Cognition and Neurosciences

Or cues knowledge of alternatives: Evidence from priming

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Recent research has determined that word meanings can instantly influence the meaning and distribution of other words in the sentence. Here, we manipulated basic carrier sentences with the disjunction *or* linking two nouns that were either filling the same thematic role or not, and were either semantically related or not. Though previous research has shown that one word can prime a semantically related word even in a sentential context, we predicted that if *or* cues knowledge about contextually-relevant alternatives, priming for semantic relatives will only obtain when those words also fill the same thematic role. These predictions were confirmed, as self-paced reading times of the second alternative in the sentence were faster only when the two alternatives shared the same thematic role and semantic category, suggesting that disjunction words like *or* function similarly to verbs, which cue knowledge about expected argument structure and sense depending on sentential context. The relevance of these findings for basic reasoning phenomena (i.e., the subadditivity effect) is also discussed.

Key words: Disjunction, alternatives, thematic roles, priming, familiarity, subadditivity.

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INTRODUCTION

Language comprehension relies on our ability to anticipate and bind together words and sentences that follow each other in speech or writing. As shown in Hare, McRae & Elman (2003), for instance, context can promote a specific sense of a verb, which subsequently imposes a specific sentence structure. Verbs also cue their arguments by imposing specific lexical preferences. For example, Kamide, Altmann & Haywood (2003) showed that eye movements are rapidly driven towards a glass of beer when hearing *The man will taste the* … but towards candy when hearing *The girl will taste the* …, although the verb itself combines equally well with both *beer* and *candy*. Their results confirm similar findings (MacDonald, 1994; Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995; etc.) that comprehenders use lexical information provided by context at the earliest stages of processing to build expectations for subsequent lexical items.

A special type of contextual cues are logical connectives such as *because*, *but*, or *if* that invariably cue knowledge of specific relations (causal, contrastive, conditional, etc.) between events in different sentence fragments (cf. Gernsbacher, 1996; Sanders, Spooren & Noordman, 1992; Zwaan & Radvansky, 1998) – for instance between starting a car and getting home late when reading *Sam got home late because the car wouldn't start*. In our example, *because* allows us to infer that *the car wouldn't start* encodes the cause of the main event in *Sam got home late*. In the present paper, we aim to determine whether and how the disjunction word *or* (e.g., *Have some coffee or tea!*) cues knowledge of alternatives and therefore prompts people to interpret as such two sentence fragments. Knowledge of alternatives should be easily available during sentence processing insofar as it draws on people's experience with comparing and eventually choosing between similar items in disjunction contexts (cf. Fillenbaum, 1974). For example, because comprehenders are often prompted

to choose between coffee and tea, they should read the word *tea* faster in *coffee or tea* than in *soup or tea*.

The idea that connectives may facilitate processing is not new (e.g., Britton, Glynn, Meyer & Penland 1982), but here we aim to show that comprehenders anticipate the second noun based on a combination of disjunction and first noun that goes beyond mere lexical co-occurrence. In particular, we advance the hypothesis that, like verbs, disjunctions introduce specific thematic roles (henceforth T-roles). Recovering the meaning of a sentence during online comprehension requires retrieval of the main verb's argument structure and associated T-roles (also known as 'thematic relations' and sometimes identified with the syntactic notion of 'theta-roles'). Each verb introduces several T-roles that together determine the particulars of who did what to whom (for further information see Dowty, 1979; Frawley, 1992). Whereas T-roles introduced by verbs are usually different (an agent and a patient as in *The schoolmaster praised the children*, or a theme and a location as in *The clock is on the bookshelf*), T-roles introduced by disjunction should be identical (e.g., two objects, two locations, or two instruments) because disjunctions are usually used in contexts where people are confronted with relevant alternatives (cf. Braine & Rumain, 1981; Fillenbaum, 1974; Johansson & Sjolin, 1975). We further hypothesise that, also like verbs, disjunctions impose detailed preferences for their T-role fillers. Alternatives are thus likely to share a semantic category as well (e.g., two pieces of furniture, two vacation-destinations, or two chopping-utensils) as people are used to comparing and eventually choosing between similar items in disjunction contexts.

