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Lexical, syntactic, and pragmatic sources of countability: An experimental exploration of the

mass-count distinction

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Language provides a system of mental representation that encodes meaning at multiple levels. When a speaker utters a sentence, inferences regarding its meaning can be derived from its grammatical structure, from the lexical meanings of the individual words that are used, and also via pragmatic inference – by considering how the chosen utterance contrasts with alternative utterances that the speaker might have uttered but chose not to.

Among the many case studies of meaning that linguists have investigated, the mass-count distinction may offer the clearest window into how lexical, syntactic, and pragmatic processes interact. The mass-count distinction is not only among the most studied semantic topics in linguistics, but is also heavily studied by philosophers, psycholinguistics, developmental psychologists, and neuroscientists. Researchers in these areas have made striking progress in understanding the cognitive underpinnings of the distinction, their origins in development, how conceptual representations get linked to grammar, and how pragmatic inferences are used to enrich semantic meanings in online processing.

In the present chapter, we provide an overview of this remarkable progress, and how the mass-count distinction provides a way forward for understanding other domains of linguistic meaning, and a model for interdisciplinary language research. In this chapter, we focus on the semantic notion of countability. In the first part of the paper, we begin by sketching a history of how countability has been measured in philosophy, psychology, and linguistics, and what the sum of this evidence suggests about its representation both at the lexical and syntactic levels. In the second part of the chapter we argue that a complete model of the compositional semantics of the mass-count distinction ultimately depends on a theory of lexical concepts, and how lexical items encode criteria for individuation (or countability). We argue that this problem remains unsolved in the current literature in large part because theories of concepts attempt to explain too

much, and that some of the most difficult phenomena are explained when lexical meanings are enriched via pragmatic contrast. To make this case, we present evidence from children's surprising failures to count whole objects until relatively late in development.

Part 1. Lexical and syntactic sources of countability

Since at least the 1950's, the mass-count distinction has acted as a productive test case for understanding the relationship between language, semantic content, and perception. The topic has been studied by linguists, starting in the modern era with Jespersen (1924) and Bloomfield (1933), and picked up in the 1960's and 70's by philosophers of language like Quine (1960, 1969), Parsons (1970), and Burge (1972), among others (see also Pelletier, 1979, 2010, and articles therein). Since then, the topic has been studied extensively across disciplines, including formal semantics (Bach, 1986; Bunt, 1979, 1985; Chierchia, 1998, 2010; Gillon, 1992; Higginbotham, 1994; Krifka, 1989, 1995; Link, 1983; Verkuyl, 1993; Rothstein, 2010) psycholinguistics (Barner, Wagner, & Snedeker, 2008; Gillon, Kehayia, & Taler, 1999; Iwasaki, Vinson, & Vigliocco, 2010; Markman, 1985; Wisniewski, Imai, & Casey, 1996), neuroscience (Grossman, Carvell, & Peltzer, 1994; Mondini, Angrilli, Bisiachhi, Spironelli, Marinelli, & Semenza, 2008; Vigliocco, Vinson, Martin, & Garret, 1999), language acquisition (Barner & Snedeker, 2005, 2006; Bloom, 1999; Brown, 1973; Gathercole, 1985; Gordon, 1985, 1988; Macnamara, 1982; Soja, 1992; Samuelson & Smith, 1999; Subramanyam, Landau, & Gelman, 1999), and by cross-linguistic researchers interested in variability in the expression of mass and count syntax (Cheng & Sybesma, 1998, 1999; Chien, Lust, & Chang, 2003; Krifka, 1995; Li, Barner, & Huang, 2008; Matsumoto, 1987; Senft, 2000; Yamamoto & Keil, 2000) and the effects such variability has on semantic content and non-linguistic thought (Barner, Inagaki, & Li, 2009; Barner, Li, & Snedeker, 2010; Gentner & Boroditsky, 2001; Imai & Gentner, 1997; Li,

Dunham, & Carey, 2009; Li, Ogura, Barner, Yang, & Carey, 2009; Lucy, 1992; Mazuka & Friedman, 2000; Soja, Carey, & Spelke, 1991; Srinivasan, 2010).

The range of topics covered by this now vast literature is heterogeneous. However, this interdisciplinary approach has flourished – in a way almost completely foreign to other areas of semantics – because of a central assumption that count nouns denote kinds of countable atoms, and that these atoms correspond to psychological representations of objects and abstract individuals. Perhaps few other psychological phenomena are understood as well as object perception and individuation – a topic that has received experimental attention since the Gestalt psychologists, and which has subsequently been studied in work on visual attention, object tracking and permanence in infancy, and numerical cognition in adults, infants, and non-human animals, among others. Thus, unlike in many areas of semantics, the study of the mass-count distinction has benefitted from a well-articulated psychological theory of conceptual content, to which formal semantic representations might correspond. Among the many consequences of this, perhaps foremost in importance is that theories of the mass-count distinction generate predictions that can be readily tested using simple experimental methods. Since we know what an individual is – both semantically and psychologically – we can ask whether claims about the relationship between mass-count syntax and individuation are supported by experimental evidence – whether it be from psycholinguistics, neuroscience, or language acquisition.

Here, our purpose is to provide a non-exhaustive overview of the history of experimental efforts to understand the semantics of the mass-count distinction, with a focus on how lexical concepts and syntactic structures interact to generate meaning. Our proposal will be that the mass-count distinction cannot be properly understood if it is treated as a distinction between classes of words (i.e., lexical categories), though lexical meanings are critical to restricting the

interpretation of nouns and their use as mass and count. Our position is that some nouns (e.g., *shoe*) have semantic and conceptual content which, when used in grammatical contexts that license individuation – e.g., count syntax – generate specific individuated meanings (e.g., such that *a shoe* labels one whole shoe). Other nouns do not provide such criteria for individuation (e.g., *water*), and thus are either uninterpretable when used in count syntax, or result in coerced meanings (e.g., a contextually specified unit of water). Critically, although objects and substances are prototypical instances of entities denoted by count and mass nouns respectively, our argument will be that a focus on these ontological classes is ultimately misleading in the case of the mass-count distinction, and that the formal semantic distinction must be captured at a more abstract level.

1.1. Early experimental studies of the mass-count distinction: Objects and substances.

Experimental research on the semantic content of mass and count nouns has a relatively long history in psychology, dating back to at least Roger Brown, who conducted one of the first studies of word extension in children (Brown, 1957), spawning a wave of studies over the following five decades. Brown's experiment was important, both because it created a method for assessing how grammatical categories relate to meaning, but also because it created a precedent for how to conceive of the mass-count distinction, as rooted in the ontological distinction between objects and substances.

In his experiment, conducted with a small group of 3- to 5-year-old children, Brown presented subjects with a scene depicting “a pair of hands performing a kneading sort of motion, with a mass of red confetti like material ... piled into a blue-and-white striped container.” Thus, the scene depicted an action (kneading), a substance (confetti), and an object (the container). Brown next presented three words to describe the scene (*niss*, *sib*, and *latt*), which were

presented in different grammatical frames, intended to indicate status as count noun, mass noun, or verb. For example, in one case the word *sib* was used to describe the action of kneading as follows: “Do you know what it means to *sib*? In this picture you can see *sibbing*. Now show me another picture of *sibbing*.”¹ If the word was presented as a count noun, children heard, “Do you know what *a sib* is? In this picture you can see *a sib*,” etc. And for the mass presentations, they heard, “Do you know what *sib* is. In this picture you can see *some sib*.” For the nouns, children were asked at test, “Now show me another picture of *a sib* / of *some sib*.”

