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Brief article

Revealing abstract semantic mechanisms through priming: The distributive/collective contrast

Mora Maldonado[a,b,*], Emmanuel Chemla[a], Benjamin Spector[b]

[a] Laboratoire de Sciences Cognitives et Psycholinguistique, PSL University, CNRS, EHESS, École Normale Supérieure, Département d'Études Cognitives, 29, Rue d'Ulm, 75005 Paris, France

[b] Institut Jean-Nicod, PSL University, CNRS, EHESS, École Normale Supérieure, Département d'Études Cognitives, 29, Rue d'Ulm, 75005 Paris, France

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ABSTRACT

Sentences such as *The bags are light* allow both collective (they are light *together*) and distributive interpretations (*each* bag is light). We report the results of two experiments showing that this collective/distributive contrast gives rise to priming effects. These findings suggest that collective and distributive readings involve different interpretative mechanisms, which are at play during real comprehension and can be targeted by priming, independently of the specific verification strategy associated with each interpretation.

1. Introduction

In the last thirty years, priming has served to identify the abstract representations that people construct when producing or comprehending language (Branigan & Pickering, 2017; Pickering & Ferreira, 2008, for reviews). This type of priming is known as *structural priming* and it occurs when the processing of a structure is facilitated after the same structure has been recently processed. While structural priming has often been associated with *syntactic priming*, recent studies have revealed that priming methods also serve to tap into abstract semantic mechanisms at play during the interpretative process (Bott & Chemla, 2016; Feiman & Snedeker, 2016; Maldonado, Spector, & Chemla, 2017; Raffray & Pickering, 2010).

Semantic theories have proposed the existence of invisible operations to derive specific sentence interpretations. For example, a silent distributivity operator (*D* operator) has been proposed to explain why sentences such as "Two boys hold three bags" can have not only a basic *cumulative* reading (e.g., Two boys hold three bags *in total*) but also a distributive interpretation (e.g., Two boys hold three bags *each*). Its meaning roughly corresponds to that of *each* in English (Champollion, 2016; Link, 1998; Roberts, 1987). When modified by the *D* operator, the VP 'hold three bags' applies to each atomic member of the plural subject, so each boy is allowed to hold three bags (i.e. the bags can *covary* with each boy). Distributive readings are thus explained by postulating the presence of this *D* operator in the semantic representation. Using a priming paradigm, Maldonado, Chemla, and Spector (2017) have recently shown that this cumulative/distributive contrast gives rise to priming effects. Specifically, they found evidence for an asymmetric distributive priming, suggesting that an abstract mechanism such as the one proposed by semanticists is at play during the comprehension of these ambiguities and can be primed.

Importantly, the optional insertion of the *D* operator has been proposed to account not only for the cumulative/distributive contrast but also for every sentence that can optionally have a distributive interpretation. Our goal here is to extend these results to what is thought to be another instantiation of the same operator: the collective/distributive ambiguity illustrated in (1) and (2):

(1) The bags are heavy.
   a. Collective reading
      The bags together are heavy, without each bag necessarily being heavy.
   b. Distributive reading
      Each bag is heavy (and the bags are heavy in total as well).

(2) The bags are light.
   a. Collective reading
      The bags together are light (and each bag is light as well).
   b. Distributive reading
      Each bag is light, without the bags necessarily being light together.

* Corresponding author at: Laboratoire de Sciences Cognitives et Psycholinguistique, PSL University, CNRS, EHESS, École Normale Supérieure, Département d'Études Cognitives, 29, Rue d'Ulm, 75005 Paris, France.
E-mail addresses: mora.maldonado@ens.fr (M. Maldonado), chemla@ens.fr (E. Chemla), benjamin.spector@ens.fr (B. Spector).

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In their collective reading, (1) and (2) are true as long as the predicate can denote a property of the plural subject as a whole, without necessarily being true of each individual member. Distributive readings, instead, entail that the predicate is true of each atomic member of the plural subject. VPs that present this ambiguity, such as 'heavy' or 'light', are called 'mixed' predicates (Link, 1983; Scha, 1984; Schwarzschild, 1996, 2011).[1]

Note that collective and distributive readings of (1) and (2) are not logically independent: one reading entails the other. A scenario that makes the distributive reading of (1) true (i.e. each bag is heavy) also makes the collective reading true. The distributive interpretation *entails* the collective interpretation. This entailment is asymmetric: the collective reading of (1) can be true while the distributive reading is false. Changing the polarity of the adjective switches the direction of the entailment (see Table 1).

Collective interpretations of (1) and (2) seem to be the result of just applying the plural subject to the predicate, whereas distributive readings are thought to arise by inserting the covert *D* operator. That is, the collective/distributive ambiguity of adjectival predicates is explained analogously to the distributive/cumulative contrast tested by Maldonado, Chemla, et al. (2017). If the same mechanism is required to derive optional distributive readings across different sentences and predicates, we would expect to see priming effects at play for sentences such as (1)/(2) as well as in the cases discussed in the previous study.

