

Priming as a window to the collective/distributive ambiguity

Structural priming can detect abstract semantic compositional rules. We report the results of two studies showing that the collective/distributive contrast gives rise to priming effects. These findings suggest that the mechanisms posited to account for collective and distributive interpretations are represented as such during comprehension.

Puzzle. Certain predicates give rise to an ambiguity when they are combined with plural expressions. For instance, (1) and (2) below have a *collective* and a *distributive reading*:

- (1) The girls painted a sand castle.
 - a. The girls jointly painted a single sand castle without each separately doing so. **(Collective)**
 - b. Each of the girls painted a potentially different sand castle. **(Distributive)**
- (2) The bags are light.
 - a. The total weight of the bags is low (and thus each bag is light). **(Collective+Distributive)**
 - b. Each bag is individually light without the total weight being low. **(Distributive)**

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. Distributive readings, instead, are diagnosed by the existence of a *distributive entailment* such that the predicate is inferred to be true of each atomic member of the plural subject. Additionally, if the predicate is transitive (e.g. 1), distributive readings make the sentence compatible with *covariation* scenarios, where objects (sand castles) *covary* with members of the subject (girls).

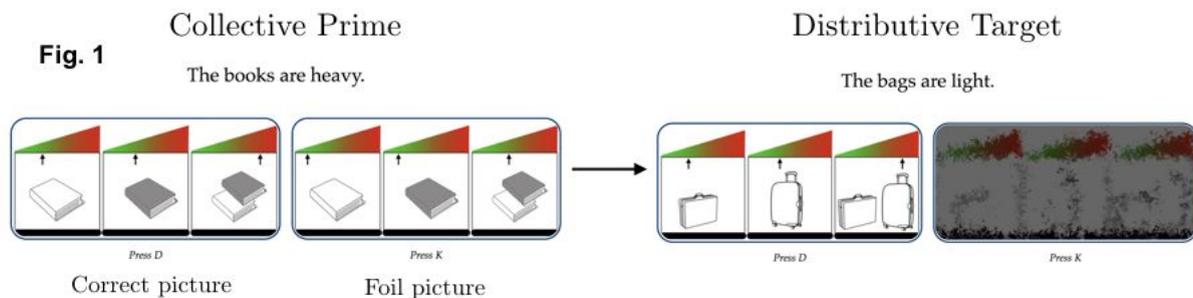
Each of these readings is derived by specific semantic mechanisms. Collective interpretations are often considered to be the result of directly applying the plural subject to the predicate, whereas distributive readings are generally thought to arise through the insertion of a covert distributivity operator *D*, whose meaning roughly corresponds to that of adverbial *each* in English (Link, 1983; Champollion, to appear). The *D* operator applies the VP to each member of the plural subject, guaranteeing the distributive entailment.

Our goal is to assess whether the abstract rules proposed to explain the collective/distributive contrast are accessed during sentence comprehension. We will address this question by testing whether the collective/distributive ambiguity of sentences such as (2) gives rise to *priming effects*. Structural priming has shown to be a useful method to identify the abstract mechanisms and representations that people construct when comprehending language (Maldonado et al, in press). As a result, priming might offer a direct window into the elementary rules involved in the interpretative process.

Moreover, by testing adjectival predicates, our approach allows us to isolate distributivity from covariation, removing a potential confound in previous studies. In the psycholinguistic literature, the collective/distributive contrast has been investigated by comparing distributive and collective understandings of sentences such as (1) (Frazier et al. 1990; Syrett and Musolino, 2013). In order to isolate distributive interpretations, most studies have used *covariation* scenarios such as (1b). However, the covariation of objects and subjects can be decoupled from distributivity: distributive readings could be true in a scenario without covariation (e.g. the girls individually painted the same castle). In previous approaches, covariation and distributivity were equated, and the processing pattern found could just as well be due to distributive interpretations or to verification strategies related to covariation. Adjectival mixed predicates dissociate distributivity from covariation, and will thus allow us to isolate the specific effect of semantic interpretation.

Experimental Design. We ran a sentence-picture matching experiment, where we presented a sentence with two different images and participants had to select the image that best corresponds to the sentence (modeled after Raffray & Pickering 2010, Maldonado et al 2017). In **target trials**, an ambiguous sentence such as (2) was presented with an overt picture that made the sentence true under only one of its readings, and a blurred picture (cf.

Fig 1), which could in principle be anything. Participants were told that they should go for the ‘blur’ picture only if the overt image did not capture the meaning of the sentence (following the procedure in Huang et al. 2013). There were two types of targets: *collective targets* involved sentences with positive adjectives (e.g. “heavy”), and the overt picture made only the collective reading true; *distributive targets* involved negative adjectives (e.g. “light”), and the overt picture made only the distributive reading true. Participants’ responses in targets were thus indicative of the reading they access: Choosing the blur option in collective targets would suggest having a distributive understanding of the sentence, whereas the same choice in distributive targets would be indicative of a collective reading (see Table 1). We were interested in how this preference could be influenced by prime trials that immediately preceded a target.