At test, children were asked to map the new word to one of three pictures, which held constant either the object, the substance, or the action. What Brown found is that children strongly preferred the object-match when the word was first presented as a count noun, that they preferred the substance-match when presented with the mass noun, and that they preferred the action-match when presented in Brown’s verb context.

Subsequent studies, conducted in the several decades since, have replicated this finding and extended it in a variety of ways. Early among these efforts was a word extension experiment by Katz, Baker, and Macnamara (1974), which showed that still younger children (22- to 24-month-olds) differentiated count nouns from proper nouns (see also Gelman & Taylor, 1984). Later studies, which focused more directly on mass and count nouns, repeatedly found that children are more likely to associate count syntax with objects, and mass nouns with substances,

¹ It is generally not noticed that Brown’s verb condition presented the novel action word in *mass* syntax two out of the three times it was used (i.e., in the gerundive form *sibbing*). This suggests that children are quite happy to map nouns to actions – somewhat contrary to the conclusion generally drawn from this work, that children map verbs to actions, and nouns to either objects or substances. We return to this issue when we discuss abstract mass nouns.

when given a forced choice between the two (Dickinson, 1988; Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988; Samuelson & Smith, 1999; Soja, 1992). For example, in one such study, Soja, Carey, and Spelke (1991) presented 2-year-old English-speaking children novel referents that were either solid or non-solid, and that varied in shape. Labels for these items were presented either with what they called “neutral” syntax (e.g., *the blicket*), in count syntax (e.g., *a blicket*), or in mass syntax (e.g., *some blicket*). At test, children were then shown two stimuli, one that matched the initial item only in shape (but not substance) and the other which matched the original item in substance (but not shape). Overall, when children initially saw a solid object during training, they extended the label to a shape-matched test stimulus, but when they saw a non-solid stimulus during training they extended its label to a substance-matched test item. This was true to the same degree whether or not children received supportive (unambiguous) mass-count syntax. In a later experiment, Soja (1992) crossed the object-substance distinction with the mass-count distinction, and found that children were relatively insensitive to syntax when learning object words, but not when learning substance words. Specifically, 2 ½ year old children overwhelmingly extended words according to shape whenever these labels referred to solid things; they extended by shape 90% of the time when the label was used in count syntax and 76% of the time when it was used in mass syntax. For non-solids, however, children showed a much bigger effect of syntax: they extended by substance 91% of the time when they were labeled with mass nouns, but only 51% of the time when labeled with count nouns (suggesting that about 50% of the time, they extended according to shape when non-solid substances were labeled with count nouns).

Similar results have been found repeatedly in subsequent studies (Dickinson, 1988; Imai & Genter, 1997; Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988; Samuelson &

Smith, 1999; etc.). Children strongly assume that count nouns label objects (or non-solid portions), but accept mass nouns more freely as labels for either substances or objects. For example, in one study Subrahmanyam, Landau, and Gelman (1999) found that 3-year-old children extended a novel noun labeling a solid entity by shape 90% of the time when it was introduced as a count noun, and 86% of the time when it was introduced as a mass noun. This shape bias for mass nouns declined somewhat with age, but nevertheless remained at 30% in adult subjects, suggesting that even mature speakers of English are willing to accept objects as referents of mass nouns. Also, critically, the tendency to accept mass nouns as labels for objects is even greater when the novel referents have complex shapes, suggestive of a function. In a word extension study by Barner and Snedeker (2006), both 3-year-olds and adults extended novel mass nouns by shape more than 50% of the time (62% and 53%, respectively), when the nouns labeled complex solid objects. Thus, for these stimuli, there was a slight preference to extend mass nouns according to shape, rather than substance.

These studies of how subjects relate the mass-count distinction to objects and substances suggest three conclusions. First, there is not a 1-to-1 mapping between mass-count syntax and the object-substance distinction. While count nouns are often used to label objects, subjects of all ages are also willing to accept objects as the referents of mass nouns, even when substance interpretations are readily available (e.g., in a two alternative forced-choice task). Second, because children are *less* likely to associate mass-count syntax with an object-substance distinction than adults, the object-substance distinction is almost certainly not the foundation of the mass-count distinction in language acquisition. Third, not only does the object-substance distinction fail to capture how children interpret mass and count nouns, but it also doesn't capture the subtleties of adult usage. In particular, adults often extend count nouns to label

portions of non-solid stuff, which are not in any normal sense “objects” (e.g., “Two *waters*”).

Thus, although objects and substances may be prototypical referents of count and mass nouns, the actual mass-count distinction appears to have a more abstract foundation, which may be appreciated from early in language acquisition.

Some early work on the mass-count distinction, conducted in the 1980’s and 90’s argued for this more abstract analysis, drawing upon intuitions from formal semantics and the philosophy of language. In one such study, conducted as a test of so-called semantic bootstrapping theories of language acquisition (Braine, 1992; Fodor; Grimshaw, 1981; Macnamara, 1982; Pinker, 1984; Schlesinger, 1971; see also Gentner, 1982), Gordon (1985) hypothesized that children were relatively unconcerned with the object-substance distinction when classifying nouns as mass or count, and that instead they cared more about the syntactic profiles of words, such that they would accept a substance noun as count or an object noun as mass. In his experiment, Gordon presented 3-, 4-, and 5-year-olds with either a solid object, a collection of solid objects, or a portion of non-solid stuff (e.g., in a test tube), and then presented one of two labels: “This is *a garn*” (singular count) or “This is *some garn*” (mass). Children were then shown either a collection of things like those shown during the object training (if the training stimulus was a solid object or collection) or a set of test tubes containing the non-solid substance used during training (if they were trained with the non-solid), and were told: “Over here we have more...”. Children were then prompted to complete the phrase, as in the classic Wug test (Berko, 1958). What Gordon found was that most children pluralized the novel word – e.g., *garms* – when they were presented with a single solid object labeled with a singular count noun. However, when they were presented a collection of solid objects or a portion of non-solid stuff, and heard the stimuli labeled with mass syntax – “This is *some garn*” – they almost never

used the plural, suggesting that their use of the plural was conditioned on the syntax of the training sentence, rather than on the ontological status of the training stimulus (i.e., its status as object or substance).

From this study, Gordon argued that the mass-count distinction is not learned from the object-substance distinction, and that in adults it is also more abstract, and related to the quantification of *individuals*, which include not only objects, but also more abstract things like events, ideas, and actions. While not necessarily a new idea among linguists, Gordon's proposal was controversial among developmental psychologists at the time, who had hoped to anchor syntactic learning in transparent categories that could be identified independently of language. To these psychologists, it seemed unlikely that young children could identify abstract individuals for the purposes of acquiring the semantics of the mass-count distinction, without already having acquired that distinction in the first place, scaffolded by an ontological object-substance distinction.