We tested our hypothesis in a self-paced reading study, where sentence stimuli formed two sets. In the first set, *or* linked nouns that typically have the same T-roles, whereas in the second set *or* linked nouns that typically have different T-roles. The nouns in the first set were either semantically related or unrelated in the sense that they belonged to the same or to different semantic

categories (e.g., *carpet/train* >> *rug*). The nouns in the second set were semantically related or unrelated in the sense that they were arguments of the same event or of different events (e.g., agents primed by events – *olympics/funeral* >> *athlete*, themes primed by locations – *garage/office* >> *car*, and themes primed by instruments – *key/ladle* >> *door*).

Previous word-word priming studies have found processing facilitation in all cases where prime and target were semantically related regardless of their T-role. In particular, there is an extensive literature showing that people respond faster to target words preceded by semantically-related, relative to semantically-unrelated primes when they have the potential of filling the same T-role (for a review, see Neely, 1991). Also, as shown in Hare *et al.* (2009), robust priming obtains for words that are semantically related (i.e., arguments of the same event) but have different T-roles. However, the literature on sentence-level priming suggests that, in order for priming to obtain, words must not only fill particular T-roles, but also follow each other in the right sequence. Traxler, Foss, Seely, Kaup & Morris (2000), for instance, reported that typical instruments fail to prime typical agents (e.g., *axe* following *lumberjack* in *The lumberjack chopped the axe*) in the same fashion as they fail to prime neutral agents (*The young man chopped the axe*), because comprehenders anticipate a patient immediately following *chopped*, not an instrument. These findings suggest that the information encoded with lexical concepts must include relational knowledge, namely, that axes are instruments typically used for chopping. Similarly, O'Seaghdha (1989) found facilitation for *book* following "The author of the" but not following "The author the and." So, even when two short function words (e.g., prepositions or logical connectives) were all that intervened between prime and target, there was no priming unless the target fit the local context. Also, O'Seaghdha (1997) found no evidence for priming in short phrases that were syntactically correct but in which the target word was not locally appropriate.

Our hypothesis that disjunction cues knowledge of alternatives predicts that priming should obtain when nouns are semantically related in the same-T-roles condition but not in the different-T-roles condition because only the former allows comprehenders to easily grasp the similarity between items. We used minimal contexts in our study, as we intended our sentences to function as simple carriers of the disjunction structures and thus prevent further contextual effects, to which priming is highly sensitive (cf. Ferretti, Kutas & McRae 2007; Zwaan and Radvansky 1998; among others).

METHOD

Participants

A total of 32 volunteering students participated in the experiment in return for course credit. They were all native speakers of English and were tested in individual sessions lasting up to forty minutes.

Stimuli

We constructed two sets of sentences in which *or* linked two nouns. One set contained nouns that filled the same T-role and hence could be

alternatives of each other, and the other set contained nouns that filled different T-roles and hence could not be alternatives of each other. Half of the nouns in each set were semantically related, and the other half unrelated. Related and unrelated primes were matched in length (number of letters) in the same-T-roles set ($M = 5.22$, $SD = 1.39$ vs. 5, $SD = 1.41$) and in the different-T-roles set ($M = 6.05$, $SD = 2.57$ vs. 6.50, $SD = 1.94$). Primes were also matched on lexical frequency, estimated from log-transformed frequency counts reported in the SUBTLEX$_{US}$ corpus (Brysbaert & New, 2009) in the same-T-roles set ($M = 2.76$, $SD = 0.484$ vs. 2.90, $SD = 0.504$) and in the different-T-roles set ($M = 2.53$, $SD = 0.55$ vs. 2.48, $SD = 0.604$). Previous studies have obtained priming for semantically-related nouns both in the same-T-roles and in the different-T-roles condition. In particular, nouns in the same-T-roles set were selected mainly from stimuli used in Balota & Lorch (1986), whereas nouns in the different-T-roles set were selected from the stimuli used in Hare *et al.* (2009) and featured the following semantic relations: event-agent, event-theme, instrument-agent, instrument-theme, location-agent, and location-theme. The following are example stimuli:

Same T-roles, related:
Brian sees a circle or a square after lunch.

