

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

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Quantity judgments and individuation: evidence that mass nouns count

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Abstract

Three experiments explored the semantics of the mass-count distinction in young children and adults. In Experiments 1 and 2, the quantity judgments of participants provided evidence that some mass nouns refer to individuals, as such. Participants judged one large portion of stuff to be "more" than three tiny portions for substance-mass nouns (e.g. *mustard*, *ketchup*), but chose according to number for count nouns (e.g. *shoes*, *candles*) and object-mass nouns (e.g. *furniture*, *jewelry*). These results suggest that some mass nouns quantify over individuals, and that therefore reference to individuals does not distinguish count nouns from mass nouns. Thus, Experiments 1 and 2 failed to support the hypothesis that there exist one-to-one mappings between mass-count syntax and semantics for either adults or young children. In Experiment 3, it was found that for mass-count flexible terms (e.g. *string*, *stone*) participants based quantity judgments on number when the terms were used with count syntax, but on total amount of stuff when used with mass syntax. Apparently, the presence of discrete physical objects in a scene (e.g. stones) is not sufficient to permit quantity judgments based on number. It is proposed that object-mass nouns (e.g. *furniture*) can be used to refer to individuals due to lexically specified grammatical features that normally occur in count syntax. Also, we suggest that children learning language parse words that refer to individuals as count nouns unless given morpho-syntactic and referential evidence to the contrary, in which case object-mass nouns are acquired.

Introduction

An ongoing debate in the study of language and its acquisition is how syntax and semantics are related, and how knowledge in one domain might facilitate acquisition of knowledge in the other. One example of where the relationship between syntax and semantics in acquisition has been thoroughly debated is the case of the mass-count distinction, which surfaces in many of the world's languages. In English, count nouns (e.g. *cat*, *table*) are those words that can appear in both singular and plural forms and can be modified by cardinal numbers (e.g. *one*, *two*), and quasi-cardinal determiners such as *several*, *many*, *these*, and *those*. Mass nouns (e.g. *milk*, *sand*), can take none of these determiners, cannot be pluralized, and sometimes are modified by terms such as *little* or *much*. Psychologists have long wondered whether this distinction might be rooted in prelinguistic ontological knowledge, or inversely, whether syntax might provide the foundations for conceptual development.

Quine (1960) adopted the latter position, and intimated that the acquisition of mass-count syntax is necessary for individuating and tracing the identity of physical objects in the world. According to Quine, count nouns, but not mass nouns "possess built in modes, however arbitrary, of dividing their reference" (p. 91). Whereas cats are quantified in cat-sized units, water can be divided and quantified in arbitrary portions. Thus, determining a quantity of cats involves enumerating cat-sized units of stuff, while quantifying water involves no such default unit of measurement. By delineating boundaries of perceived phenomena, the divided reference of count nouns could provide the inner walls of an "intellectual chimney", up which the developing child could scramble to an understanding of the spatio-temporal continuity of objects, as objects (see Carey, 1993, for discussion).

However, contrary to Quine (1960), a growing body of evidence indicates that well

before children master the mass-count distinction they have a rich base of knowledge about the world and the physical objects that fill it. For example, studies of word extension in 2-year-olds (e.g. Imai & Gentner, 1997; Soja, Carey, & Spelke, 1991) and numerical cognition in infants (e.g. Carey & Xu, 2001; Spelke, 1985; Wynn, 1992), indicate that linguistically naïve children are able to individuate and trace the identity of objects, and that their treatment of objects differs systematically from their treatment of non-solid substances (Huntley-Fenner, Carey, & Solimando, 2002). Such studies suggest that knowledge of objects, individuation, and identity is not supplied by the acquisition of noun phrase quantifiers and the mass-count distinction.

Quite opposite in spirit to Quine, Macnamara (1972, 1982) suggested that prelinguistic semantic categories might form the core of syntactic categories (see also Braine, 1992; Schlesinger, 1971). Thus, categories such as "object" and "substance" might be used by children to infer or build the categories "count" and "mass", respectively. While many of children's early words appear to respect this semantic categories hypothesis, several studies suggest that children's acquisition of the mass/count distinction is not based on an object/substance distinction (Gathercole, 1985; Gordon, 1985, 1988). For example, according to Gordon (1985), when provided with syntactic and semantic cues, children ranging in age between 3;5 and 5;5 years old overwhelmingly categorized words on the basis of syntactic context, even when syntactic and semantic cues were in conflict. In fact, when semantic cues were provided to children in isolation, only older subjects (between 4;6 and 6;0) were able to consistently use semantics as a basis for category assignment.

As noted by Bloom (1999), mapping theories of the type proposed by Macnamara (1982) do not capture what children seem to know about the relation between NPs and their semantics. Various studies suggest that, very early in life children have an abstract notion of "individual",

which is superordinate to the notion physical object. For example, evidence exists that 6-month olds quantify over non-objects like sounds (Starkey, Spelke, & Gelman, 1990), and that 2-year olds, who are just beginning to count physical objects, can also count sounds or actions (Wynn, 1990 ; also, see Giralt & Bloom, 2000, for evidence that 3-year-olds can count holes and parts). Studies of language development mirror these results, showing that children are sensitive to syntactic information when acquiring nouns that refer to sounds (Bloom, 1994), puddles (Soja, 1992) and collections of things (Bloom & Keleman, 1995). As noted by Gordon (1985), early knowledge of grammar seems to reflect an adult-like appreciation of quantification, and seems to have little concern for semantic distinctions such as object/substance.

Based on this kind of evidence, Bloom (1999) suggested that children might identify count and mass nouns in the input on the basis of their use to refer to individuals or non-individuals (see Gordon, 1985, 1988; Macnamara, 1986; Xu & Carey, 1996 for similar suggestions). For example, hearing the word *chair* used to refer to an individual thing, the child might infer that a count noun expression is being used. Likewise, having construed a spatially bounded body of water to be an individual thing, the child might assume that the word *puddle* is a constituent of a count noun phrase. In any case where the child construes a referent to be an individual, whether that individual be a chair, puddle, sound, idea, or unified group of objects, he or she might also assume that the noun phrase used to express the concept is a count noun phrase. Correspondingly, any phenomenon that is referred to by a noun phrase, yet that is not an individual, could be mapped to a mass noun phrase, yielding the following mappings:

- (1) a. individual → count noun
- b. non-individual → mass noun

Although this seems to capture a much wider range of empirical phenomena than

previous proposals such as Macnamara (1982), it is not clear that Bloom's proposal remedies the problems it was intended to solve. While infants appear to have a rich understanding of individuation that spans both concrete and abstract domains, it is not clear that the mass-count distinction is based on a referential difference of this nature. In fact, a large literature in linguistics has debated this question since Quine's initial discussion of the mass-count distinction, resulting in at least three distinct views of what the correct interpretation of mass-count syntax might be. As we will show below, none of these three alternatives is clearly favored by existing evidence. However, the theories do make empirically distinguishable predictions regarding language acquisition and the nature of mass-count semantics.

Three Theories of Mass-Count Semantics

Since Quine (1960), numerous linguists, philosophers and psychologists have put forth proposals regarding the semantics of the mass-count distinction. Most of these proposals agree with Quine's primary claim that count nouns possess built in modes of dividing their reference, and thus entail reference to individuals (Bloom, 1994, 1999; Bunt, 1985; Chierchia, 1998; Gillon, 1992, 1996; Gordon, 1985; Jackendoff, 1991; Link, 1983, 1998; Macnamara, 1986). However, the investigation of mass nouns has spawned a striking variety of positions, resulting in entire volumes of debate (e.g. Pelletier, 1979). No less than three basic views of how mass nouns relate to linguistic individuation have been put forth, each of which is discussed below. We call the alternatives the "Quinian correspondence hypothesis", the "linguistic non-specification hypothesis" (Gillon, 1992, 1996), and the "inherent plurality hypothesis" (Chierchia, 1998).