However, around the same time that Gordon was conducting his experiments, others were beginning studies of abstract mental representations in preverbal infants, using subtle looking time measures. In one early study, for example, Starkey, Spelke, and Gelman (1983) found that when 6- to 8-month-old infants were presented two images – one depicting two objects and the other depicting three – they preferred to look at the image that matched a subsequent auditory sequence of either two or three sounds (see also Féron, Gentaz, Streri, 2006; Kobayashi, Hiraki, Mugitani, & Hasegawa, 2004). Based on such results, Starkey et al. argued that infants must represent numerosity amodally, such that they can compare number across objects and sounds. Later studies supported this idea that infants and older children represent number amodally, and thus that they can represent and compare abstract individuals. Infants notice numerical

differences between sequences of jumps (Sharon & Wynn, 1998; Wynn, 1996), and between numbers of collections (Wynn, Bloom, & Chiang, 2002), and can extract individual actions from continuous sequences of ongoing events (Hespos & Saylor, 2009). Older children, who are just learning to count objects, also happily count abstract individuals like jumps (Wagner & Carey, 2003; Wynn, 1990). Also, based on Gestalt cues like common motion, they learn nouns that label collections of objects (Bloom & Keleman, 1995).

Later work on the mass-count distinction, described in the following section, fortified this view that children's early grammatical distinction is rooted in individuation and quantification, rather than in the object-substance distinction. Also, using methods that test quantification, rather than reference to objects and substances, these later studies showed that the mass-count distinction is asymmetric, such that while count nouns denote individuals (or sets thereof), mass nouns can denote a wider range of phenomena including objects and substances, but also a host of other abstract phenomena, individuated or not.

1.2. Quantification over individuals and mass-count asymmetry: Evidence for lexical and syntactic sources of individuation

The main thesis of this chapter is that the meanings of mass and count nouns result from the interaction of three components of language – lexical roots, syntax, and pragmatic inference. The evidence for this idea, we believe, is provided most strongly by evidence from language acquisition. By testing how children's interpretation of mass and count nouns changes over time, we can pull apart the contributions of these three components, and show how each contributes to interpretation in a way not possible in adults.

The first step in this argument was to provide a brief history of early work on the mass-count distinction, and how in the experimental literature researchers gradually converged on the

idea that the distinction is rooted in quantification, rather than in reference to objects and substances. Another important finding in this literature was that the mass-count distinction appears to be asymmetric. Although children and adults have a strong preference to link count nouns to countable things (whether objects or portions of stuff), they do not have robust preferences for mass nouns, and can learn mass nouns that denote concrete objects.

In this section we present recent evidence in favor of both of these conclusions, based on studies of mass-count quantification. Also, we argue that the asymmetry between mass and count nouns provides strong evidence that there are both syntactic and lexical sources of individuation – i.e., that syntactic count functional heads specify individuation, whether for non-solid substances, actions, or novel phenomena, and that lexical semantic representations can also specify individuation and quantify over individuals when used in mass syntax.

In linguistics, the idea that the mass-count distinction is defined in terms of individuation (or atomic reference) emerged relatively early, and was expressed both informally (e.g., see Pelletier, 1979, and papers within), and in formal algebraic models (e.g., Link, 1983). Disagreement among these theories focused primarily on the semantic treatment of mass nouns, with relatively broad agreement with respect to count nouns, which by most accounts denote sets of atomic individuals. However, prior to recent empirical work, the distinct empirical predictions of these different approaches had not yet been tested.

According to one broad class of accounts, which we will call the Quinian Correspondence hypothesis, while count nouns divide their reference and denote countable individuals, mass nouns do not, and instead denote various types of non-individuals. A version of this idea is proposed by Link (1983, 1998) and also by many psychologists who study the mass-count distinction (e.g., Bloom, 1994, Bloom, 1999, Gordon, 1985, Macnamara, 1986; Soja,

1992; Wisniewski et al., 1996, and many more). According to Wisniewski et al. (1996), for example, language users “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).

In favor of this idea, two linguistic tests have been proposed to show that only count nouns individuate. The first, described by Quine, is cumulative reference. According to Quine, only mass nouns refer cumulatively. For example, for a mass noun like *mud*, if A is *mud* and B is *mud*, then A and B taken together is also *mud*. In contrast, the same inference is not valid for a count noun like *shoe*. If A is *a shoe* and B is *a shoe*, it is not the case that A and B taken together are *a shoe*. However, as noted by Gillon (1996), cumulative reference, though relevant to understanding the semantics of singular and non-singular reference, does not characterize the difference between mass and count, since plural count nouns refer cumulatively: if the things in box A are *shoes* and the things in box B are *shoes*, then the things in the boxes A and B taken together are also *shoes* (see Gillon, 1996; Landman, 1991; Link, 1998; Pelletier, 1979; Schwarzschild, 1996). Thus, rather than carving out a difference between mass and count nouns, cumulative reference is a shared attribute of mass nouns and plural count nouns (see Chierchia 1998; Gillon, 1992, 1996).

A second and related semantic criterion for differentiating mass and count nouns was later proposed by Cheng (1973). Specifically, he argued that only mass nouns are subject to divisibility of reference: a portion of *mud* divided in two arbitrary portions is still *mud*, but a *shoe* divided in two arbitrary pieces is no longer a *shoe*. However, this generalization fails to describe many count nouns, and a good number of mass nouns as well. First, many count nouns are subject to divisibility: a *string*, *fence*, *rope*, *stone*, *curtain*, and *party* can each be divided into two

arbitrary pieces, resulting in two individuals that can be labeled by the same count noun. Second, many mass nouns do not admit arbitrary divisibility: *furniture*, *clothing*, *jewelry*, *luggage*, *underwear*, *mail*, and *ammunition* each have minimal parts, which if divided no longer count as *furniture*, *jewelry*, *luggage*, etc. Just as half a shirt is not *a shirt*, it is also not *clothing*.

In response to these problems, several linguists have argued against the Quinian view, and suggested that individuation is not restricted to count nouns. According to one such account, proposed by Gillon (1992, 1996), whereas count nouns specify reference to countable individuals, mass nouns are unspecified with respect to individuation. To determine whether a mass noun individuates, on Gillon's view, the language user must look out into the world: "World knowledge tells one that ammunition has minimal parts, or atoms, known as rounds" (p. 9). In other words, the semantics of mass and count nouns can be known by identifying what types of entities each class of word refers to in the world. Consequently, on this view, nouns that can be used flexibly as either mass or count (e.g., *a string*, *some string*) must always denote individuals both in their mass and their count forms, since to convert a noun from mass to count "requires that its denotation must be such that it has minimal parts, or atoms" (p. 28).

