
Sentence Processing: Classifiers & Count-Mass Distinction, Behavioral studies

This article reviews psycholinguistic studies on classifiers that have provided insights into human categorization behaviors, human conceptual structures, and cross-linguistic universals and variations in language processing. Following the Classifier entry, the term “classifier” will refer to sortal classifiers (also known as individual or “count” classifiers in the literature). In some cases, sortal classifiers are contrasted with mensural classifiers (also known as measure words, “mass” classifiers, or massifiers).

1. Language as a Window to our Cognitive Structure

1.1. Classifiers and Categorization. The study of classifiers serves as a window into understanding how humans learn categories and make categorization decisions. Crosslinguistic comparisons have revealed that animacy, shape, and functionality are common schemes to classify nouns (e.g., Lyons 1977, Allan 1977, Tai 1994), but within these partitions, the specific classifiers and the number of them vary across languages. Unsurprisingly, the classifiers within each language cannot sufficiently partition all nouns in a well-defined manner (Gao and Malt 2009), leading psycholinguists to ask how speakers learn the classifier system of a language despite its idiosyncrasies, how they generalize from known classifier-noun pairings to newly encountered nouns, and how they choose the appropriate classifier for a given noun online (i.e. in real time).

Although speakers have prescriptive notions of what constitutes the “correct” classifier for a given noun, conceptual factors can affect classifier selection online (Tai 1994, Ahrens 1994, Huang and Ahrens 2003, Tien et al. 2002). For example, varying depictions of objects for eliciting classifiers (e.g., length and width of bones for eliciting the classifier -gen 根 for bones), Tien et al. found that Mandarin speakers’ classifier selection was modulated by how much the depictions matched shapes specified by other competing classifiers. Conceptual factors can also affect the likelihood a classifier is substituted, or “neutralized”, by a general (default) classifier during colloquial speech. Classifiers are more likely to be neutralized for nouns that are atypical of the classifier category (e.g., the general  ge 個 classifier is more often used with  shàfā 沙發 ‘sofa’, which is fluffy, than its expected classifier  zhāng 張, which mainly classifies flat things such as paper or tables; Ahrens 1994). Also, classifiers that classify by conceptual rather than perceptual categories (function vs. animals or shapes) are neutralized more often (Loke 1994).
1.2. Rules, Analogies, and Classifiers. Myers and colleagues (Myers 2000, Myers and Tsay 2002) studied people’s choice of classifiers to address whether our representation of language is rule-like (symbol-manipulating) or built from associations as behaviorists would have it (Pinker and Ullman 2002 vs. McClelland and Patterson 2002; see Abrahamsen and Bechtel 2006 for a conciliatory view). Proponents of symbolic representations believe that “default” grammatical rules for general productivity (e.g., adding /d/ to create the past tense in English) exist alongside lexical and associative memories for irregular cases (e.g., sang and rang as the past tenses of sing and ring). Others posit that general associative learning is sufficient to account for both regulars and irregulars.

Myers (2000) suggested that many classifier languages have a default classifier, observing that Mandarin speakers tend to use the default ge classifier with novel nouns that lack an associated classifier, and that ge is often the stand-in classifier when speakers experience lexical retrieval difficulties, as evident by aphasics and children (Tzeng et al. 1991, Erbaugh 1986), and normals retrieving classifiers for low frequency (Myers et al. 1999) or non-prototypical (Ahrens 1994) classifier-noun pairs. Lastly, Myers and Tsay (2002) trained up connectionist networks with the kind of input that children might receive to model classifier choice, capturing how associations between nouns and classifiers on the basis of semantic features such as shape predict classifier choices for new nouns and why classifier choices are nevertheless probabilistic and contingent upon other available classifiers competing for selection.

1.3. Count-Mass Syntax Reflecting Individuation. Categorization is also central to choosing between count-mass construals. We can represent spatio-temporally discrete objects as individuals and quantify over them by number (e.g., “Mary had three little lambs”) or we can represent the same individuals as stuff (“The Big Bad Wolf had some lamb”). We can also represent substances as individuals, and use number information to make inferences (“There are three new drops of blood at the crime scene”). Our construal is often determined by the nature of the entities and influenced by the ways in which we interact with them (e.g., Wierzbicka 1988, Prasada et al. 2002). Studying people’s choice of count-mass syntax and number marking has served as a window into how people typically represent reality.