The Quinian correspondence hypothesis. Corresponding to Quine's view that count nouns divide their reference was his suggestion that mass nouns do not. While count nouns

provide the logical structure required for individuating entities and tracing their identity through space and time, mass nouns fail to provide principles of individuation. Only count nouns refer to individuals or "atoms". A form of this view is adopted by Link (1983, 1998) and is assumed in most discussions of the mass-count distinction in psycho-linguistics (see Bloom, 1994, 1999; Gordon, 1985; Link, 1983, 1998; Macnamara, 1986; Wisniewski, Imai, & Casey, 1996). For example, according to Wisniewski et al. (1996), given a strong correspondence between mass-count syntax and semantics, language users should "conceptualize the referents of count nouns as distinct, countable, individuated things and those of mass nouns as non-distinct, uncountable, unindividuated things" (Wisniewski et al., 1996, p. 271). The spirit of this is summarized in (2):

- (2) a. count noun → individual
 b. mass noun → non-individual

In attempts to support this, two semantic criteria have been proposed to distinguish mass nouns from count nouns, and to demonstrate that only the latter individuate. First, Quine noted that mass nouns have the property of cumulative reference. For example, given a mass noun such as water, it is true that "if *a* is water and *b* is water then *a* and *b* taken together are water". Given a count noun such as horse, it does not follow that "if *a* is a horse and *b* is a horse then *a* and *b* taken together are a *horse*". However, cumulativity of reference fails as a criterion for distinguishing mass from count, since it is true of plural count nouns: "if the animals in this camp are horses and the animals in that camp are horses, then the animals in the two camps are horses" (see Gillon, 1996; Link, 1998; Pelletier, 1979; Schwarzschild, 1996).

The second criterion, first proposed by Cheng (1973), is that any part or portion of some thing that is denoted by a mass noun is denoted by the same mass noun, a property Cheng termed

”divisibility of reference”.¹ Thus, a portion of water divided in two is still water, whereas a cat divided in two is neither two cats nor one. Clearly, if divisibility of reference were true of all mass nouns there would be good reason to believe that no mass nouns refer to discrete individuals, and that divisibility characterizes mass nouns as distinct from count nouns. However, two putative counter-examples have been discussed in the mass-count literature. First, Gillon (1996) notes that various count nouns permit divisibility of reference, including such terms as *rope*, *rock*, *ash*, *cord*, and *tile*. Thus, one ash split in two equals two ashes, in the same way that a rope cut in two equals two ropes. However, while such examples indicate that divisibility of reference is not exclusive to mass nouns, they do not rule out the possibility that all mass nouns exhibit divisibility of reference, and thus fail to individuate as a class. According to Gillon (1996), this possibility is ruled out by mass nouns in English that have individuals in their denotations, including *furniture*, *silverware*, *jewelry*, *clothing*, *traffic*, *infantry*, and *footwear* (see also Chierchia, 1998). By Gillon’s account, such terms (heretofore ”object-mass” nouns) clearly denote ”minimal parts” or ”atoms” (e.g. *tables*, *chairs*) which must be preserved in order to support naming (e.g. half a chair does not count as *furniture*). Given Gillon’s argument, divisibility of reference would fail as a characterization of mass nouns, and so too would the notion that only count nouns quantify over discrete individuals.

“Linguistic non-specification” and ”inherent plurality”. Based on examples of object-mass nouns such as *furniture* and *jewelry*, Gillon (1996) proposed that the denotation of all mass nouns, including terms like water, string, and mustard, are linguistically unspecified for whether or not they denote individuals (i.e. neither the syntax nor the lexical roots themselves are

¹ Prasada (1999) makes a very similar proposal, stating that only count terms denote objects with non-arbitrary structure. Consequently, Prasada’s proposal can be evaluated on the basis of comments directed at Cheng (1973) discussion of divisibility of reference.

specified). However, an examination of the world indicates that, despite not being specified, *furniture* does denote individuals, while *water* does not. For example, according to Gillon (1996) “World knowledge tells one that ammunition has minimal parts, or atoms, known as rounds” (p. 9). This view is schematized in (3):

- (3) a. count noun → individual
 b. mass noun → specified by world knowledge

According to Gillon (1996), mass-count flexibility can also reveal the denotation of mass nouns. A mass noun’s “conversion to a count noun requires that its denotation must be such that it has minimal parts, or atoms” (p. 28). Thus, any term that can appear as either mass or count (e.g. *string*) must denote individuals in its mass realization.

Extending this, Chierchia (1998) proposed that all mass nouns refer to sets of atoms or individuals, and are “inherently plural”. On analogy with terms like *furniture*, even abstract expressions like *hope* and *joy* denote sets of atoms, which are simply vague and difficult to specify. Chierchia rejects the view whereby a mass noun is interpreted as a mereological whole or has an extension “drawn from a domain of substances”, and instead claims that the denotations of mass and count terms are essentially the same: “mass nouns come out of the lexicon with plurality already built in. this is the only way in which they differ from count nouns” (p. 53). This view is schematized in (4):

- (4) a. count noun → individual (or atom)
 b. mass noun → plurality of individual (or atoms)

Emphasizing a common semantics for mass nouns and plural count nouns, Chierchia notes that previous theories of the mass-count distinction have distinguished the categories on the basis of mass nouns like *water* and *rice* whose minimal parts are vague: “this has contributed

to obscuring the relation between mass nouns and plurals and led to the idea that the denotation of mass nouns is somehow qualitatively distinct from that of count ones. Focusing on mass nouns like *furniture*, whose minimal parts are no more vaguely determined than tables and chairs, helps us individuate what the right relationship between mass and plural is: what else can the denotation of furniture be, if not all the pieces of *furniture* (right down to the single ones)?” (p. 68).

Linguistic construal versus world knowledge. Clearly, the linguistic non-specification and inherent plurality views are not consistent with the Quinian correspondence hypothesis. Were it true that all or even some mass nouns denote individuals, a semantic mass-count distinction based on reference to individuals would not be supported. As a result, the question of whether or not object-mass nouns truly do refer to and quantify over individuals becomes of central importance. Indeed, in the cases discussed by Chierchia (1998) and Gillon (1996), it is not clear that the presence of individuals in the world should be taken as evidence that the particular terms refer to individuals and quantify over them as such. With object-mass nouns such as furniture in mind, several researchers have suggested that, although such words may refer to phenomena in the world that can be construed as discrete physical objects, they do not quantify over them as such, but refer to them in a non-individuated fashion (Bloom, 1994; Wiesniewski et al., 1996). As a result, such terms may not constitute counter-examples to the Quinian correspondence hypothesis.

Defending this view, Bloom (1994) argued that what matters in determining the lexicoconceptual representation of words is not relationships between language and worldly objects, but rather mappings between words and the mental representations they invoke. According to Bloom (1994) “mappings relevant to the study of linguistic competence must be

between grammatical classes and *cognitive* classes—not classes of entities in the world” (p. 45). As an example of how this might work, Wiesniewski et al. (1996) suggested that: ”on a particular occasion, we may conceptualize a swan, several ducks, and a heron on a lake as an unindividuated group called *waterfowl*, and not think of them individually as birds” (p. 295). Thus, while object-mass nouns may permit individuals in their extensions, naming individual things with mass syntax may cause these things to be construed as non-individuals. The individuals or atoms that happen to exist in the world are irrelevant to semantic interpretation if they are not specified by particular lexical items. In Quine’s words, the mass-count distinction may lie ”in the terms, and not the stuff they name” (p. 91). Terms such as ”shoes”, and ”pairs of shoes” divide reference, but ”footwear” may not.

Given this modification, the Quinian characterization of mass-count semantics can be maintained as a theory of how syntactic categories relate to cognitive classes. Object-mass nouns such as *silverware* do not quantify over individuals, but respect a uniform semantics of mass syntax. As a result, merely pointing to objects in the world as evidence against syntax-semantics correspondences is not sufficient to rule out correspondences. In order to challenge such mappings, any relevant evidence must address how speakers construe the referents of mass nouns, and how such construals relate to the quantification of mass-count syntax.

Summary. To summarize, at least three distinct views exist of how mass-count syntax relates to linguistic individuation. At issue is whether mass syntax has particular semantic requirements, or whether mass nouns, like count nouns, can be used to quantify over individuals. This question hinges on whether the referents of mass nouns are construed as unindividuated, or whether reference to individuals is a matter of world knowledge. The answer has important implications not only for the correct characterization of how mature speakers interpret terms

such as *furniture*, but also for how mass nouns are characterized as a class. As will be shown below, the picture of how children acquire the mass-count distinction also shifts importantly depending on which view is adopted.