Chierchia (1998) proposed a similar, though stronger, idea. On his account, which he labeled the inherent plurality hypothesis, not only do mass nouns like *furniture* and *jewelry* denote sets of countable individuals, but so too do substance nouns like *mustard*, and even abstract nouns like *hope*. In these cases, atoms exist, but are either difficult to specify or vague in nature. Thus, on his view, "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). And like Gillon, Chierchia predicted that flexible mass nouns like *hair*, *string*, and *stone* must denote the same things whether used in mass syntax or in count syntax. In reference to the Italian word for hair, *capelli*,

which is a count noun unlike in English, Chierchia argued that, “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... Yet, on most theories, Pavarotti's hair is some kind of atomless substance in English, but turns into an atomic one in Italian. 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)

Although the primary semantic tests for identifying nouns that individuate – e.g., cumulativity and divisivity of reference – fail to differentiate mass and count nouns, proponents of the Quinian view nevertheless resist the idea that some – or perhaps even all – mass nouns denote countable things. Instead, by Quinian accounts, appearances of things in the world can be deceiving, and what really matters is not how things appear in the world, but instead how these things are encoded linguistically. For example, proponents of the Quinian view propose that words like *furniture* and *jewelry* do not in fact pick out countable things like chairs, couches, necklaces, and rings, but instead cause language users to construe these entities as unindividuated masses. In the words of Wisniewski et al., “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). Likewise, on this view, the words *capello* and *hair* do not obviously denote the same stuff. The first word – *capello* – denotes a kind of countable thing (i.e., an individual hair), whereas the second – *hair* – denotes a kind of substance from which individual hairs are made.

As can be seen, these two accounts of the mass-count distinction are impossible to differentiate without an empirical test of “construal” that not only captures our intuitions about

uncontroversial cases, like *water* and *shoe*, but can also resolve differences about words like *string* and *jewelry*.

One such test, quantity judgment, meets these requirements, and provides two important insights into the mass-count distinction. First, as we describe below, this test shows that contrary to both Chierchia and Gillon, the presence of countable individuals in the world does not determine whether a noun individuates. Instead, as argued by the Quinian view, individuation depends on how an entity is construed, and thus depends upon which information about an entity is linguistically encoded by a word: *hair* and *capelli* do not name the same stuff in the world. Second, the quantity judgment test shows that, contrary to the Quinian view, although syntax affects construal, it does not do so for both count and mass nouns alike. In particular, although the use of a word in count syntax coerces an individuated meaning – e.g., such that *a water* must denote a countable entity – the use of a word in mass syntax does not force language users to construe its referents as unindividuated masses.

To show this, Barner and Snedeker (2005) presented 4-year-old children and adults with familiar count nouns that name solid objects (e.g., *shoe*, *candle*), substance-mass nouns that name non-solid substances (e.g., *mustard*, *ketchup*), and object-mass nouns like *furniture* and *jewelry*, which by some accounts should not denote atomic individuals, but by other accounts should (Gillon, 1992, 1996; Chierchia, 1998). Also, they presented subjects with flexible words like *string*, *stone*, *paper*, and *chocolate*, and presented these words to some subjects using mass syntax, and to other subjects using count syntax. In these experiments, subjects saw two characters, Farmer Brown and Captain Blue, one of whom had one large object or portion (e.g., one giant shoe, or portion of mustard), and the other who had three tiny objects or portions (e.g.,

three tiny shoes or portions of mustard), and were asked who had more (e.g., Who has more shoes? Who has more mustard?).

As predicted by all previous accounts, subjects based their judgments on number for the count nouns (e.g., selecting three small shoes as *more shoes* than one big shoe), but on overall mass or volume for substance-mass nouns (e.g., selecting the large portion of mustard as *more mustard* than the three tiny portions). Critically, however, when tested with object-mass nouns, subjects based their judgments on number, and selected three tiny pieces of furniture as *more furniture* than one large piece, three pieces of jewelry as *more jewelry* than one large piece, and so on. Identical results were found when sets of 2 large things (or portions) were compared to 6 tiny things (or portions), and when the items came from heterogeneous kinds in the case of the object-mass nouns (e.g., when the furniture included both tables and chairs, or when mail included both packages and letters).

These results are consistent with the proposals of Chierchia and Gillon, but not with Quinian accounts like those of Bloom (1999), Gordon (1985), Link (1983, 1998) and others, which predict that all mass nouns denote non-individuals. For Gillon, on the other hand, judgments based on number for object-mass nouns but on mass or volume for substance-mass nouns is predicted if subjects look into the world to determine what mass nouns refer to, and formulate their judgments accordingly. And for Chierchia, these results are consistent with the idea that all mass nouns denote pluralities: atoms of furniture are chairs and tables, and thus 6 pieces of furniture contain more atoms than 3 pieces; atoms of mustard are not portions, but whatever minimal part satisfies the criteria for counting as mustard. Thus, a larger amount of mustard will contain more mustard atoms, regardless of how this portion is divided into smaller portions.

Results from flexible nouns, however, provided a key piece of additional data. On the Quinian view, the data from the quantity judgment task are only relevant if we know that the task taps into how language users construe referents, and how they are encoded linguistically – and not simply how things look in the world. Evidence that quantity judgments for flexible words shift according to their use in mass-count syntax would satisfy this requirement, and thus support the conclusion that even on a strong test of construal, object-mass nouns like *furniture* individuate. On the views of Gillon and Chierchia, however, flexibility is not predicted to shift interpretation. For Chierchia, hair is hair, whether it is described as *hair* or *capello*. And for Gillon, the conversion of a noun from mass to count requires that the word pick out countable individuals when used in the mass form.

Interestingly, for words like *string*, *stone*, *chocolate* and *paper*, Barner and Snedeker found that subjects *did* shift their quantity judgments according to syntax. When words were presented in count syntax – e.g., Who has *more stones*? – subjects based their judgments on number, and selected three stones as *more stones* than one large one. When the same words were presented in mass syntax – e.g., Who has *more stone*? – subjects based their judgments on mass/volume, and now picked the large stone as *more stone* the three small ones. These results clearly show that hair is not hair by any name, and that individuation is not determined wholly by how things appear in the world. Instead, nouns can be used flexibly, to represent different semantic content when used in mass or count syntax. These results therefore are not compatible with the hypotheses of Gillon and Chierchia. Further, because these results show that subjects shift their interpretation of words depending on how they are used syntactically, they suggest that the quantity judgment task is indeed sensitive to construal. Consequently, when subjects based judgments on number for object-mass words like *furniture*, these judgments reflected how

subjects construed the referents as they were encoded by mass nouns. These findings are thus difficult to explain for Quinian views, which hold that mass nouns should induce substance construals.

Instead, the data support an alternative, novel account of the mass-count distinction, with two basic generalizations:

Generalization 1: All count nouns quantify by number (and thus denote countable individuals).

Generalization 2: Mass nouns quantify by heterogeneous measuring dimensions, including mass, volume, and number.

By this account, the mass-count distinction is semantically asymmetric. Count syntax specifies a single measuring dimension, but mass syntax does not. Also, as noted by Bale and Barner (2009), two additional generalizations can be made regarding which mass nouns can denote individuals:

Generalization 3: Nouns that denote individuals in mass syntax never denote the same individuals as count nouns.

Generalization 4: Nouns that can be used flexibly as mass and count never denote individuals in their mass forms.