Surveying multiple languages that vary in obligatory and optional number marking or classifiers, researchers discovered that nouns fall along an “individuation” continuum/hierarchy which reflects people’s tendency to treat entities as individuals. Nouns for humans are most likely to be marked by number morphology and counted directly with numerals, followed by nouns for animals, then discrete objects, and finally non-discrete stuff (Lucy 1992, Allan 1980, Corbett 2000, Imai & Gentner 1997). Likewise, Wierzbicka
uncovered generalities regarding why nouns for aggregates (e.g., beans, rice, and sand) and superordinates (e.g., furniture, jewelry, vehicles) vary in whether they are lexicalized as count or mass. Nouns naming kinds of things whose constituents are more distinguishable from each other, and/or where people are more likely to interact with each of the constituents individually, lead to greater likelihood of count lexicalization (e.g., beans vs. rice). English speakers’ ratings of distinguishability and of their experience interacting with members named by the noun support Wierzbicka’s generalizations (see Wisniewski et al. 2003 for a review). For example, when asked to label novel aggregates, participants tend to use count syntax for spread-apart collections (“These things are blickets”) and mass syntax for bunched-up collections (“This stuff is blicket”) (Middleton et al. 1996). When asked to rate known nouns, English speakers indicated that they tend to encounter and interact as a group with members of mass superordinates (e.g., chairs, tables for furniture) and individually with members of count superordinates (cars, buses for vehicles) (Wisniewski et al. 1996).

2. Language as an Organizer of Cognition

2.1. Classifier Effects on Conceptual Organization: Researchers have asked whether learning classifiers imposes a system of organization upon one’s conceptual structure (e.g., Zhang and Schmitt 1998, Saalbach and Imai 2007, Kuo and Sera 2009, Srinivasan 2010; see also entry on The Sapir-Whorf hypothesis). These studies suggest that speakers of a classifier language tend to judge two nouns that share the same count classifiers as being more similar than speakers whose language does not group these nouns together via a classifier. When asked to list features shared by the referents of two nouns, speakers are also more likely to list features linked to the classifier than speakers of other languages (e.g., long and flexible for “snake” and “scarf”). When asked to memorize and then recall a list of nouns, nouns that share the same classifiers are more likely to be consecutively listed. This suggests that speakers use classifier categories as a means to organize nouns they have to recall.

Recent studies asked how the effect of classifier on conceptual organization compare against other ways in which people might reasonably organize conceptual categories, such by taxonomic categories (“dogs” and “cats” are kinds of animals) or thematic relations (“bones” are what “dogs” like to chew on), and found that classifiers had a smaller impact than these other organizational influences (Saalbach and Imai 2007, 2012). For example, when asked to recall a list of nouns, speakers tend to consecutively list nouns that share the same taxonomic or thematic categories before they consider classifier categories. In fact, getting participants
to consider the classifier as a means for grouping nouns often required its explicit mention (Gao and Malt 2009, Huang and Chen 2011).

Finally, classifier effects are mediated by frequency of classifier use. The effects of classifiers on noun similarity judgment, feature listing, and other such tasks are much smaller or non-existent in Japanese, where classifier use is less frequent than in Mandarin (Saalbach and Imai 2012).

2.2. Count-mass Syntax Effects on Individuation: Researchers have also asked whether differences between obligatory number-marking languages and classifier languages influence how their speakers see things as individuals versus unindividuated stuff (see Barner et al. 2010 for a review). In English, count nouns name individuated entities, while mass nouns often do not. Researchers have shown that English speakers are more likely than speakers of Mandarin (or other classifier language) to construe an unknown entity as a kind of object rather than a kind of substance (Lucy and Gaskins 2001, Imai and Gentner 1997). That is, English speakers are more likely to think that a noun in neutral syntax (“Look at this (blicket)” paired with a novel entity (e.g., a kidney-shaped object made of wax) names the object (kidney) rather than the substance (wax).

Some have argued that this finding reflects language learning affecting the saliency of objecthood; the obligatory marking of count nouns and their greater frequency leads speakers of count-mass languages to shift their ontological boundaries, so that they treat ambiguous simple-shaped entities as objects while classifier language speakers treat them as substances (Imai and Mazuka 2007, Yoshida and Smith 2003). Others have argued that language learning does not shift ontological boundaries, and instead advocate a “language-on-language” account of the findings (Fisher and Gleitman 2002). According to this account, the instruction “Look at this (blicket)” is in fact not neutral for English speakers, because there are statistically more count nouns in their experience. Mandarin speakers, having no obligatory count-mass markings, evaluate only the entity. Several pieces of evidence support this account. First, the effect of language on construal is limited in scope. When asked to “Classify the entity as either a kind of object or a kind of substance,” Mandarin and English speakers do not differ (Li et al. 2009). Second, Mandarin-English bilinguals respond like native English speakers when tested in English, and like Mandarin speakers when tested in Mandarin (Barner et al, 2009). Lastly, there is no difference in how likely Mandarin, Japanese, or English speakers are to treat known nouns as referencing countable things or substances (Barner et al. 2009; Iwasaki et al. 2010; Cheung et al. 2010, 2012).