Acquiring the Mass-Count Distinction

Given the current disagreement and lack of decisive evidence regarding the linguistic representation of mass-count semantics, there are several plausible accounts of how acquisition might proceed. Although it now seems clear that ontological categories such as "physical object" are developmentally prior to the acquisition of natural language quantification (Imai & Gentner, 1997; Soja et al., 1991), it is equally clear that simple ontological categories do not exhaust the interpretation of mass-count semantics (Bloom, 1999; Gathercole, 1985; Gordon, 1985). Instead, most current accounts agree that children's knowledge of noun phrase semantics is relatively abstract from early on. A good deal of evidence suggests that children have an abstract notion of "individual" from early in language acquisition, as expressed in the content of their early nouns, and in their ability to count abstract individuals such as actions, sounds and holes. As noted by Bloom (1999), these abilities suggest that children converge on the adult interpretation of count noun semantics almost from the beginning, and use count nouns to quantify over individuals (i.e. count noun → individual).

Less clear is how children arrive at the correct representation of mass nouns. Based on the discussion thus far, there appear to exist three empirically distinguishable courses of development for the acquisition of the mass-count distinction. First, it is possible that from the beginning of acquisition the mass-count distinction corresponds to a semantic distinction based on quantification over individuals. As a result, children might use semantics to identify the syntactic environments of mass nouns and count nouns using the mapping rules shown in (1)

above (Bloom, 1999), and repeated in (5):

- (5) a. individual → count noun
 b. non-individual → mass noun

The second possibility is that mass syntax never has any unique semantic requirements, and that children do not use semantics to identify the syntactic environments of mass nouns. Instead, the mass-count distinction might be acquired primarily on the basis of distributional analysis, and might involve the specification of lexical items with arbitrary syntactic features such as + /- count. Such a possibility would be consistent with either the theory of Gillon (1992, 1996) or Chierchia (1998). On this account, from the moment that object-mass nouns are acquired, children would be expected to use them to quantify over individuals.

Finally, a third possibility, which posits discontinuity in development, is that children begin acquisition with mappings from semantics to syntax that are eventually jettisoned on the way to linguistic maturity. For example, children might begin acquisition by assuming that all names for individuals are count nouns and all names for non-individuals are mass nouns, only to revise these representations later in acquisition and allow mass nouns that quantify over individuals. This possibility is schematized and contrasted with the two continuity views in Table 1.

	Quantification of mass nouns	
	Children	Adults
Syntax-semantics correspondence	Non-individuals	Non-individuals
Inherent plurality	Pluralities of individuals	Pluralities of individuals
Non-specification	Individuals or non-individuals	Individuals or non-individuals
Discontinuity hypothesis	Non-individuals	Individuals or non-individuals

Table 1. The semantic interpretation of mass nouns throughout development

The current study evaluated adults' representation of mass-count semantics, and also whether children's knowledge is continuous or discontinuous with that of adults. Perhaps the most transparent measure of whether words refer to individuals is provided by natural language quantification. According to Quine (1960), "To learn 'apple' it is not sufficient to learn how much of what goes on counts as apple; we must learn how much counts as *an apple*, and how much as another" (p. 91). Implicit in this is the idea that natural language quantification is based on, and is evidence for, individuation. "More apples" means "more individual things", whereas "more butter" means more homogeneous stuff. Following this logic, several previous studies have examined children's understanding of the term more using quantity judgment tasks (Donaldson & Balfour, 1968; Gathercole, 1985; Palermo, 1973). For example, Gathercole (1985) used quantity judgments to assess children's knowledge of the term *more*, by asking children questions such as "which piece of paper has more cheese?", where one alternative always had a greater number of pieces and the second alternative was less in number but greater in overall mass. In this way, Gathercole was able to determine when children quantified over individuals and when they did not.

Using this method, the current study examined children's and adults' knowledge of mass-count semantics. Experiment 1 examined the referential entailments of object-mass nouns like *furniture*, as well as basic-level count nouns and mass nouns that refer to substances. Experiment 2 tested whether quantity judgments for object-mass nouns are affected by the presence of multiple basic level kinds. Finally, Experiment 3 explored the effect of shifting mass-count syntax when particular terms and referential contexts are held constant (e.g. *a string /some string*), to assess the role of syntax in quantification judgments. All experiments were performed with both adult and child participants, in order to evaluate the possibility that the representation

of the mass-count distinction changes through the course of acquisition.

Experiment 1

The first experiment explored the interpretation of terms like *furniture* (object-mass nouns), as compared to mass nouns like *toothpaste* that refer to substances (substance-mass nouns) and count nouns like shoe that refer to objects (count nouns). Of interest was whether adults and children would treat object-mass nouns like the count nouns and quantify over individuals, or whether they would treat them like the substance-mass nouns and fail to quantify by number (e.g. and choose by overall mass).

If a strong correspondence exists between mass-count syntax and semantics and all mass nouns refer to non-individuals (Bloom, 1994, 1999; Link, 1983, 1998; Quine, 1960; Wisniewski et al., 1960), participants should not quantify over individuals when interpreting object-mass nouns. Thus, when asked to compare amounts of *furniture*, participants should choose the larger mass or volume of stuff, despite the existence of discrete individuals in the referential context. In contrast, if object-mass words individuate (Chierchia, 1998; Gillon, 1992, 1996), participants should base quantification judgments on number and not overall mass or volume. Finally, if adults interpret object-mass nouns as quantifying over individuals but children do not, this would suggest that children begin acquisition with semantics-to-syntax mappings that are lost later in development.

Methods

Participants were 16 Harvard University undergraduates and 16 children aged 4;1–4;6 (mean = 4;3). This age group was selected based on Gordon's (1985) study, which suggested that children begin to show knowledge of object-mass nouns at around 4;0. This was confirmed by an analysis of 37 corpora of early child language from the CHILDES database (MacWhinney,

2000), which indicated that the average age that children began using object-mass nouns was between 3;5 and 5;0.²

Adults were shown photos of two characters and were asked to choose which of the two characters had more (e.g. *who has more mail?*). One character always had a single large object while the other character had three small objects of the same kind. The three objects had a smaller combined volume and surface area than the large object, allowing responses based on number to be distinguished from those based on mass or volume. Three categories of words were tested: object-mass (*furniture, clothing, jewelry, silverware, mail*), count nouns (*shoes, candles, cups, plates*) and substance-mass nouns (*ketchup, butter, mustard, toothpaste*). Examples of stimuli from each category are depicted in Fig. 1. Object-mass and substance-mass nouns were always presented with mass syntax, while count nouns were presented with count syntax. All trials were counter-balanced such that the order in which object-mass, substance-mass and count nouns was systematically varied. Each participant received 12 trials in all, including four from each category, unblocked.

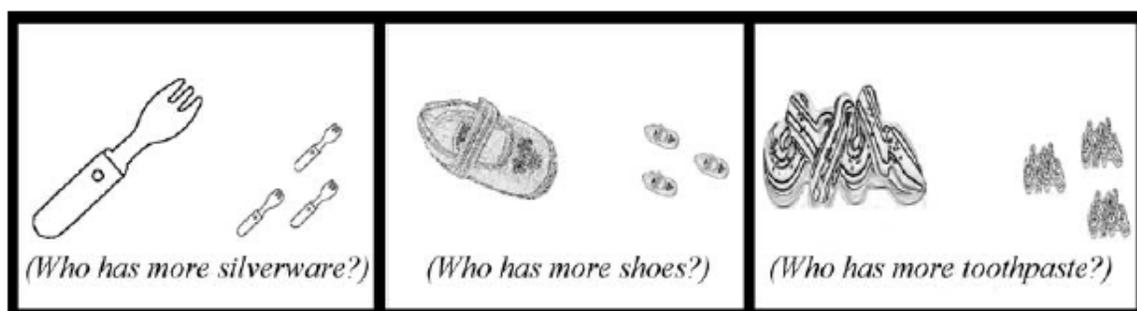


Figure 1. Images of selected stimuli from Experiment 1 (object-mass: *silverware*; count: *shoes*; substance-mass: *toothpaste*)

² Average ages of first use for particular terms were as follows: *furniture* (3;8), *jewelry* (4;5), *clothing* (4;4), *mail* (3;5), *silverware* (5;0). The overall average age of first use for all object-mass terms combined was 3;10 (n = 52).