To explain these latter generalizations, Bale and Barner (2009) argued that count syntax takes unindividuated semantic representations as inputs, and returns individuated representations, whereas mass syntax applies an identity function to whatever semantic representation it takes as

an input. Therefore, on this view, any noun that can occur in count syntax must have an unindividuated semantic representation in the lexicon, while nouns with individuated lexical representations *must* occur as mass nouns. Thus, in some sense, object-mass nouns like *furniture* are prespecified for individuation, and by virtue of this cannot also take the individuating function of count syntax, thereby explaining Generalization 3. Likewise, this model easily explains Generalization 4: only unindividuated nouns can appear in both count syntax (where they receive the individuating function) and in mass syntax (where they do not receive an individuating function, and thus take on the unindividuated interpretation).

Critically, on this model the semantic representation of the noun – whether individuated or unindividuated – is *not identical* to the concept that noun is associated with, which specifies whether the item is a kind of object, what it is made of, etc. Thus, by this account, while the word *shoe* may be associated with the concept SHOE – which may provide criteria indicating that shoes are discrete physical objects with specific properties – the semantic representation of the lexical item *shoe* is unspecified with respect to whether the noun should individuate or not, leaving this to the syntax (and thus the compositional semantics of English). However, concepts *do* determine whether an individuated meaning will be interpretable when derived grammatically. For the word *shoe* to be interpreted as a count noun, there must be some kind of countable thing that can be identified as its referent – e.g., a whole shoe – and this may be guided by conceptual criteria. Likewise for flexible words like *paper*, *chocolate*, *string*, and *stone*, and coerced meanings like “a water”. Some kind of individual, whether conceptually specified or provided by context, must be available.

This idea of an asymmetry between count and mass syntax is supported not only by the data from the quantity judgment task just presented, but also by the word extension data

described in the previous section. As already noted, when subjects are presented with a novel count noun that labels an unfamiliar object, they almost always assume that the noun denotes a kind of countable thing, and thus extend the word according to shape (e.g., when given a choice between an object that matches the original in shape, but not substance, vs. one that matches in substance but not shape). However, for novel mass nouns, do not make such an assumption, and sometimes extend words by substance, and sometimes by shape (especially when the original object has a complex form).

Corroborating this connection between word extension and quantity judgment, Barner and Snedeker (2006) tested 3-year-olds and adults with both tasks, using novel objects. Subjects were presented with either four “simple” novel objects or four “complex” novel objects, which were classified according to adult ratings of both complexity (in a 1-7 scale), and the appearance of having a function (also a 1-7 scale), such that complex objects were also more likely to be seen as having a function (for discussion, see Prasada, Ferenz & Haskell, 2002). Subjects were also tested with four kinds of non-solid substances, which were presented on plates in simple shapes. Each subject was presented all novel nouns either in mass syntax only, or in count syntax only. After learning a name for an unfamiliar object or portion of stuff (e.g., *tulver*) subjects were then given a word extension trial and a quantity judgment trial (with order varied across subjects). On the word extension trial, they saw a stimulus that matched the original only in shape, and another that matched only in substance, and were told, e.g., “Show me *a tulver*” (count condition) or “Show me *some tulver*” (mass condition). On the quantity judgment trial, they saw one large instance of the original stimulus (in the possession of one character) and three tiny versions (in the possession of a second character) and were asked, e.g., “Who has *more tulvers*?” (count condition) or “Who has *more tulver*?” (mass condition).

Using this method, Barner and Snedeker found that when nouns were presented in count syntax, adults extended the words by shape and based quantity judgments on number, regardless of whether the stimuli were simple or complex objects, or portions of non-solid stuff. However, when words were presented in mass syntax, judgments differed according to the nature of the stimuli. Subjects extended novel mass nouns overwhelmingly by shape and based quantity judgments on number if they were used to label complex, functional objects, and did so somewhat less so for simple objects, and less still for non-solid substances. Three-year-old children showed a similar pattern, though overall they were less sensitive to syntax than adults, and much more likely to accept objects as referents of mass nouns. Thus, as with the familiar stimuli studied by Barner and Snedeker (2005), word extensions and quantity judgments involving novel stimuli provide evidence for an asymmetry in the mass-count distinction: whereas count syntax specifies reference to countable individuals, mass syntax permits reference to countable things or to non-solid substances, and thus permits quantification by number in addition to mass/volume.

A further study using the quantity judgment method showed that this mass-count asymmetry is not specific to a small set of words like *furniture* and *jewelry*, but is instead a design feature that allows mass nouns to encode heterogeneous phenomena, and to quantify using diverse measuring dimensions. In this study, Barner, Wagner, and Snedeker (2008) presented adult subjects with written stories that described two characters, Jerry and Jake, who each performed some action described in either mass or count syntax. For example, in one scenario, one character performed one very long dance, and the other performed three very short dances (described without mass or count syntax), and subjects were asked to judge either who did *more dances* (count condition), or who did *more dancing* (mass condition). Critically,

subjects were asked these questions for a wide variety of action words, which differed according to their degree of iterativity. Prior to the study, a separate group of subjects were asked to rate a set of 45 verbs including *dance*, *cry*, *walk*, *run*, and also *jump*, *kick*, *step*, and *bite*, etc. according to whether they were durative or iterative. For example, for a word like *dance*, they were asked to consider sentences like “John jumped all day” or “John danced all day” and to judge whether the events described would require repeating an action over and over (iterative), or instead could be done continuously without stopping (durative). In the quantity judgment experiment, when subjects were presented with words rated as durative, such as *dance*, they based their quantity judgments exclusively on number when the words were presented in count syntax (e.g., Who did *more dances*?), but on non-numerical dimensions like time and distance when presented in mass syntax (e.g., Who did *more dancing*?). However, words that were rated as iterative, like *jump*, were interpreted differently. Now, judgments were based on number, regardless of syntax: if Jake did a greater number of jumps than Jerry (even very small ones that took much less time), subjects judged both that he did *more jumps*, and that he did *more jumping*.

These data from action words support the idea that whereas count syntax imposes number as a measuring dimension on words, mass syntax leaves this up to specific lexical items, allowing for a wide range of possible measuring dimensions. This is true of familiar words, novel object and substance words, and familiar action words too. These same intuitions can be readily obtained for more abstract words, too. To demonstrate that count syntax, but not mass syntax, imposes a uniform, commensurable measuring dimension on nouns, but that mass syntax does not, consider the nouns *hope* and *string*. Although we might know precisely how much hope we have, and precisely how much string we have, there is no single measuring dimension by which these two quantities can be compared, such that we can decide whether we have more

hope than string, or vice versa. The question makes little sense. However, if we know precisely how many hopes we have, and how many strings, it is trivial to decide whether we have more hopes or strings, because both nouns are now measured according to number. Thus, count syntax can take as input two nouns that specify incommensurable measuring dimensions, and output nouns that specify number as a common measure.