Same T-roles, unrelated:
Brian sees a lamp or a square after lunch.

Different T-roles, related:
Peter sees a cemetery or a gravestone in the afternoon.

Different T-roles, unrelated:
Peter sees a bathroom or a gravestone in the afternoon.

Design

Two stimulus lists of 72 sentences each were constructed, such that one list contained half of the targets paired with related primes and the other half targets paired with unrelated primes; the second list contained the same targets paired with the remaining primes that is, unrelated primes for the first half and related primes for the second half (Latin-square design). Participants were randomly assigned to one of the lists. An equal number of filler sentences were included, which shared the same structure as test sentences and in which nouns were linked by the conjunction *and*. No participant saw a noun pair more than once. Five practice trials preceded the stimuli, which were presented in individually randomized orders in two equal blocks. The dependent variable was reading latency. Comprehension judgements followed a third of the trials.

Procedure

Participants were seated in front of a personal computer with a 40 cm 19" flat CRT monitor and were instructed to read each sentence at a normal, comfortable pace. The text was presented in white letters against a black background in five segments (e.g., "Adam remembers/ a plane/ or/ a boat / every day."). Each segment appeared in the center of the screen, with subsequent segments overwriting the first. Each trial was cued by the word "Ready" presented in the center for 1,000 ms, followed by a 500 ms blank screen; subsequent text appeared in the same location. We opted for central presentation as we originally designed our study for MEG testing, where presentation is central.

Participants were instructed to press the spacebar to initiate each presentation; the trial ended either with the word "NEXT" or with a comprehension judgement presented in green letters, prompting participants either to go on to the next trial or respond by "true" or "false." Answer accuracy was recorded, together with the reading times for each sentence segment.

RESULTS

The preliminary treatment of trials was as follows. To reduce the effects of extremely long and short latencies, the cut-off was set for each participant at 3 standard deviation units from each participant's mean latency, and those shorter or longer than the cut-off were replaced by the individual mean. This affected less than 1% of all trials. Response accuracy to comprehension judgements averaged 97%. Figure 1 shows the effects of T-role (same vs. different) and semantic relatedness (unrelated vs. related) measured at the second noun (following the disjunction word *or*).

The 2×2 ANOVA (thematic role by semantic relatedness) at the target (i.e., the second noun offset) revealed a significant interaction between factors, $F(1, 31) = 5.79$, $p = 0.022$, $\eta_P^2 = 0.645$. Planned comparisons showed significant priming for semantic relatedness in the same-T-role condition, $t_1(31) = 2.73$, $p = 0.011$; $t_2(17) = 2.06$, $p = 0.054$, with reading times shorter in related trials compared to unrelated trials ($M = 690$ ms, $SD = 214$ ms vs. $M = 750$ ms, $SD = 278$ ms), but no priming in the different-T-role condition, $t_1(31) = 0.15$, $p > 0.8$; $t_2(17) = 0.91$, $p > 0.3$, with similar reading times in related and unrelated trials ($M = 735$ ms, $SD = 241$ ms vs. $M = 740$ ms, $SD = 306$ ms).