3. Language Comprehension
3.1. **Classifiers and Referent Selection:** Comprehension studies address the extent to which listeners make use of classifiers in their interpretation of referential expressions as speech is unfolding. Like gender markers in Indo-European languages, classifiers are grammatical elements that must agree (and be rote-memorized) with the noun. Several visual-world eye-tracking studies using arrays of pictured objects show that classifier language speakers, upon hearing the classifier, quickly look at classifier-consistent referents (e.g., animals when presented with the animal classifier *zhī*; Huettig *et al.* 2010, Tsang and Chambers 2011, Klein *et al.* 2012). This finding aligns with speakers of Indo-European languages, who show a preference for gender-consistent referents over gender-inconsistent ones as soon as the gender marker is heard (Dahan *et al.* 2000).

Unlike gender markers, classifiers often carry semantic information about the entities that the noun denotes. To address whether semantic information provided by classifiers is considered, Tsang and Chambers (2011) focused on Cantonese speakers’ processing of shape-based classifiers. For example, the classifier *tin4* 條 is associated with long and flexible objects (e.g., scarf, trousers), although it also goes with referents lacking such properties (e.g., key) and excludes some that possess those properties (e.g., flag). Such mismatches allowed Tsang and Chambers to pit grammatical requirements (whether the referent is classifier-consistent) against semantic information (whether the referent matches the classifier’s typical semantic properties). They found that grammatical requirements outweigh semantic information, but that under some circumstances listeners can be lured into considering a classifier-inconsistent, but semantically matching referent (e.g., flag for *tin4*).

Event-related potential (ERP) studies provide another route to studying the grammatical and semantic constraints on classifier processing (Zhang *et al.* 2012, Mueller *et al.* 2005, Tsai *et al.* 2008). In these studies, participants read phrases in which the classifier either matched or mismatched a noun, while being monitored for signatures associated with processing anomalous semantic (N400s) and syntactic information (P600s) (see *Neurolinguistics: an overview*). In general, mismatches (compared with matches) tend to elicit N400s, suggesting that semantic information is relevant, while P600s are found when classifier-noun mismatches are embedded in sentential contexts.

3.2. **Classifier-Noun Agreement and Parsing Decisions:** Other researchers have examined how classifier-noun mismatches affect online parsing decisions (e.g., Zhou *et al.* 2010, Jiang and Zhou 2012, Wu *et al.* 2009). For example, in Mandarin, relative clauses are head-final with the relativizer and the head noun occurring at the very end of the phrase (see *Comprehension of Chinese relative clauses*). Several eye-tracking reading studies have examined whether people could use the classifier-noun incongruence as a cue that they are processing a
relative clause (Hsu et al. 2009; Wu et al. 2009; Wu 2011). These studies found that classifiers quickly help reduce the processing difficulty of subject-gapped relative clauses (see (2)), but not of object-gapped relative clauses (see (1)), which require additional supportive discourse context to ease processing. This is because subject-gapped pre-relative clause classifiers are more frequent than object-gapped ones. Studies such as these provide evidence for a constraint-satisfaction view of sentence processing, where multiple sources of information, such as referential context or probability of a syntactic structure, are weighed rapidly in parsing.

Examples from Wu et al. (2009:336)

(1) 那位巨石砸中的記者警惕得環顧四周。

nà-wèi          jùshí      zázhòng de jìzhě jiāngtínghuángguì sìzhōu.
that-CLhuman boulder hit DE journalist cautiously look-about surroundings

‘The journalist that the boulder hit __ looked about his surroundings cautiously.’ (Object-Gapped)

(2) 那塊砸中記者的巨石密密得長著青苔。

nà-kuài          zázhòng  jìzhě de jùshí mìmìde zhǎngzhé qīngtái
that-CLboulder hit journalist DE boulder thickly grow moss

‘The boulder that __ hit the journalist is thickly covered with moss’. (Subject-Gapped)

3.3. Count vs. Mass Classifiers: Linguists have argued that sortal and mensural classifiers occur in different syntactic constructions, and reflect the count-mass distinction in classifier languages (Cheng and Sybesma, 1998). Much of the psycholinguistic research inspired by this argument has focused on when (Mandarin-speaking) children acquire “count” vs. “mass” classifier distinction (see Li et al. 2008, and Acquisition of classifiers and count-mass distinction), but some has explored whether adults process these two types of classifiers differently. For example, using visual-world eye-tracking, Klein et al. (2012) addressed whether sortal classifiers and mensural classifiers both aid Mandarin speakers in referent selection equally quickly. Listeners might be expected to rely more heavily on sortal classifiers because sortal classifier-noun pairings are rote-memorized while mensural classifier-noun pairings are not. However, their study showed that mensural classifiers led to faster referent selection than sortal classifiers, leading them to speculate that mensural classifiers are more informative about the visual properties of referents than sortal classifiers, which more often pick out properties internal to the object’s structure.