The methods for children were identical, except that they were shown actual scenes, while adults were tested using photos of the scenes. Also, children were given a picture-word matching task as a pre-test to determine which object-mass words they would be tested on. For each potential target word they were asked using mass-count neutral syntax to point to the picture that matched each word among pictures of the other target words and distractor items such as people, apples, etc. (e.g. *Can you point to their furniture?*). For adults, object-mass items were selected at random for each subject.

Results and Discussion

As shown in Fig. 2, adult participants based their quantity judgments on the number of individuals significantly more for count and object-mass nouns (100 and 97%), compared to substance-mass nouns (0%), $F(2,28) = 1441.6, P < .001$. There was no main effect of or interaction involving order of presentation. Wilcoxon signed-rank tests confirmed that there was a significant difference between object-mass and substance mass judgments ($T = 0, P < .001$), but no difference between object-mass and count terms ($T = 65, P > .25$).³ This pattern fails to support the hypothesis that adults construe the referents of object-mass nouns as unindividuated. As a result, theories that require a strong mapping between mass-count syntax and semantics (e.g. Link, 1983, 1998; Quine, 1960) appear unable to account for such terms. If mass syntax forced a construal of objects as unindividuated (Bloom, 1994; Wisniewski et al., 1996), then participants should have quantified by mass or volume for such terms, and never by number.

³ Zero differences (subjects for who performed equivalently in the two conditions) were not removed from the data set. Instead they were ranked and the ranks were split between the sum for positive differences and the sum for negative differences. This is a conservative strategy which minimizes Type 1 error (Dixon & Mood, 1946; Fong, Quan, Lam, & Lam, 2003). Results of the Wilcoxon tests were confirmed with paired sample t-tests.

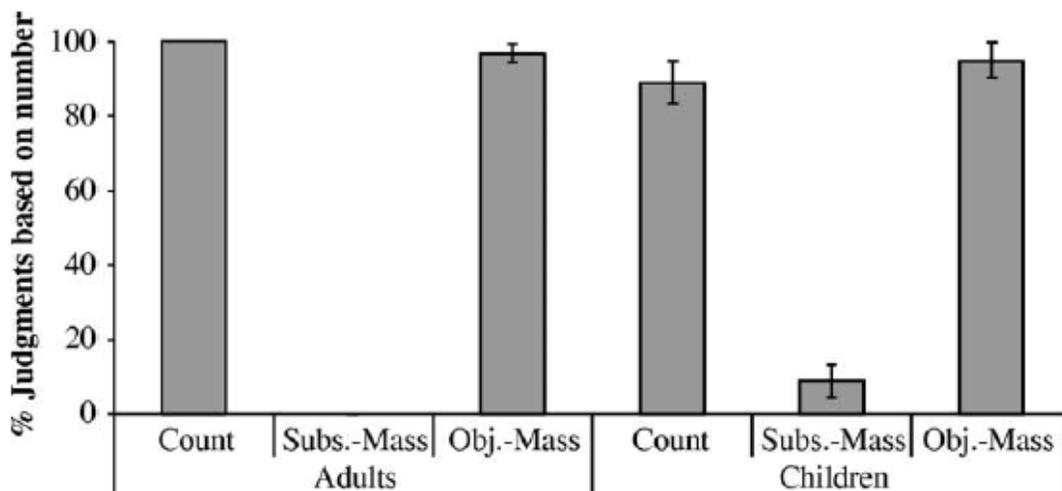


Figure 2. Adults' and children's quantity judgments, as a percentage of judgments based on number of individuals.

As noted above, several authors have proposed that strong correspondences between syntax and semantics might exist only early in development (Macnamara, 1982; Schlesinger, 1971). Children might begin with semantically homogenous syntactic categories that become more diverse as the child assimilates a wider range of lexical items. In such a case, children might use mappings from semantics to syntax to identify members of each syntactic category, and then base further acquisition on primarily distributional information. Given this view, it might be expected that children first encountering terms such as *furniture* would show evidence of their syntax-semantics mappings and fail to quantify by number. However, as shown in Fig. 2, children also based quantity judgments on number for both the count noun and object-mass nouns (89 and 95%) but not for substance-mass nouns (9%), $F(2,28) = 151.90$, $P < .001$, with no interaction involving order of presentation. Wilcoxon signed-rank tests confirmed that there was a significant difference between object-mass and substance mass judgments ($T = 0$, $P < .001$), but no difference between object-mass and count terms ($T = 46$, $P > .25$).

These results suggest that both children and adults interpret some mass nouns as quantifying over individuals. In each case, participants consistently quantified over mass or volume for substance-mass nouns like *ketchup* but over number for count nouns like shoe and object-mass nouns like *furniture*. These results support the predictions of Gillon's (1992, 1996) linguistic non-specification view, and Chierchia's (1998) inherent plurality hypothesis, but not the Quinian view that only count nouns individuate.⁴

Experiment 2

Three objections regarding Experiment 1 might be raised. First, as noted by Wisniewski et al. (1996), terms like *furniture* may apply best to groups of things. Thus, the judgment that three chairs are more *furniture* than one chair might reflect the fact that one chair is not a good example of furniture to begin with. Second, while object-mass words are superordinate terms, in each case only one "basic level kind" (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) was presented to participants. This possible mismatch between the utterance and the situation may have led participants to reject the experimenters question and replace it with their own more specific paraphrase (e.g. glossing *furniture* as *chairs*). As a result, participants may have based their judgments on the quantificational properties of the relevant basic-level terms that are typically count nouns. Finally, a third possibility is that participants ignored the linguistic component of the task altogether, and adopted a strategy of quantifying by number whenever discrete physical objects were presented as stimuli, and by mass or volume when stimuli were nonsolid substances. In order to rule out the first two possibilities, Experiment 2 examined

⁴ The data for substance-mass terms do not pose a problem to Chierchia, since by his view even terms like *ketchup* denote pluralities of individuals (e.g. *ketchup* atoms). In keeping with this, terms like *ketchup* only seem to quantify by mass or volume; these properties are only clues to number (i.e. the number of atoms in each portion of stuff).

adults' and children's quantification judgments for object-mass nouns when both sets under consideration contained multiple individuals and multiple basic level kinds. The third potential objection was examined in Experiment 3.

Method

Adult participants were 16 Harvard University undergraduates. Child participants were 12 Boston area children (six girls and six boys), aged 4;0–4;6 (mean = 4;3). The procedures and stimuli used were identical to those in Experiment 1, except that for object-mass nouns each character was always shown with instances of two basic level kinds. For example, for *furniture*, one character had a large table and chair, while the other had three tiny tables and chairs. Consequently, all three types of items (object-mass, count and substance-mass) were shown in 2:6 ratios where the six small objects comprised less overall *stuff* in terms of total mass (see Fig. 3). Object-mass items were: *furniture* (tables, chairs), *mail* (letters, parcels), *jewelry* (rings, necklaces), and *clothing* (shirts, pants). Again, children were shown actual scenes while adults saw photos of stimuli.



Figure 3. Images of selected stimuli from Experiment 2 (object-mass: *silverware*; count: *shoes*; substance-mass: *toothpaste*).

Results and Discussion

Adult participants based judgments on number 93.8% of the time for count nouns, 97.9% of the time for object-mass nouns, and 0% of the time for substance-mass nouns, $F(2,28) = 465.5$, $P < .001$. Wilcoxon signed-rank tests confirmed that there was a significant difference between object-mass and substance mass judgments ($T = 0$, $P < .001$), but no difference between object-mass and count terms ($T = 60$, $P > .25$).

Similarly, children based responses on number for both the count noun and object-mass nouns (97.9 and 91.7%) but significantly less for substance-mass nouns (39.6%), $F(2,20) = 26.455$, $P < .001$. Wilcoxon signed-rank tests confirmed that there was a significant difference between object-mass and substance mass judgments ($T = 2$, $P < .001$), but no difference between object-mass and count terms ($T = 23$, $P > .2$). These results indicate that, for both adults and children, when multiple items of different kinds are presented, quantity judgments for object-mass nouns continue to be based almost exclusively on number. These results confirm the conclusion of Experiment 1 that both children and adults interpret some mass nouns as quantifying over individuals. These results support the linguistic non-specification and inherent plurality hypotheses, but not the Quinian view that only count nouns individuate.