As already noted our proposal requires that a distinction be made between lexical semantic representations and lexical concepts. We have argued above that count syntax interacts with unindividuated lexical semantic representations to yield the interpretation that a noun denotes countable individuals. This implies that lexical concepts aren't necessary to reach the interpretation that a count noun denotes countable individuals. Concepts, however, may be necessary for determining *what* those countable individuals could be, and thus whether an individuated meaning will be interpretable when derived grammatically. This is evident by comparing how novel and familiar nouns are interpreted when embedded in count syntax. If we are told that a person has *a blicket*, we understand that the person has an individual of some kind, due to the countability function of count syntax. But we do not know what kind of individual a *blicket* is, presumably because we have not learned the concept BLICKET. In contrast, if we are told that a person has *a shoe*, we both understand that the person has an individual *and* what kind of individual it is. Because we have learned the concept SHOE, we can consult our knowledge of what counts as a shoe, which may include information about what shoes look like, what their function is, and so on. To sum up then, in mass-count languages, the interpretation that a noun denotes countable individuals may depend solely on lexical roots and syntax, but concepts may do the work of specifying what those countable individuals are.

In other languages, where no mass-count distinction exists, this separation between conceptual structure and lexical semantics may not exist in the same way. Evidence for this comes from studies of Japanese, which has no grammatical mass-count distinction. When Japanese adults are asked to make quantity judgments for novel or familiar nouns like those used in studies of English, subjects base their judgments on number if their translation-equivalents in English are used in count syntax (e.g., *shoe*, *candle*), but on mass/volume if their translation-equivalents in English are substance terms that are used in mass syntax (e.g., *mustard*, *toothpaste*; see Inagaki & Barner, 2009). Interestingly, for mass-count flexible words, like *string*, *stone*, *chocolate*, and *paper*, Japanese quantity judgments are on average directly between the mass and count judgments of English speakers for these same words. This result is important for two reasons. First, it again suggests that syntax has a strong effect on how these items are construed, and that when there is no syntax, subjects face uncertainty, and sometimes choose by number, sometimes by substance. Contrary to Chierchia and Gillon, the world alone cannot determine whether or not these words individuate. Second, the Japanese data suggest that words which are ambiguous in absence of mass-count syntax are precisely those words which are likely to be flexible in other languages. Not only were Japanese judgments mixed for words like *chocolate*, which are flexible within languages like English, but they were also mixed for words that vary in mass-count status across languages like *spinach*, *hair*, and *toast*, which are mass nouns in English (and lead to quantity judgments based on mass/volume) but are count nouns in French (and lead to quantity judgments based on number in speakers of Quebecois; Inagaki & Barner, 2009). Thus, although the semantics of words differ across languages, as a function of syntactic variation, it appears that the conceptual underpinnings of mass and count nouns are highly similar across languages, if not identical. Languages differ with respect to how different

aspects of conceptual structure are selected by syntax, and not with respect to how concepts are represented (for additional evidence of this, see Li, Dunham, & Carey, 2009; Barner, Inagaki, & Li, 2009; Barner, Li, & Snedeker, 2010).

In this section, we have argued that quantity judgment provides a strong test of mass-count semantics that is sensitive both to psychological construal, and effects of syntax for uncontroversial words like *shoe* and *mustard*. This test reveals that flexible words like *chocolate* and *string* are interpreted differently depending on their use in mass or count syntax, and that in general whereas count syntax specifies quantification over countable individuals, mass syntax does not specify a single measuring dimension. Instead, mass syntax leaves the measuring dimension up to individual lexical items, such that in some cases (e.g., *furniture*, *jewelry*) nouns are lexically specified to individuate. Overall, these data suggest two sources of individuation: one syntactic (in the form of count syntax) and the other lexical (in the form of lexical specification for individuation on a subset of nouns). In languages that lack mass-count syntax, like Japanese, these measuring dimensions are mediated entirely by conceptual structure, without intervening grammatical functions to specify individuation.

In the final section, we expand on this general idea, and focus on non-grammatical sources of individuation, and in particular on the roles of conceptual and pragmatic information.

Part 2: Conceptual and pragmatic sources of countability

In Part 1, we described how syntax and lexical semantic representations help determine whether nouns are interpreted to denote countable individuals. Specifically, count syntax specifies the existence of countable individuals, such that when nouns are used in count syntax, they quantify according to number: If Farmer Brown has *more shoes* than Captain Blue, he has a larger number of shoes than Captain Blue. In contrast, mass syntax leaves the measuring

dimension up to the semantic representations of individual lexical items, such that some nouns quantify according to mass/volume, while others are lexically specified for individuation and accordingly quantify according to number: if Farmer Brown has *more furniture* than Captain Blue, he has a larger number of pieces of furniture than Captain Blue.

Although these considerations clarify the role of syntax and lexical semantic representations in determining whether a noun denotes countable individuals, they do not specify which of the world's many countable individuals are actually in the noun's denotation. Thus, a question like "Does Farmer Brown have more *books* than Captain Blue?" does not simply ask whether Farmer Brown has more countable individuals than Captain Blue. Instead, it provides a clear specification of what should be counted. The question directs the listener to count only the whole books that Farmer Brown and Captain Blue have, as opposed to their blood cells, gold chains, or even the pages of the books they own. But how might this work, if as we have argued, the semantic representations of nouns that can appear in count syntax are unindividuated? By most accounts, the *concepts* associated with nouns do this work, by providing criteria for individuation – i.e., for judging whether an entity is a countable individual of a particular kind (Carey, 2009; Macnamara, 1986; Xu, 2007). A full understanding of how a noun phrase denotes individuals, then, may depend not only on syntax and lexical semantic representations, but also on using the conceptual criteria for individuation associated with a noun (which as we have argued, are not part of the noun's semantic representation). In this section, we explore how such criteria may be encoded by concepts, drawing on evidence from how young children count objects.

On first glance, studies of language development suggest that children readily acquire nouns that encode full conceptual criteria for individuation. Many of the first words that children

learn are count nouns that label concrete objects (Fenson et al., 1994) and children appear to use these early nouns to guide individuation appropriately. For example, when exposed to a new noun for a previously-unnamed object, three-year-olds expect the noun to label the whole object, rather than its parts (Markman & Wachtel, 1988), which suggests that children may correctly apply object nouns like *book*, *shoe*, or *fork*, to whole books, shoes, and forks, as opposed to their parts. Further, nouns appear to guide children's hypotheses about individuation, such that even infants expect to see two distinct objects when hearing two distinct count nouns, but to see two identical objects when hearing a single noun repeated twice, consistent with the idea that like adults, children expect individual nouns to label items of a single kind (Dewar & Xu, 2007, 2010; see also Waxman & Markow, 1995; Xu & Carey, 1996).

Recent studies, however, suggest that children actually struggle to use nouns to denote individuals in the ways that adult speakers do, suggesting that they may only gradually acquire complete lexical concepts – and full criteria of individuation – to guide their interpretation of nouns (e.g., Ameel, Malt & Storms, 2008; Wagner, Dobkins & Barner, 2013). For example, although children rapidly construct form-meaning mappings for color words, they initially use these words too broadly – e.g., labeling green, blue, and purple as “blue” – and only name colors like adults after several years (Wagner, et al., 2013; Carey & Bartlett, 1978). Similarly, children have difficulty mastering adult uses of artifact words like *bottle* and *jar*, which depend on a complex set of factors, including information about an artifact's function, form, and process of creation (e.g., Bloom, 1996; Malt, 2010). Indeed, according to one recent report, children only converge on adult patterns of naming artifacts after a protracted period that extends into adolescence (Ameel et al., 2008).

