure to the relevant language input. The emergence of adultlike preferences for number-based or volume-based interpretations in child Mandarin is moreover argued to be linked to the acquisition of the classifier system. Interestingly, object-mass nouns such as *furniture* are interpreted adultlike from early on. This is explained by invoking Barner & Snedeker's (2005) and Bale & Barner's (2009) lexical [+individual] feature on such nouns, which gives rise to a clear number-based interpretation, regardless of their syntactic contexts.

The idea that syntax plays a crucial role in (the L1 acquisition of) the mass-count distinction and its semantic correlates is again emphasized in van Witteloostuijn & Schaeffer's study on Dutch-speaking children with Specific Language Impairment (SLI). They show that children with SLI after the age of six, whose primary language impairment is in morphosyntax, have most problems with the interpretation of flexible nouns, which relies solely on plural morphology. These children also have some problems with the distinction between classical count and substance-mass nouns, the interpretation of which is supported by world knowledge. However, these children display virtually no problems with object-mass nouns, which always receive a number-based interpretation, despite the fact that they always appear in mass syntax. Similar to Lin & Schaeffer (this collection), van Witteloostuijn & Schaeffer argue (following Bale & Barner's 2009 suggestion) that object-mass nouns are lexically marked for a number-based meaning. These results underscore the morphosyntactic impairment of children with SLI and suggest that their lexical-semantics is intact. At the same time, the results emphasize the crucial role that (sensitivity to) syntax plays in the adultlike interpretation of all mass and count nouns (except for, perhaps, object-mass nouns).

Research in bilingual acquisition raises the question of how learners of two languages map the (morpho)syntax of one language to target-like semantic interpretations in the other language, especially when the (morpho)syntax of one of the language differs from that of the other language. Yin & O'Brien address this question by investigating Chinese-English bilingual adolescents' interpretations of English mass-count morphosyntax. As mentioned above, Chinese does not have the syntactic mass-count distinguishing mechanisms that English has, such as indefinite articles and plural morphology, but employs a substantially different way to realize the mass-count distinction in its syntax. Yin & O'Brien report that overall, their Chinese-English bilingual participants display target-like patterns regarding all noun types they investigated (count nouns, substance-mass nouns, object-mass nouns, and flexible nouns). This is similar to previous findings in L2 English speakers as reported by Inagaki (2014). When analyzing the data by age and noun type Yin & O'Brien notice a developmental effect whereby the participants become more and more target-like in their quantity judgement of substance-mass nouns as they grow older. Furthermore, they find that in the condition of flexible nouns, in which participants were forced to use the cues of morphosyntax, the quantity judgment patterns of their bilingual participants were similar to the ones Barner & Snedeker (2005) found for monolingual English speakers, but different from those of adult L2 learners of English, as reported in Inagaki 2014. Given these results, the authors conclude that bilingual learners, unlike

second language speakers, are able to develop sensitivity to morphosyntax in the mass-count distinction. However, compared to monolingual speakers, bilingual speakers take longer to establish the target-like grammatical mechanism for the mass-count distinction. This is explained as a consequence of differences in both quality and quantity of the input, in line with Argyri & Sorace (2007), Gathercole (2007), and Serratrice et al. (2009).

Investigating a language without any plural marking or indefinite articles, MacDonald & Carroll report on the second language processing of English mass and count nouns by adult native speakers of Korean. Interestingly, the Korean participants perform target-like on three noun types in their L2, namely, count nouns such as *bees*, substance-mass nouns such as *lotion*, and object-mass nouns such as *jewelry*. However, for flexible nouns such as *stone(s)*, whose interpretation depends on their syntactic contexts, the L2 learners of English do not seem to be able to make use of the syntactic information when making their quantity judgments. According to MacDonald & Carroll, these results show that second language learners rely heavily on lexical-semantic knowledge, or world knowledge, and remain largely insensitive to English plural-marking, a morphosyntactic mechanism that can distinguish between mass and counts nouns, that Korean lacks. As argued by many scholars, including Barner & Snedeker (2005), Bale & Barner (2009), Lin & Schaeffer (this collection), and van Witteloostuijn & Schaeffer (this collection), MacDonald & Carroll assume that object-mass nouns are lexically marked for an individual-item interpretation. They further argue that count and substance-mass nouns have conventionalized lexical-semantic inventories, that strongly push into the direction of a number-based interpretation of count nouns, and of a volume-based interpretation of substance-mass nouns. This, rather than plural morphology, is what facilitates the target-like interpretation of count and substance-mass nouns for the Korean learners.