Experiment 3

The third experiment tested the quantity judgments of adults and children for words that can appear in either mass or count contexts, in order to evaluate whether judgments are guided by mass-count syntax, as opposed to the ontological category of referents. This question is important, since it remains possible that participants in Experiments 1 and 2 based judgments on number according to the ontological categories of stimuli, rather than on linguistic information. While previous studies have suggested that children use syntax to guide judgments in quantity

judgments (Palermo, 1973), these experiments did not rule out the possibility that judgments were based solely on lexical or conceptual knowledge (since both syntax and the lexical items, e.g. *apple* and *water*, varied between trials). In the present experiment only syntax was manipulated between conditions. Of interest was whether participants would base their judgments on number when terms were presented as mass nouns.

Method

Adult participants were 16 Harvard University undergraduates. Child participants were 12 Boston area children (six of each sex), aged 4;0–4;5 (mea 4;2).

As in Experiments 1 and 2, adults were shown photos of two characters and were asked to choose which of the two had more (e.g. *who has more string(s)?*). One character always had a single large object while the other character had three small objects of the same kind. Again, the three objects had a smaller combined volume and surface area than the large object. Four flexible terms were tested: *string*, *chocolate*, *paper*, and *stone*. Mass-count syntax was manipulated between participants, such that each subject was given flexible terms either all in mass syntax or all in count syntax. Images depicting three of these stimuli are shown in Fig. 4. For children, procedures and stimuli were identical except that they were shown actual scenes instead of photographs.

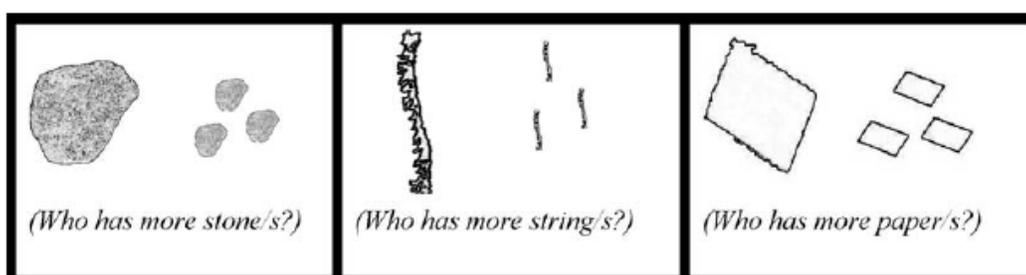


Figure 4. Images depicting selected experiment from Experiment 3 (*stone/s*, *string/s*, *paper/s*).

Results and Discussion

Both adults and children used syntax to guide their quantity judgments (see Fig. 5). Adults who heard count syntax based significantly more judgments on number than those who heard mass syntax (97 vs. 3%), $W = 36$, $P < .001$, as did children (95 vs. 25%), $W = 26$, $P < .05$, by Wilcoxon rank-sum tests. Thus, participants appeared to interpret count uses as quantifying over individuals, and mass uses as quantifying over mass or volume.

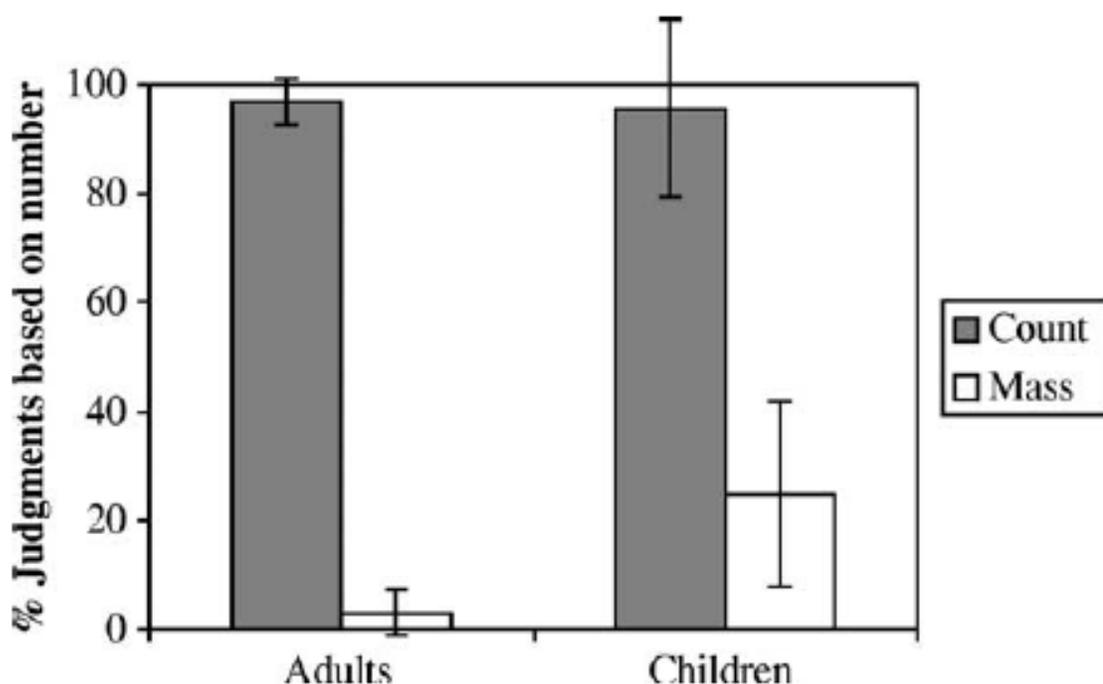


Figure 5. Percentage of flexible words interpreted as quantifying over individuals, when presented in count syntax versus mass syntax

All participants appeared to respect a correspondence between syntax and semantics for flexible terms like *string* and *stone*. These results are important in two respects. First, they rule out the possibility that participants performing quantity judgments base their judgments strictly on the presence of individuals in particular scenes, and indicate that both children and adults

employ syntactic information in forming their judgments. Second, and perhaps more interestingly, these results do not appear to seem to follow naturally from the proposals of Gillon (1992, 1996) or Chierchia (1998), since participants treated mass and count nouns differently despite identical referential contexts (i.e. containing discrete individuals) in each case. As will be discussed in greater detail below, the explanatory force of both theories appears to be compromised by efforts to integrate these data.

General Discussion

The current study described three experiments that used quantity judgments to assess adults' and children's knowledge of mass-count semantics. While studies such as Donaldson and Balfour (1968), Gathercole (1985) and Palermo (1973) used similar methods to investigate children's early interpretation of terms like *more* and *less*, no previous judgment task has investigated object-mass nouns or terms that can be used as either mass or count to evaluate the exact semantic contribution of mass-count syntax.

The current method addressed how children and adults represent the semantics of mass nouns and count nouns. Experiment 1 suggested that a strong correspondence exists between syntax and semantics for count nouns (e.g. *shoes*) and substance-mass nouns (e.g. *butter*), but not for object-mass nouns like *furniture*, *jewelry*, and *mail*. Instead, adults and 4-year-old children based quantity judgments almost exclusively on number for object-mass nouns. Participants interpreted the question "who has more x" as pertaining to the number of individuals in both the count and object-mass conditions, but did not quantify over individuals for other mass nouns. Experiment 2 ruled out two possible objections regarding object-mass judgments in Experiment 1; neither the number of objects in each scene nor the presence of multiple basic-level kinds reduced the extent to which participants quantified over individuals for object-mass nouns.

Finally, Experiment 3 suggested that both adults and children interpret a given item differently when it is used in a mass versus a count context. Terms such as string and stone were interpreted as quantifying over individuals only when used as count nouns. This result ruled out the possibility that judgments in Experiments 2 and 3 were based on the presence of discrete physical objects alone, and demonstrated that both children and adults employ mass-count syntactic information when making quantity judgments.