Finding priming effects related to the collective/distributive ambiguity would provide further evidence for the existence of an abstract mechanism to derive distributive readings. Moreover, the use of adjectival predicates brings two important advantages. First, as observed, distributive and collective interpretations can be weak or strong depending on the polarity of the adjective (cf. Table 1). Consequently, 'mixed' adjectival predicates allow us to test, for the first time, priming of specific readings independently of logical strength (i.e. *weak* distributive readings might prime *strong* distributive readings, while before strong distributive could only be related to strong distributive readings). We can thereby dissociate priming effects revealing some aspects of semantic representations and those due to logical strength during parsing.

Furthermore, sentences such as (1) and (2) allow us to dissociate the processing of distributive readings from verification strategies that are not inherent to distributivity. In psycholinguistics, the collective/distributive ambiguity has been mostly investigated by testing transitive sentences such as "The boys are painting a castle" (Brasoveanu & Dotlačil, 2015; Frazier, Pacht, & Rayner, 1999; Syrett & Musolino, 2013, among others). Distributive interpretations were isolated here by presenting participants with scenarios where the object co-varies with each member of the plural subject. In the example above then, the distributive scenario would involve a different castle per boy. Participants may use a verification strategy specific to distributive interpretations, based on checking for covariation of the object with respect to the subject. The processing pattern attributed to distributivity therefore confounds verification strategy with semantic interpretation. Mixed adjectival predicates allow us to isolate distributivity from covariation, and therefore to remove this confound.

[1] There is a question in plural semantics of whether or not all gradable adjectives give rise to the collective/distributive ambiguity. Some gradable adjectives have been traditionally considered to be "stubbornly-distributive" in that they do not seem to admit collective interpretations (Glass, 2018; Schwarzschild, 1996, 2011; Syrett, 2014). Recent evidence, however, has challenged this hypothesis (Scontras & Goodman, 2017). Given that the predicates used in these experiments are undoubtfully ambiguous, we will not address this discussion here.

Table 1
Entailment relation between readings. Distributive readings asymmetrically entail collective readings of positive adjectives (e.g., 'heavy'). The reverse pattern is attested for negative adjectives (i.e. 'light'). The distributive interpretation is the *strong* reading for sentences involving positive adjectives, and the *weak* interpretation for sentences involving negative adjectives (and the other way around for collective readings). This entailment pattern arises for most *adjectival* mixed predicates (e.g., expensive/cheap; noisy/quiet).

	Collective reading		Distributive reading
Positive adjective:			
The bags are heavy	The bags are heavy together	⇐	Each bag is heavy
Negative adjective:			
The bags are light	The bags are light together	⇒	Each bag is light

2. Experiment 1

2.1. Methods and materials

We used a sentence-picture matching task where participants had to read a sentence and match it with one of two pictures (Maldonado, Chemla, et al., 2017; Raffray and Pickering, 2010, among others). In experimental trials, the sentence involved adjectival predicates and was ambiguous between a collective and a distributive reading. Each sentence was presented with two out of three possible pictures: (a) a **foil** picture, that made both readings of the sentence false, (b) a **weak** picture, that made only one reading of the sentence true (whether this reading is the collective or the distributive one depends on the adjective polarity, Table 1), and (c) a **'blur'** picture, where the relevant information was blurred so participants could not see it. Specific arrangements between pictures and sentences gave rise to two experimental items: primes and targets (see Fig. 1).

Primes were designed to force one specific sentence interpretation. There were two types of primes: *Collective primes* displayed a foil and a weak *collective* picture, so participants would click on the collective picture and access the collective reading of the sentence. *Distributive primes* displayed a foil and a weak *distributive* picture, forcing participants to access the distributive reading. **Targets** could also be either *collective* or *distributive*. They displayed a weak picture, compatible with the collective or the distributive reading depending on the condition, and a 'blur' picture. Participants were instructed to select the 'blur' option if they felt that the overt picture was not a sufficient match for the sentence (modeled from the "covered picture" method, Huang, Spelke, & Snedeker, 2013). Table 2 illustrates how target responses are indicative of a choice between a collective and a distributive interpretation.

Targets immediately followed prime trials. After being biased towards one specific sentence interpretation in primes, participants were expected to select more often a picture compatible with this same interpretation in targets, independently of the target condition. For example, collective primes should lead to a greater proportion of overt responses in collective targets and of 'blur' responses in distributive targets. Priming of semantic interpretation would then be observed as a main effect of Prime condition in target responses. Given that the picture compatible with the primed reading is not the same across target conditions, we control for visual priming.

The four possible prime-target combinations were present in the experiment. There were two primes of the same condition preceding each target (cf. Maldonado, Chemla, et al., 2017), forming experimental *triplets*. Primes and target within one experimental triplet could use predicates from the same or different degree dimension (i.e. height, price, volume), resulting in matching or mismatching predicate conditions. The left/right position of the 'weak' image was counterbalanced.

The experimental design consisted of four fully-crossed factors to obtain 16 prime-target triplets (48 trials): 2 (prime condition) × 2 (target condition) × 2 (Predicate condition) × 2 (weak image position). A further