We also analyzed the sentence regions preceding the critical region (i.e., the word *or*) and following it (i.e., the last phrase of the sentence) in order to determine the source of priming for the second noun as well as any spill-over effects. The 2×2 ANOVA over reading latencies at the offset of the disjunction word *or* showed no effect of thematic role, $F(1, 31) = 1.53$, $p = 0.225$, no effect of semantic relatedness, $F(1, 31) = 0.869$, $p = 0.359$, and no interaction between factors, $F(1, 31) = 0.865$, $p = 0.359$, suggesting that the source of priming must be located somewhere between the onset of the disjunction word *or* and the offset of the second noun but not in earlier sentence fragments. The 2×2 ANOVA over reading latencies at sentence offset showed no significant effect of thematic role, $F(1, 31) = 1.82$, $p = 0.187$, a close-to-significant effect of semantic relatedness, $F(1, 31) = 3.22$, $p = 0.082$, and no interaction between factors, $F(1, 31) =$

1.76, $p = 0.193$. Planned comparisons revealed significant priming for semantic relatedness in same-T-role trials ($M = 797$ ms, $SD = 268$ ms vs. 853 ms, $SD = 315$ ms), $t_1(31) = 2.652$, $p = 0.012$; $t_2(17) = 2.122$, $p = 0.049$, but not in different-T-role trials, ($M = 795$ ms, $SD = 240$ ms vs. 805 ms, $SD = 284$ ms), $t_1(31) = 0.373$, $p > 0.7$; $t_2(17) = 0.36$, $p > 0.7$, suggesting that the priming effect is long-lasting.

DISCUSSION

We investigated whether and how the disjunction word *or* cues knowledge of alternatives. As predicted, we obtained priming for semantic relatedness between two nouns that typically have the same thematic role and no priming between nouns that typically have different thematic roles. At first, these findings may seem at odds with previous reports in the word-word priming literature (e.g., Moss, Tyler & Marslen-Wilson, 1995; McRae, Hare, Elman & Ferreti, 2005) showing that structural information is encoded with verbs as well as with verb arguments such that nouns denoting agents, patients, instruments, or locations can prime each other in the absence of relevant verbs or action nouns (e.g., *restaurant* primes *wine* and *broom* primes *floor*). These findings warrant the assumption that priming for semantic relatedness should also obtain between different-T-role nouns when the verb is absent but the disjunction *or* is present. This assumption is nevertheless unwarranted if disjunction imposed its own identical T-roles. Different-T-role nouns would then yield no priming in disjunction contexts, which is what we observed. Our results are compatible with findings by O'Seaghdha (1989, 1997) among others, that semantic priming among related words is not an automatic consequence in a sentence processing task and that specific conditions (e.g., no random words and certainly not the wrong role provider between prime and target) must be present for priming to take place.

The results of these and other studies suggest that prime and target in a sentential context only function as such in the presence of an appropriate T-role provider (i.e., verb or disjunction), with important consequences for the priming literature. In particular, we may infer that priming in word-word studies is elliptical – a hypothesis that has recently received strong support from studies showing that comprehenders are able to easily recover missing lexical items based on their experience with concrete situations. Indeed, as shown in Khalkhali, Wammes & McRae (2012), pairs of words denoting events that can plausibly occur in sequence (e.g., *marinate-grill*) generate expectancies for a target denoting a subsequent event (*chew*) in conditions where neither *marinate* nor *grill* prime *chew*. Comprehenders are thus able to instantly reconstruct missing cues to temporal structure. Similarly, Chwilla and Kolk (2005) found priming in a word triplet paradigm (e.g., *director* and *bribe* together prime *dismissal*), showing that comprehenders can instantly reconstruct missing cues to causal structure.

The results of our study are further compatible with previous findings suggesting an immediate influence of local (i.e., nonsyntactic) factors on sentence comprehension. Roll, Horne & Lindgren (2009), for instance, reported that comprehenders are able to instantly integrate prosodic factors (i.e., left-edge boundary tones) as well as pragmatic factors to guide the syntactic
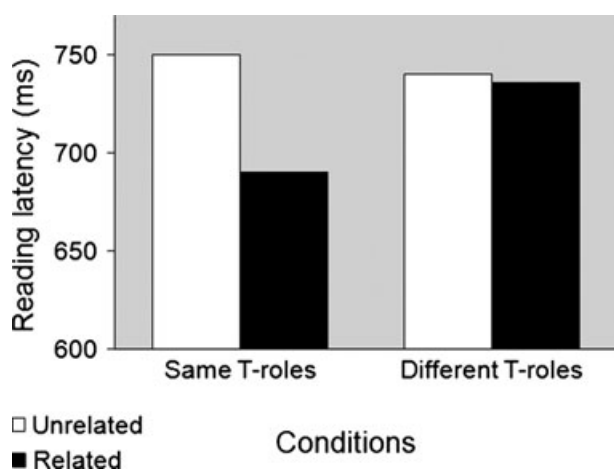