Three Theories Revisited

The pattern of results reported here suggests that adults and 4-year-old children interpret some mass nouns as quantifying over individuals. As a result, the studies do not support the hypothesis that mass syntax causes language users to construe referents as unindividuated (Bloom, 1994; Wisniewski et al., 1996). If the content of object-mass nouns were truly unindividuated, participants should not have employed number information to perform judgments of quantity. Thus, it seems that count nouns and at least some mass nouns (e.g. *silverware*) quantify over individuals. While count syntax entails individuation, mass syntax has no strong entailments. Apparently, the Quinian proposal regarding syntax-semantics mappings is incorrect.⁵

Above, we discussed two additional hypotheses regarding mass-count semantics. Based

⁵ An anonymous reviewer noted that judgments involving the referents of object-mass nouns may not always be clearly based on number. For example, when using silverware as ammunition for a cannon, what matters is total amount of metal stuff, not number of pieces. Thus, given a choice of two piles, we might choose the bigger pile. However, there are two reasons to believe that this type of example does not speak to the semantics of mass nouns. First, the example appears to involve re-conceptualizing the referents (e.g. as "stuff to fire"), and does not involve assessing amounts of silverware *qua silverware*. Second, in cases where the cardinality of sets is not readily discernable (e.g. when piles each contain large numbers of objects), volume or mass may act as a proxy for number (since the two are normally highly correlated). As evidence for this, the same intuition seems to apply for count nouns—when shown a thousand skinny cats and nine hundred and ninety fat ones, we may judge the smaller set to be more cats; however, when *told* the cardinality of each set the clear choice is the larger set—not the fatter one.

on the existence of object-mass nouns in English, both Chierchia (1998) and Gillon (1992) proposed that mass noun semantics must permit reference to individuals. While Gillon suggested that mass syntax is linguistically unspecified, Chierchia (1998) suggested that both count and mass nouns denote minimal parts, and that mass nouns are inherently plural. We believe that the results reported here do not follow naturally from either of these views. The problem in each case is how mass-count flexible terms like *string* and *stone* are represented. Since neither theory proposes a distinct interpretation for mass syntax (e.g. relative to plural count nouns), the distinct treatment of flexible terms in mass and count syntax is not an obvious outcome for either account. If the mass-count distinction had no direct bearing on denotation, then there should be no reason to expect a systematic shift in meaning.

As noted earlier, Gillon (1996) proposed that knowledge regarding the individuation of mass nouns is unspecified linguistically and is determined based on world knowledge of things referred to. Thus, upon hearing a term such as *furniture*, the language user determines, independent of language, that individual pieces of furniture are present in the world, and thus that the term refers to individuals. In such cases, the language user gains no knowledge regarding the individuation of the terms from mass syntax. As a result, the theory correctly predicts the treatment of object-mass nouns such as *furniture* and *jewelry*. However, the proposal does not appear to predict judgments for terms like *string* and *stone* in Experiment 3. For Gillon, evidence that the mass noun *string* denotes individual pieces of string comes from the fact that these are the things denoted by the corresponding count noun (e.g. *some strings*). However, despite the existence of clear, linguistically accessible, individuals in the world (as evidenced by the count usages of each word), participants in Experiment 3 failed to base judgments on number for mass

versions of the terms *string*, *paper*, *stone*, and *chocolate*.⁶ Thus, the mechanism of Gillon's (1996) proposal that allows the correct treatment of object-mass nouns (in addition to substance mass and regular count nouns) appears to make the wrong prediction regarding flexible terms such as *string* and *stone*.

In the case of Chierchia (1998), similar questions arise. As noted earlier, Chierchia (1998) proposed that all mass nouns refer to pluralities, and that the denotation of mass nouns is not qualitatively distinct from that of plural count nouns. Based on this, the proposal appears, like Gillon's, to make the correct prediction about the interpretation of count nouns, substance-mass nouns and object-mass nouns. However, for flexible terms like *string* and *stone* the situation is less clear. On the surface, nothing in the proposal is posited to distinguish the interpretation of count uses of terms like *string* from their mass uses. For example, Chierchia appears to believe that shifts in syntax should have no effect, at least across languages, "Pavarotti's hair is Pavarotti's hair, whether we talk about it in Italian or in English, i.e. whether we get at it through a mass noun or through a count noun. If we don't want semantics to start looking like magic, we have to say that in the real world "hair" and "capello" obviously denote the same stuff." (p. 88). However, elsewhere he suggests that flexible terms might be qualitatively different from other count and mass terms, in that they are related by a type shifter or conversion rule, whereby conversion of count to mass renders parts-of-x (e.g. *some house*) and conversion from mass to count renders portions-of-y (e.g. *a beer*). While such rules may

⁶ Note that pieces of string or stone satisfy the content of quantification by number (i.e. in being discrete individuals). Why these individuals should never be selected by mass syntax while individual pieces of clothing or furniture are is not indicated by Gillon's account. Below, we suggest a way in which the content of number judgments (i.e. quantification over individuals) can be maintained grammatically, while still explaining the difference between *string* and *furniture* type words. The difference, we argue, originates in acquisition, when the terms are initially added to languages.

patch up the problematic cases by specifying minimal parts for converted terms in a way not done for other count or mass items, it is too powerful: when applied to object-mass terms the "portions-of" type-shifter fails to render a coherent interpretation. If the expression "a furniture" is grammatical at all, it does not mean "portion of furniture pieces" (see footnote 8). Instead, object-mass terms must always occur with an overt classifier to achieve a portions-of reading, despite being able to occur as a count noun to denote types of furniture (e.g. *fine furnitures*). This prohibition on conversion seems to uniformly affect those words that Chierchia takes to be the strongest evidence for his proposal—object-mass nouns—while conversion works best for those terms that would otherwise present the greatest problem—terms like *string* and *stone*. Were it to be discovered that *only* nouns that quantify by non-number (in experiments like those presented here) are subject to a portions-of type shifter, Chierchia's theory would be forced to appeal to coincidence; the theory appears to make no predictions about the relationship between quantification of individuals and mass-count conversion.⁷

To summarize, each of the three theories of mass-count semantics discussed appears to have difficulties naturally integrating the comparative judgment results of Experiments 1, 2, and 3. While the Quinian proposal is able to account for count, substance-mass, and flexible terms, it

⁷ This possible problem with Chierchia's type-shifting mechanism is also suggested by two pieces of unpublished data. First, data from our lab fail to support Chierchia's prediction regarding terms like *hair*. In one study, speakers of French judged six tiny pieces of hair to be "plus de cheveux" (i.e. more hairs) than two long ones, while English speakers picked the two long pieces as "more hair". This pattern was also found for the three other "cross-linguistic flexible" terms tested: *pasta*, *toast*, and *spinach*, all of which are used as count nouns in French. It is difficult to see how Chierchia's theory could naturally predict this result. Systematically different denotations for mass and plural count terms appear to be necessary. Second, data from Japanese collected with Peggy Li, Yarrow Dunham, and Susan Carey suggest that Japanese speakers quantify by number around 40% of the time for English flexible terms and the same amount for cross-linguistic flexible terms (when shown the identical stimuli). This suggests that the context of reference is perfectly adequate for quantifying by number, but that only in languages without obligatory number marking is this possible in absence of count syntax.

does not adequately deal with object-mass nouns such as *furniture* and *jewelry*. In contrast, the inherent plurality and linguistic non-specification proposals both account for object-mass, count and substance-mass nouns. However, each encounters complications in simultaneously explaining the interpretation of both flexible nouns like *string* and object-mass terms like *furniture*. Based on the data described here, it seems that current theories of mass-count semantics have difficulty naturally accounting for both object-mass terms *and* the mass-count flexible terms.

An Alternative: Lexico-Syntactic Selection of Individuation

An alternative to these three existing views is that the referential entailments of a noun phrase can have either lexical or syntactic origins. Specifically, the referential entailments for a particular noun phrase might be contributed either by the phrasal syntax itself or by the lexical item acting as head noun. The idea can be unpacked into four basic claims. First, for most lexical items, the entailment of reference to individuals is created by use in a count noun context. This claim is consistent with the fact that all count nouns individuate, and the result from Experiment 3 that flexible terms are made to individuate when used as count nouns. Thus, the judgment that count uses of terms such as *string* and *stone* quantify over individuals can be described as resulting from the interpretation of phrasal count syntax. Second, the use of a term in a mass context creates no particular entailment or presupposition regarding individuation. That is, mass syntax is unspecified with regards to quantification over individuals.⁸ Third, linguistic individuation must always result from linguistic features. In the absence of linguistic

⁸ Note that this does not mean that particular mass nouns are unspecified, as is the case for Gillon (1996). As a result, non-specification does not predict equal likelihood to quantify by number or non-number for particular terms. In languages with obligatory number marking, like English, linguistic individuation must always result from linguistic features, and is not determined by world knowledge alone.

individuation quantification can occur along any number of dimensions. Thus, most mass nouns fail to individuate because mass syntax does not contribute this linguistic feature. Fourth, certain terms used in mass syntax individuate due to lexical features. For example, in the case of terms such as *furniture*, lexical features combine with unmarked mass syntax to create entailments about reference to individuals. In such cases, features that normally originate in count noun syntax are instead contributed by specific lexical items, thus allowing mass nouns to quantify over individuals as though they were count nouns, as per Experiments 1 and 2. This idea is schematized in Fig. 6 (see Bale and Barner (2004) and Barner and Bale (2002), for a full defense of this view).