Also consistent with the idea that young children may not possess a full set of conceptual knowledge to guide individuation, and most relevant to this chapter, is that children are surprisingly willing to use object nouns like *fork* to denote not only whole objects, but also their arbitrary parts. In a classic study, Shipley and Shepperson (1990) presented children with sets of objects, like forks, in which one of the objects had been broken into two or three arbitrary pieces. Whereas an adult will count two whole forks and a third that has been cut in half as either *two forks* or as *three forks*, children under age 7 often include broken pieces in their counts of whole objects – e.g., resulting in a count of *five forks* (Brooks, Pogue, & Barner, 2011; Shipley & Shepperson, 1990). Strikingly, children do this even though the broken pieces of the object are spaced close together, making it easy to recognize that they form a single whole object. This behavior also persists when children are asked to count only the “whole” objects (Shipley & Shepperson, 1990; Sophian & Kalhiwa, 1998), and even when the object has been broken in front of them and they had counted it as “one” just seconds before (Brooks et al., 2011). Critically, such behavior is also not limited to counting tasks, as children treat broken pieces as kind members when interpreting nouns more generally (Brooks et al., 2011). For example, when asked to “touch every *shoe*” or to “place a *shoe* in the circle”, four-year-olds touch broken pieces of shoe, and are happy to place a broken shoe-piece in a circle. Together, then, these findings suggest that in contrast to adults, children do not restrict nouns like *shoe* to apply only to specific countable individuals like whole shoes.

So how might children begin to act like adults, and restrict their application of nouns like *shoe* only to whole objects? One possibility is that children’s concepts initially encode only partial criteria for individuation, explaining their errors, but that these concepts are ultimately revised by age 7, when children stop making errors. For example, prior to age 7, children’s

concept SHOE could allow any object with shoe-like properties to be counted as *a shoe*, but such criteria could later be revised to allow only whole shoes to be counted as *shoes*. Thus, there may be a discontinuity between children's and adults' concepts, with only adult concepts providing full criteria for individuation. One reason to doubt that this is the case, however, is that children under age 7 do not treat all broken parts of objects as kind members. For example, when four-year-olds are presented with two whole bicycles and a third that has been broken into functional, nameable parts (e.g., into frames and wheels), children are less likely to count the broken bicycle-parts as *bicycles*, and more likely to exclude them from their counts like adults (Brooks et al., 2011).

The fact that 4-year-olds exclude functional parts from their counts of whole objects but continue to include arbitrary parts in their counts until age 7 suggests an alternative hypothesis about how children begin to count like adults. In particular, children may begin to count like adults not because of conceptual change, but instead through a developing pragmatic ability to contrast what a speaker said with what they *could* have said (Clark, 1987, 1990; Grice, 1969). For example, when asked to "count the bicycles," children may infer that functional parts like wheels shouldn't be counted, because if the experimenter had wanted them to be counted, she would have said to "count the *wheels*". Thus, four-year-olds may not count wheels as *bicycles*, because they recognize that *wheel* is a better, more informative description of a wheel than is *bicycle*. In fact, children may not even need to know what functional parts like wheels are called to exclude them from their counts of whole objects: by non-linguistic criteria alone, parts like wheels may stand out as different kinds of objects than whole objects like bicycles, because they

possess distinct, unique functions.² By contrast, children of this age may continue to count arbitrary parts of objects (e.g., pieces of fork) as kind members, both because these parts do not have unique functions, and because children may fail to access better descriptions for these parts than whole object labels: e.g., *fork* may be the best available description children have for pieces of fork.

Importantly, by this account, children do not ultimately achieve an insight through which lexical concepts like FORK or SHOE begin to specify full criteria for individuation. Instead, older children's and adults' concepts may be quite similar to those of young children, and may provide only partial criteria for individuation. However, older children and adults may behave differently from younger children because they may contrast their use of whole object labels against a wider set of alternative expressions, including not only nouns that label functional parts of objects (e.g., *wheel*), but also measure phrases that apply to arbitrary parts of objects (e.g., *piece of fork*, *half of shoe*, etc.). Thus, older children and adults may identify relevant countable individuals not because their lexical concepts provide full criteria of individuation, but instead via pragmatic inference, by contrasting whole object nouns with alternative expressions on-line. Critically, this approach lightens the explanatory burden traditionally placed upon concepts: concepts do not need to provide full criteria to restrict reference to whole objects, but can instead provide partial conditions that are enriched pragmatically. This may help make sense of why all theories of concepts to date have faced problems in explaining how concepts restrict reference to

² Indeed, consistent with this, children exclude functional parts from their counts of whole objects (e.g., wheels from their counts of bicycles) more often than they are able to name them (e.g., to label them “wheels”; Brooks et al., 2011).

kind members (for discussion, see Laurence & Margolis, 1999): these theories may be attempting to explain too much.

The proposal outlined above predicts that children under age 7 should be capable of excluding parts from their counts of whole objects when these parts have unique functions, or when they have unique labels. To test these predictions, Srinivasan, Chestnut, Li & Barner (2013) presented children with sets of whole and broken novel objects, and manipulated whether these objects were broken into arbitrary or functional parts, and whether these parts were labeled or unlabeled. Thus, in one condition, children learned the name of a novel object (e.g., “This is a *zerken*”), and were then presented with a set containing two whole novel objects and a third broken into arbitrary pieces, and were asked to enumerate the set using the novel object label (e.g., “Can you count the *zerkens*?”). To assess whether labels are sufficient for the exclusion of arbitrary parts, in another condition children also learned a name for an arbitrary part of the novel object before being asked to count the set (e.g., “This is a *zerken*. And do you see this part? This is a *tamble*”). Finally, to probe the role of functional information, Srinivasan et al. (2013) also included two conditions in which children were taught the function of the novel object (e.g., “A *zerken* is for stirring juice”), and in which the novel object was broken into functional parts rather than arbitrary parts prior to the counting phase. To explore whether labels are necessary for excluding functional parts, these conditions also manipulated whether children learned a unique label for a functional part prior to counting.

Consistent with the predictions, children were more likely to exclude the broken parts of objects when these parts were functional or had been labeled. In particular, although children often counted arbitrary parts when they had not received unique labels, they were significantly less likely to do so when these parts had received labels, consistent with the idea that labels are

sufficient for excluding parts. Further, children counted functional parts significantly less often than they counted arbitrary unlabeled parts, independent of whether the functional parts had been labeled or not, providing evidence that functional information is also sufficient for excluding parts.

The fact that the label manipulation affected whether arbitrary parts were excluded, but not whether functional parts were excluded, suggests that labels may be critical to how arbitrary parts are excluded. Thus, children under age 7 may include arbitrary parts, like pieces of shoe, in their counts of whole objects, like shoes, because they cannot access better descriptions for these parts than whole object labels. One possibility, then, is that young children have simply not learned measure phrases, like *piece of shoe* or *half of fork*, and do not understand that these phrases are better descriptions of pieces of objects than whole object labels. This could prevent children from inferring that a request to “count the forks” implies that only whole forks, and not arbitrary parts of forks, should be counted.