Overall, the results of the studies in this special collection suggest that lexical-semantic mass-count knowledge (e.g., the [+individual] feature on object-mass nouns) is in place first, followed by the acquisition of the sensitivity to mass-count (morpho)syntax. This is demonstrated by the early emergence of adultlike number-based interpretations of object-mass nouns by all L1 and L2 learners, even learners with SLI, and supports the claim that the interpretation of object-mass nouns is lexically specified. The early acquisition of lexical-semantics is further corroborated by the relatively low rate of non-target-like responses found for L2 learners when interpreting classical count and substance-mass nouns. This early acquisition of lexical-semantics may be aided by conventional bounded or unbounded meanings. Interestingly, the same trajectory, in which object-mass, classical count, substance-mass nouns are first acquired, is also observed with the typically developing Dutch-speaking children and those with SLI. Target-like interpretation of flexible nouns, which exclusively relies on plural morphology in the Barner & Snedeker experimental paradigm, is most problematic in all relevant learner populations.

This raises the question as to how exactly number-based vs. volume-based interpretations, or bounded vs. unbounded interpretations are mapped onto what cognitive systems. It is precisely this question that is addressed in the paper by Odic, Pietroski, Hunter, Halberda and Lidz. Odic et al. depart from Barner & Snedeker's experimental paradigm and develop novel experiments to explore the cognitive magnitude systems of number and area, as well as the interface between these systems and the linguistic mass/count distinction. First, their results show that number and area involve independent magnitude representations, namely the Approximate Number System (ANS) and the Approximate Area System (AAS), respectively. Furthermore, and of particular interest for this Special Collection, the data reveal a systematic interface between language and cognition in the context of the bounded-unbounded distinction. Specifically, Odic et al. demonstrate that

while the ANS is employed for the evaluation of comparative sentences containing nouns representing a bounded category, sentences with nouns representing an unbounded category are evaluated by the AAS.

Alan Bale and David Barner conclude the special collection by taking a wide perspective on the topic. They provide an in-depth overview of the advances in the cross-linguistic empirical study of the mass-count distinction as well as the challenges it faces. The paper begins with a discussion of the importance of scientifically investigating the mass-count distinction and lays out what the authors believe are the necessary assumptions for the progress of the enterprise, particularly in light of the ever-growing complexity of the empirical facts. The authors then continue to describe the current body of cross-linguistic findings obtained by the quantity judgment task and the implications of these data for the nature of the mass-count distinction. The paper concludes with a discussion of the cognitive correlates of the mass-count distinction, highlighting the perils of not distinguishing between the linguistic mass-count distinction and the cognitive object-substance distinction.

To summarize, the experimental studies on the semantic and cognitive correlates of syntactic count and mass structures in this special collection provide novel insights into the relative weights of lexical-semantic meanings vs. meanings derived from syntax with respect to the interpretation of mass and count nouns. It also gives rise to many new questions regarding the interface with human cognition. A first step in addressing this latter issue is taken in the Odic et al.'s study, suggesting that bounded categories and unbounded ontological categories involve different types of cognitive systems, and as such, cannot be explained by one unified semantic account (cf. Chierchia 1998a; b; Rothstein 2010). These insights in turn, raise new questions for acquisition: What drives the acquisition order of count nouns, substance-mass nouns, and flexible nouns? What role does the development of cognitive systems such as the ANS and the AAS play in the acquisition of the mass-count distinction? How do object-mass nouns such as *furniture* fit into this picture?

In order to answer these questions, many more experimental studies ought to follow, in order to ultimately provide a clear picture of the (acquisition of the) mapping of linguistic structures (lexical, semantic and syntactic) to cognitive systems. Such studies should include new experimental paradigms and techniques, allowing for the investigation of (the development of) cognitive systems, alongside linguistic systems, and their actual processing.

Competing Interests

The authors have no competing interests to declare.

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