Given this view of the mass-count distinction, the results from Experiments 1–3 can be explained. For most terms, whether or not a quantity judgment is based on number is determined by the type of syntax in which it is used. Thus, count nouns refer to and quantify over individuals, while mass nouns (lacking a syntactic entailment regarding individuation) do not. Such is the case for the flexible terms in Experiment 3 and the count and substance-mass nouns in Experiments 1 and 2. For exceptional terms such as *furniture* it is clear that syntax does not create the entailment that reference is to individuals. Thus, a lexical feature for such items is posited, thereby accounting for the quantity judgments shown by children and adults in Experiments 1 and 2.

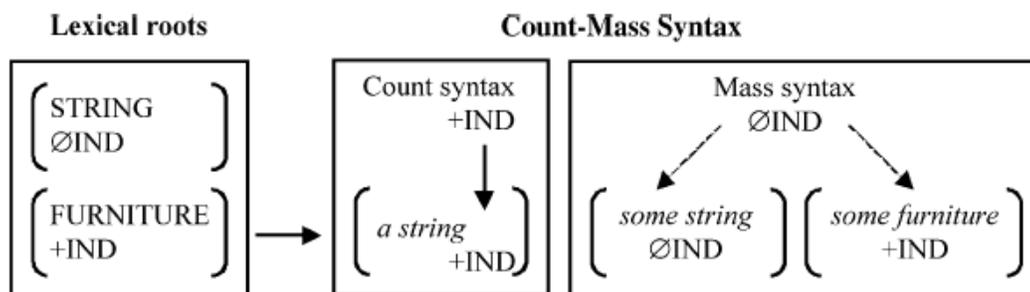


Figure 6. Lexical and syntactic origins of individuation. Count syntax supplies the feature *+individual* (+IND), while mass syntax is unspecified for this feature (ØIND). Terms specified lexically as +IND (e.g. *furniture*) individuate in mass syntax, while lexical items lacking this feature (e.g. *string*) individuate only in count syntax.

By our analysis, the *+individual* feature amounts to a grammatical element whose primary semantic function is to license the use of a principle of individuation (see Macnamara, 1986, for discussion). As a result, the feature should only be licit when used with a lexical root that supplies a principle of individuation. For example, the lexical concept DOG supplies a principle of individuation that allows a pair of dogs to be identified as two discrete individuals, rather than one amorphous amount of DOG-STUFF. This principle is licensed in the context of count nouns phrases such as "*those dogs (on the road)*". However, in the context of a mass noun phrase such as "*there is dog (on the road)*" the principle cannot be accessed linguistically and a default interpretation prevails, such that DOG quantifies non-numerically. Similarly, the lexical concept FURNITURE supplies a principle of individuation that is made available via lexical specification of the *+individual* feature. In contrast, a lexical concept that lacks a principle of individuation (e.g. FUN) should be unable to occur with the *+individual* feature. The fact that we cannot conceive of what would constitute a unit of fun (i.e. its lack of a principle of individuation) is sufficient to restrict its grammatical distribution to mass contexts only. This is distinct from the case of object-mass nouns, where potential units for quantification are readily apparent, but use with count syntax is prohibited by the lexical *+individual* feature. Importantly,

the conceptual apparatus associated with the principle of individuation is distinct from the linguistic feature that licenses its direct expression in language. As a result, pre-linguistic children and speakers of languages that lack the mass-count distinction (e.g. Japanese, Mandarin) may still have the conceptual capacity to distinguish "many strings" from "much string". Given that the specification of number is not obligatory in such languages (and is performed optionally with classifiers), determining whether terms individuate may rely on non-linguistic cues (i.e. based on the assumption that grammatical specification of individuation is only obligatory in languages where number is obligatorily expressed). Thus, speakers of Japanese, for example, may rely heavily on pragmatics to disambiguate reference (see footnote 7).

While this type of approach is new for the domain of mass-count semantics, it is an old idea in the description of natural language. At least two other domains exist where grammatical features are normally added in the syntax, and sometimes by particular lexical items. First, in the case of pluralization, plural morphemes are normally added via a rule to a word in context, generating *cats*, for example, from *cat*. However, in irregular cases, certain items have the plural feature specified lexically (e.g. *geese*, *children*). These items cannot be used with the plural morpheme (e.g. **geeses*, **childrens*). Similarly, the past tense can be expressed by either regular morphology (e.g. *jumped*; *smiled*) or lexically specified items (e.g. *ate*; *swam*). Again, lexically specified items cannot appear with regular morphology (e.g. **ated*, **swammed*).

On analogy to these cases, our proposal predicts that any mass noun that quantifies over individuals should be prohibited from being used in a count noun context to refer to those same individuals. That is, individuation features can only be realized once within a single noun phrase construction, thereby prohibiting the co-occurrence of lexical and phrasal features. In the current study, the terms *furniture*, *mail*, *jewelry*, *clothing* and *silverware* were consistently judged as

quantifying over individuals when used as mass nouns, and yet cannot be used as count nouns to name the same individual objects (e.g. **those two furnitures are painted brown*).⁹

We would like to emphasize that by our proposal, the mass-count distinction is explained by a single positive feature, +individual, with the important result that mass syntax is a default category without a unique feature to define its interpretation. The reasons for adopting this view are subtle, yet important. Four main arguments favor this approach. First, it appears that no more than one feature is needed to explain the distinction; thus, parsimony suggests that where two descriptively adequate theories exist, the simpler one should be chosen in absence of further evidence. Second, given the existence of object-mass terms, adopting a theory with explicit mass features would require an account of how these features could fail to be interpreted in the context of lexical exceptions (e.g. why furniture is not used to quantify by mass or volume). Third, although various languages have been analyzed as having only mass syntax (i.e. lacking explicit, obligatory number marking), there is no evidence for the existence of languages that have only count syntax (see Allan, 1980; Chierchia, 1998). Given a single feature account, this situation could be easily explained as resulting from an absence of the syntactic +*individual* feature in certain languages. However, by a two-feature account, these languages would either require a qualitatively different analysis, or require that all nouns be represented as - count (or + mass). Thus, a language without a mass-count distinction would nonetheless require features on every noun in order to maintain a uniform cross-linguistic analysis. Finally, perhaps the strongest evidence for a single feature account of the mass-count distinction comes from the analysis of

⁹ Of course, reference to types of furniture may permit count syntax (e.g. “Furniture Barn, vendors of fine imported furnitures for over 30 years”). This indicates that the +*individual* feature is specified for particular senses of object-mass terms (i.e. designating reference to individual pieces). This is not unlike the possibility of pluralizing irregular plurals to access the type reading (e.g. indigenous peoples; exotic fishes).

dimensional incommensurability (see Kennedy, 1999).

As noted by Kennedy (1999) in his discussion of gradable adjectives, comparative constructions cannot involve multiple dimensions. Thus in the case of adjectives, "a comparative construction is semantically well-formed only if the compared adjectives have the same dimensional parameter" (p. 50). By Kennedy's analysis, the fact that degrees of height and width can be compared while degrees of lateness and wealth cannot is due to the dimensional commensurability of the first pair and the incommensurability of the second.¹⁰ Interestingly, while comparisons involving any two count nouns are always commensurable, pairs of mass nouns are often incommensurable, even when they have roughly the same content as commensurable count noun pairs. For example, given a situation where a person has three hopes and two pieces of string, we can easily conclude that the person has more hopes than strings. However, it is impossible to meaningfully compare these same phenomena when named by mass nouns (e.g. to decide whether one has more hope or string). While count nouns unambiguously specify number as a dimension for measurement, allowing the comparison of amount between any two sets, mass terms quantify by an unbounded number of dimensions. Although the cardinality of sets of shoes, hopes, differences, and even sets of furniture and silverware can be compared, there is no common dimension of measurement for hope, wealth, mustard, and humor. Clearly, if there were a unifying specification of dimension by mass syntax this asymmetry would not be expected. This, we believe, represents important evidence that a single positive

¹⁰ As Kennedy notes, comparative judgments may also involve comparison of the relative values of two points on incommensurable normative dimensions. Thus, we may decide that someone is richer than they are smart by evaluating their wealth and intelligence relative to a population and comparing their place on each scale. The same process is possible for mass nouns involving normativity (e.g. *money*, *brains*). The crucial point is that nonnormative comparisons (e.g. *string*, *hope*) require commensurability, which is provided automatically by count syntax but not by mass syntax.

feature underlies the mass-count distinction.¹¹

To summarize, we have proposed that the facts of mass-count semantics are best described by a theory that posits a single lexico-syntactic feature for licensing individuation. The lexico-syntactic *+individual* feature accounts not only for ordinary mass and count nouns, but also for object-mass and mass-count flexible terms. In addition, a single feature may best account for cross-linguistic evidence and the facts of dimensional commensurability.