To explore when children begin to understand measure phrases and how they contrast with whole object labels, Srinivasan and colleagues probed three- and four-year-old children’s comprehension using two tasks. In the verbal forced choice task, children were presented with a set – e.g., of two whole shoes, or of a single shoe cut in half – and then heard one character describe the set using a whole object label (e.g., “Farmer Brown says it’s two shoes”), and a second character describe the set using a measure phrase (e.g., “Captain Blue says it’s two pieces of shoe”), and were asked which character said it better. Meanwhile, in the semantic forced choice task, children were presented with a single description (e.g., “Can you point to two shoes”) and chose between two referents of that description (e.g., between a set containing two whole shoes and a set containing two pieces of shoe). Interestingly, by age four, children were

well above chance on each of these tasks, suggesting that by this age, children have learned measure phrases and understand how they contrast with whole object labels.

The fact that four-year-olds have acquired measure phrases but still fail to exclude arbitrary parts from their counts of whole objects suggests that children's difficulty stems not from an ignorance of measure phrases, but instead from an inability to spontaneously generate these phrases as alternative descriptions of arbitrary object-pieces. Consistent with this, in an earlier study, when measure phrases weren't explicitly presented to children as alternatives (as they were in the forced choice tasks described above), they often accepted whole object labels as descriptions of arbitrary parts, and this predicted whether they included arbitrary parts in their counts of whole objects (Srinivasan et al., 2013). Thus, children's counting of broken objects may indeed be explained by their ability to spontaneously consider measure phrases as contrasting alternatives to whole object labels.

Interestingly, a similar account has been proposed to explain why young children often fail to compute scalar implicatures until age six or seven: e.g., to judge that "some of the horses jumped over the fence" is an infelicitous description of an event in which all of the horses jumped over a fence. Just as in the case of measure phrases and whole object labels, when children are explicitly presented with more informative descriptions in these cases – e.g., "All of the horses jumped over the fence" – they readily recognize that they are better descriptions of the events (see Foppolo, Guasti, & Chierchia, 2011; see also Chierchia et al., 2001). These findings suggest that children may have difficulty with pragmatic inference because they have trouble activating more informative alternatives during on-line processing (for further evidence and discussion, see Barner & Bachrach, 2010; Barner, Brooks, & Bale, 2011; Stiller, Goodman, & Frank, 2011).

If children exclude arbitrary parts from their counts of whole objects by making a pragmatic inference over alternative descriptions of object parts, they should quantify more like adults when these alternatives have been primed, making them more available when counting. To test this hypothesis, Srinivasan et al. (2013) conducted another study in which children in the priming group were first shown a whole object and an arbitrary piece of that object – e.g., a shoe and a piece of a shoe – and were asked to point to the referents of a measure phrase (“Can you point to the piece of a shoe?”) and whole object label (“Can you point to the shoe?”). Then, they were shown a set containing two whole objects and a third cut into two or three pieces, and were asked to count using the whole object label (“Can you count the shoes?”). Strikingly, this manipulation significantly improved children’s ability to exclude arbitrary parts from their counts of whole objects, relative to a control group who did not receive the priming manipulation. Critically, children who received the priming manipulation did not receive any feedback about which of the objects were pieces and which were wholes, making it unlikely that children’s concepts – and criteria for individuation – changed during the task. Instead, both children’s and adults’ concepts may encode only partial criteria for individuation – allowing arbitrary parts to be included as members of object kinds – and may only be filled out by contrasting them with alternative descriptions.

This conclusion, that adult-like criteria for individuation are not fully encoded by lexical concepts like FORK or BICYCLE, but instead depend on contrasting words like *fork* and *bicycle* with other nouns (e.g., in the case of nameable functional parts like *wheels*) and measure phrase descriptions (e.g., in the case of arbitrary parts), is also consistent with how children begin to use other kinds of words in adult-like ways. For instance, as children acquire more color words, and more words for artifacts, they also begin to converge on adult-like patterns of naming for

existing words in their vocabularies (Ameel et al., 2008; Wagner et al., 2013). For example, by learning *green* and recognizing that it contrasts with other color words, children may narrow their overly-broad meanings for *blue* or *yellow* (Wagner et al., 2013). Thus, children may acquire conceptual criteria for individuation for a word not simply by learning that word, but also by learning other related words, recognizing that those words form a common class, and understanding how individual words in a class contrast with one another. This may be easier to do for some classes of words, compared to others. For instance, children readily form lexical classes for words for number, time, and color (Brooks, Audet, & Barner, 2012; Shatz, Tare, Nguyen & Young, 2010; Tare, Shatz, & Gilbertson, 2008; Wynn, 1992), and thus, can provide a color word in response to a question such as “What color is that?” long before they use that color word like adults. Children may quickly construct classes in these cases because multiple words in these classes are often introduced to children at once in routines and songs (e.g., the counting routine “1-2-3-4...”), and are also encountered across different linguistic contexts (e.g., different color words are embedded in phrases such as “That color is ____”, and “My favorite color is ____” and used in responses to questions like “What color is that?”; Tare et al., 2008). By contrast, children may receive comparatively sparse evidence that whole object labels and measure phrases are alternatives to one another, accounting for their prolonged trajectory of acquisition.

As noted above, a complete model of the compositional semantics of the mass-count distinction depends not just on attending to syntax and lexical semantic representations to determine whether a noun denotes countable individuals, but also on using conceptual criteria to figure out what those individuals might be. Based on evidence from young children, we have argued that nouns themselves do not encode full conceptual criteria for individuation. Instead, they may encode partial criteria that are filled out pragmatically, by contrasting alternative

descriptions of objects and their parts.

Conclusion

In this chapter, we have described how the meanings of mass and count nouns result from the interaction of three components of language – lexical semantic representation, syntax, and pragmatic inference. We began by arguing that the mass-count distinction is best understood in terms of individuation and quantification, as opposed to in terms of an ontological distinction between objects and substances. Further, drawing on studies of word extension and quantity judgment, we suggested that the mass-count distinction is asymmetric, such that while count nouns denote individuals, mass nouns can denote a wider range of phenomena including objects, substances, and actions (whether individuated or not). These generalizations, we argued, are best understood in terms of a model in which count syntax takes unindividuated semantic representations as an input, and specifies quantification over countable individuals, while mass syntax leaves the measuring dimension up to individual semantic representations, such that some nouns quantify according to mass/volume, while others are lexically specified for individuation and accordingly quantify according to number (e.g., *furniture* and *jewelry*). Finally, we argued that while syntax and lexical semantic representations help determine whether a noun denotes countable individuals, they do not specify which countable individuals they denote, and that this depends on conceptual and pragmatic factors. Specifically, drawing on evidence from young children, we proposed that nouns themselves do not encode full conceptual criteria for individuation, but instead encode partial criteria that are filled out pragmatically, by contrasting alternative descriptions of objects and their parts.

As can be seen, the mass-count distinction offers a unique window onto how lexical, syntactic and pragmatic processes interact. In doing so, it also provides an excellent model that we hope will be applied toward understanding other domains of linguistic meaning.

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