Chou et al. (2012) used fMRI to examine the neural substrates involved in processing sortal (count) versus mensural (mass) classifiers while participants read either valid or semantically anomalous sentences with classifiers. The anomalous classifiers were either within type (e.g., a count classifier swapped for another
count-classifier, or a mass classifier swapped for another mass classifier) or across type. They found that the ventral region of the left inferior frontal gyrus IFG (Brodmann’s area [BA] 45, part of Broca’s region) was implicated in processing both count and mass classifiers, but that the ventral regions of the right IFG (BA 47 and 45) were more activated when processing mass classifiers (see Neurolinguistics for a brain map). They speculated that the posterior dorsal region of the left IFG (BA 44, another part of Broca’s region) lit up when processing a count classifier swapped for a mass classifier and vice versa because this area is involved in syntactic processing, suggesting that the mass classifier / count classifier distinction is syntactic.

4. Language Production

In studying how people string words together to form phrases, many studies on Indo-European languages have focused on the retrieval of syntactic information linked to the noun (see Caramazza et al. 2001 for a review), asking whether noun selection automatically triggers the retrieval of associated grammatical information such as gender. Similar question can be asked of the classifier associated with the noun. These studies have mainly been conducted in Mandarin (Wang et al. 2006, Zhang and Liu 2009) using the picture-word interference paradigm, where participants name a target picture while ignoring a distractor word. The studies have established that when a distractor noun is semantically related to the target noun, production of the latter is slowed due to competition between lexical entries. When the distractor noun shares the same classifier as the target noun, the distractor facilitates the production of the target noun in the noun phrase (number+CL+N), but not the production of the target noun in its bare form (N). This facilitation pattern is analogous to what has been found with determiner-noun gender agreement in Germanic languages (Costa et al. 2007). The finding in Mandarin suggests that selection of the noun does not automatically lead to the retrieval of classifier information associated with that noun. Further support comes from Bi et al. (2010). Using a blocked picture naming paradigm, Mandarin speakers were cued to produce either noun phrases or bare nouns of depicted objects. Critically within each block, the classifiers for the nouns were either all semantically related (e.g., classifiers gēn and tiào for long objects) or not (e.g., classifier zhāng for flat objects vs. gēn). Bi and colleagues found that semantic relatedness of shape information provided by classifiers affected the production of noun phrases with classifiers, but not of bare nouns. Besides supporting the conclusion that classifiers operate at a level independent of nouns, the finding also supports the position that classifiers compete with each other for selection.

In another area of research, by observing where in sentences speakers produce classifiers, researchers have addressed whether speakers tailor utterances to minimize processing difficulty for listeners (Sheng and
Wu 2012). In Mandarin, demonstrative-classifier sequences (DC) can be positioned either pre- or post-relative clauses (see section 3.2 for pre-position examples). Sheng and Wu posited that speakers who tailor their speech should put DCs in pre-relative clause positions, because early occurrence of a DC could cue listeners of the upcoming relative clause. However, for object-gapped relative clauses, where DCs are likely to be mis-parsed as modifying the embedded noun, speakers should avoid DCs in pre-relative clause positions. The prediction was born out by the fact that Mandarin-speakers who were given fragments of a sentence to assemble tended to put DCs in pre-relative clause positions for subject-gapped relative clause sentences, but not for object-gapped sentences.

As evidenced by this and other studies in this review, the recruitment of classifiers to explore issues regarding our cognitive and language architecture is ingenious. These studies have covered a spectrum of topics. However, despite the diversity and richness, there are other potential paths of inquiry. For example, psycholinguists have only just begun to consider how classifiers help encode information structure such as definiteness and specificity. Many interesting studies are sure to come.

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Summary: This article highlights why researchers study classifier languages such as Mandarin Chinese as a means for understanding language processing and, more broadly, general cognitive capacities.

Index Terms: psycholinguistics, production, comprehension, categorization, count-mass, mass-count, individuation, classifiers, measure words, number, nouns

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