Acquiring the Mass-Count Distinction

If this description of mass-count semantics is correct, then a satisfactory account of language acquisition must describe how the feature *+individual* is correctly attributed to count syntax in most cases, and also how the feature is sometimes assigned to specific lexical items like *furniture*, and why *these* particular terms are lexically specified and not others. Furthermore, the account should provide some indication of why languages tend to vary with respect to whether words like *furniture* are mass or count.

Normally, when adults speak of individual things, the grammatical default for expressing individuation is the use of count syntax. Based on this, a good strategy for acquiring the interpretation of count syntax would be to always assume that the *+individual* feature is syntactic (i.e. not lexical), so long as such a parse is consistent with morpho-syntactic information made available in the utterance. In inconsistent cases, like the use of mass nouns to refer to individuals, the feature could be assigned to the lexical level, resulting in object-mass terms. In spirit, this acquisition process would not differ significantly from how children must acquire irregular plurals, normally assigning plurality to the plural morpheme, and in exceptional cases attributing

¹¹ As an aside, the facts regarding dimensional incommensurability seem difficult to reconcile with Chierchia (1998). If all mass nouns denote sets of atoms, number should be a common dimension of measurement for all mass terms, at least to the same extent that it is for count terms.

it to lexical items.

In addition to explaining how children might initially map mass-count morpho-syntax to semantic interpretation, this proposal also provides an explanation of how object-mass nouns might originally arise in a language, and thus why there are cross-linguistic differences in their prevalence. For example, in French, most English object-mass terms are used mainly as count nouns. These include: furniture (des meubles), clothing (des vêtements), jewelry (des bijoux), and silverware (des utensils). Given an input language that is devoid of object-mass nouns, a child might still come to acquire them in one of two ways. First, in a context involving multiple novel objects, the child might incorrectly infer that a mass-count ambiguous expression like "Look at my blicket" refers to all of the objects, and not just one. Having not heard a plural morpheme, he or she might then conclude that the term must be a mass noun, and must have the *+individual* feature specified lexically. Second, the child might correctly infer that the adult has referred to multiple individuals, but fail to interpret the adult's use of the plural morpheme (see Kouider, Wood, Halberda, & Carey, under review, for evidence that young children systematically fail to perceive/interpret the plural morpheme in English after having acquired other plural morpho-syntax). Here too, the combination of apparent non-plural syntax with reference to multiple individuals might support the specification of a word as *+individual*.

Evidence from Gordon's (1985) study of the mass-count distinction lends support to this idea of how object-mass nouns arise. In his study, Gordon (1985) provided evidence that children aged 3;0–5;11 sometimes disambiguate terms like *garn* in "Look at the garn" as mass or count according to whether one or many physical objects are present. Specifically, when a single object was named with ambiguous syntax, children later pluralized the novel term to names multiple objects. However, when multiple objects were named with ambiguous syntax, children

failed to later pluralize the term, suggesting that it had been interpreted as a mass noun. As noted above, such a process would lead to misacquiring terms as object-mass nouns either in cases where children misconstrued the reference of singular count nouns as plural, or in cases where reference was to multiple objects, but children failed to interpret the plural morpheme.

Languages like English, which typically rely on a single consonant to relay plural information, may make detection of the plural more difficult than languages such as French, which requires number agreement on determiners. This in turn might explain the diachronic emergence of object-mass nouns, and thus their difference in frequency in English and French.

The final question we would like to address is why some words become object-mass terms and others do not. As noted by several researchers, many of the words that we have called object-mass nouns share particular properties such as being superordinate terms and denoting artifact kinds. Also, superordinate mass nouns may differ in subtle ways from superordinate count nouns (Bloom, 1990; Markman, 1985; Wisniewski et al., 1996). For example, in a study by Wisniewski et al. (1996) adult subjects judged that referents of mass superordinates (e.g. tables, chairs for furniture) are more likely to co-occur than referents of count superordinate terms (e.g. lions, tigers for the superordinate animal), and that people are more likely to interact with multiple mass superordinate referents at one time. In a separate experiment, participants made speeded category-membership judgments of basic-level concepts belonging to either mass or count superordinate categories. When asked to judge whether a single noun belonged to a superordinate category, subjects were faster for count superordinates than for mass superordinates (e.g. ferns are plants vs. chairs are furniture). But when test sentences involved more than one subordinate term (e.g. a pig and a cow are livestock vs. a lion and a tiger are animals) performance was faster for mass superordinates. From this, Wisniewski et al. concluded

that object-mass terms like furniture may encode "knowledge about an unindividuated group of objects united by spatial, temporal, and functional contiguity" (p. 292).

However, the evidence presented here is consistent with a slightly different interpretation of these facts. While Wisniewski and colleagues imply that a word's use in mass syntax causes us to perceive its referents as spatio-temporally contiguous objects, it seems equally sensible to reverse this conclusion and suggest that referring to sets of spatio-temporally contiguous objects makes a word more likely to be acquired as a mass noun. In fact, exactly this result is predicted by Gordon's study, discussed above, where children parsed ambiguous expressions as mass terms when they were used in the presence of multiple objects. Thus, superordinate terms that refer to spatio-temporally contiguous objects may increase the likelihood of parsing "errors" where singular terms that refer to one member of a group are interpreted as mass terms. Also, given this type of mistake (i.e. parsing a singular term as a mass noun), superordinate terms would make a substance reading difficult to entertain (since objects of different kinds are unlikely to be made from a single substance), thereby making a *+individual* specification all the more likely. Thus, superordinate terms that refer to objects with high spatio-temporal contiguity may facilitate the diachronic emergence of object-mass terms by making a plurality interpretation more likely, and a substance interpretation less likely.¹²

It should be noted that the acquisition mechanism under discussion could also be used to explain cases where object-mass terms are mis-acquired as count nouns. This could happen in cases where the child hears a mass-count ambiguous expression (e.g. don't jump on the

¹² The ability of mass nouns to refer to multiple individuals seems consistent with Markman's (1985) observation that mass syntax makes the acquisition of superordinate terms easier than count syntax. By allowing reference to multiple things of different kinds on all occasions of use (unlike, for example a singular superordinate term), mass syntax could more readily force the conceptual move to a superordinate level.

furniture), and believes that a single object is being referred to. Given the child's assumption that number should be expressed syntactically, he/she might map the term furniture to count syntax in this situation. Indeed, evidence from Bloom (1994) suggests that just such errors might occur (e.g. a bacon, a furniture).

Summary

To summarize, we presented a study of quantity judgments in English-speaking children and adults, and found that for both groups some mass nouns, like water, do not quantify over individuals, while others, like furniture do. This result suggests that the Quinian proposal regarding mass-count semantics cannot be maintained, and that the corresponding one-to-one mappings between syntax and semantics do not exist. Also, we found that mass-count flexible terms were interpreted as quantifying over individuals when used with count syntax, but not when used with mass syntax. This result appears to cause complications for the inherent plurality and linguistic non-specification views of mass-count syntax. As an alternative, we argue that quantificational interpretations are selected by grammatical features, which take their origin in both count syntax and irregular lexical items (i.e. object-mass nouns). This model is consistent with the current study, and also provides a natural explanation of the distributional properties of object-mass nouns. Finally, the proposed account supports a view of acquisition where children normally assign the *+individual* feature to count syntax, unless provided with morphosyntactic and referential evidence for lexical specification.

Acknowledgements

We would like to thank Sylvia Yuan for her help in testing and subject recruitment, and Alan Bale, Susan Carey, Peggy Li, and Laura Wagner for very helpful comments.

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