In **prime trials**, the sentence presented the same collective/distributivity ambiguity but the two images were completely visible: one of them made a specific reading true, while the other made the sentence false under all its readings. Participants thus ought to choose the former kind of image and, by doing so, they were led to access the corresponding reading. We had two types of primes: in *collective primes* participants ought to access collective readings (of positive adjectives); in *distributive primes* they ought to access distributive readings (of negative adjectives).

	Collective Target	Distributive Target
Collective Reading	Overt response	“Blur” response
Distributive reading	“Blur” response	Overt response

Table 1. Correspondences between readings and pictures in targets

Target and Prime conditions were fully crossed within subjects. Since sentences could use three different types of predicates (i.e. heavy/light, expensive/cheap, noisy/quiet), we could have matching or mismatching predicates in each experimental pair.

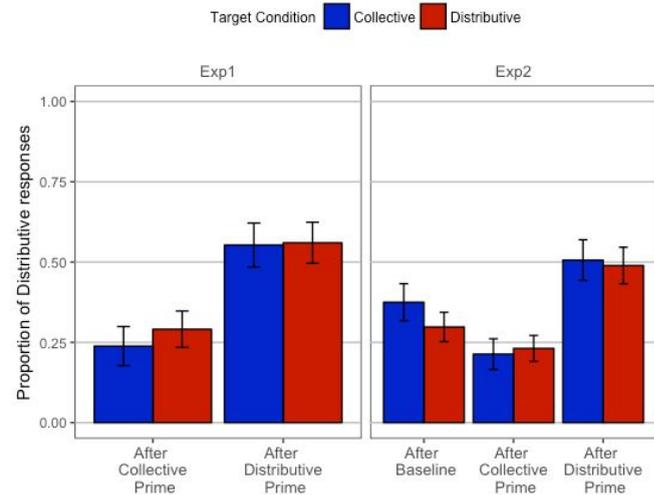
Prediction. After having been induced to access one particular reading in primes, participants were expected to be biased towards the same interpretation in targets, selecting the image accordingly (see Table 1). For example, *collective primes* should lead to a greater proportion of overt responses in *collective targets* and of “blur” responses in *distributive targets*. Priming of semantic interpretation would therefore result in a main effect of Prime condition in target responses, independently from the Target condition.

Results. Percentage of distributive responses in targets are shown in Fig. 2 (N=33, after exclusion). The analyses of the experimental results indicate a main effect of Prime condition ($\chi^2=30.76$; $p<.001$). This effect is also significant when the analysis is restricted to prime-target pairs that have mismatching predicates.

Discussion. These findings reveal that different primes have a different effect in the subsequent target, suggesting that semantic priming is at play. Our results, however, do not allow us to determinate whether the priming effect was symmetric (i.e. effects of both collective and distributive primes) or asymmetric, as it has been suggested in previous

studies (Maldonado et al, 2017 argued for a priming specifically associated with the presence of the *D* operator).

Follow up: baseline rates to test asymmetry in priming. We ran a second experiment where we had the same experimental pairs as in Exp1, but we included additional *baseline trials* before each type of target. Baseline primes showed unambiguous sentences (e.g. “The bag is light.”) together with images similar to the ones used in distributive and collective primes. Since the sentences in baselines do not instantiate the collective/distributive ambiguity, target responses after baselines should reveal the baseline preference rate for each reading.



Results. Percentage of distributive responses in targets after baselines and primes are shown in Fig. 2. (i) The priming effect attested in Experiment 1 is replicated (main effect of Prime condition restricted to targets after collective and distributive primes: $\chi^2=35.6$; $p<.001$). (ii) Target choices after collective and distributive primes are significantly different from baselines ($\chi^2= 6$, $p =.01$; and $\chi^2= 13$, $p <.001$, respectively), revealing the existence of both collective and distributive priming. (iii) Distributive and collective priming effects are not significantly different from each other: the difference between baselines and collective primes is not significantly different from the one between baselines and distributive primes ($\chi^2 <1$; $p =.4$).

Conclusions. Our findings first demonstrate that the collective/distributive contrast in sentences involving mixed adjectival predicates gives rise to priming effects. Structural priming serves here to complement introspection on truth-value and inferential judgments, revealing the mechanisms underlying these linguistic judgments. Moreover, the existence of distributive priming in absence of covariation reveals an abstract representation of the collective/distributive distinction, which is orthogonal to specific verification strategies. While the strategy required to verify whether a certain reading is true or false might play a role in comprehension (and be primed), priming can independently target basic semantic representations. Unlike previous experiments, our results suggest the existence of collective priming. This effect, moreover, does not seem to be different from the one produced by distributive primes. The lack of asymmetry indicates that the mechanisms responsible for both collective and distributive interpretations can be primed.

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