Fig. 1. Reading latencies (ms) of semantically related and semantically unrelated second noun (following the disjunction word *or*) in the same-T-roles condition and in the different-T-roles condition.

processing of embedded clauses in Swedish. Also, as shown in Gennari & MacDonald (2009), semantic factors such as noun animacy play a critical role in determining the various interpretations that readers assign to relative clauses at different points in a sentence-completion task. In our study, comprehenders could rapidly identify the second word in disjunction structures as an alternative of the first by drawing on their knowledge (i.e. frequency counts) of possible noun pairs in disjunction contexts.

An important theme for further research is the relationship between online sentence processing and higher-level cognitive processes. As shown in recent decision-making studies, for instance, individuals are often prone to making reasoning errors when presented with disjunction expressions containing semantically-related nouns. In particular, Tversky and Koehler (1994) showed that people may unduly judge the probability of an event (e.g., *homicide*) to be higher when the event's description is unpacked into a disjunction of component events and especially when these events belong to the same category as in *homicide by an acquaintance or stranger*. This reasoning error was dubbed 'subadditivity effect' and illustrates individuals' preference for retrieving fully-fledged action patterns (e.g., a particular event and associated circumstances such as an agent or cause) rather than strings of atomic concepts. This preference to instantly reconstruct structures that integrate all available information is also apparent in language processing, as witness compelling results from lexical priming studies, as discussed above (i.e. Chwilla and Kolk 2005; Khalkhali *et al*., 2012). One consequence of this general tendency to meaningfulness is that reasoners may view language patterns as sufficient grounds for validating instances of faulty reasoning. In other words, semantic priming may be driving the subadditivity effect just because alternativeness has become language-encoded such that comprehenders of disjunction expressions can instantly evoke contexts where they were prompted to compare alternatives and eventually choose between them. Indeed, as shown in Ariely & Norton (2008), people prefer to engage in behavior that is consistent with past behavior based on surface similarities rather than based on valid reasoning rules.

However, as shown in Rottenstreich and Tversky (1997), specific contextual conditions must be met for the effect to obtain. In the example above, subadditivity was found for words promoting attention to different causes of homicide – an *acquaintance* or a *stranger* – but not for descriptions designed to highlight other dimensions, as when *homicide* is unpacked into *daytime homicide or nighttime homicide*, for instance. These findings suggest that relevant circumstances such as specific *homicide* agents have also become encoded and subsequently retrieved with select events, and hence that subadditivity may reflect comprehenders' preference for quickly establishing conceptual patterns that are contextually relevant. In particular, it may be statistically more useful to investigate two causes rather than two moments in time for grasping the relevance of a homicide event and subsequently establish a valid course of action. In our semantic-priming study, we purposefully used neutral contexts to determine whether the combination of first noun and disjunction word elicits priming of the second noun. However, in further studies we expect priming for disjunction expressions in certain non-neutral contexts but not in others if language drives reasoning.

CONCLUSION

Online comprehension relies on humans' ability to rapidly draw on their experience to build connections between various sentence fragments. In the present study we showed that, like verbs, disjunctions impose specific preferences for their T-role fillers, such that comprehenders may interpret the second noun as a typical alternative of the first when nouns have the same inherent T-role. Interestingly, we found no semantic priming for semantically related nouns having different inherent T-roles, which indicates that thematic structure plays a role in understanding the meaning of nouns even in contexts where no verb is explicitly eliciting that structure. More broadly, this provides additional evidence for local sources of influence during sentence processing in neutral contexts.

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