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# Context Sensitivity of Relational Nouns

**Jennifer A. Asmuth (asmuth@northwestern.edu)**
Department of Psychology, Northwestern University
Evanston, IL 60208 USA

**Dedre Gentner (gentner@northwestern.edu)**
Department of Psychology, Northwestern University
Evanston, IL 60208 USA

**Abstract**

We present findings that relational nouns are more context-sensitive than entity nouns in two conceptual combination recognition tasks. Across two experiments, we investigated people's ability to recognize entity nouns and relational nouns either in the same context as at encoding or in a different context. We found that (1) participants showed greater recognition sensitivity for entity nouns than for relational nouns and (2) relational nouns showed a greater disadvantage in recognition in new contexts relative to old contexts. Thus, the encoding of relational nouns appears to be more influenced by context than the encoding of entity nouns. We discuss parallels with encoding patterns for verbs and nouns.

## Introduction

This paper explores the psychology of relational nouns. Relational nouns refer to relational categories: categories whose membership is determined by common relational structure (including extrinsic relations to other entities), rather than by common properties (see Gentner & Kurtz, 2005). For example, for X to be a *bridge*, X must connect two other points or entities; for X to be a *carnivore*, X must eat animals. Relational categories contrast with entity categories like *radish* or *penguin*, whose members share many intrinsic properties.

One way to distinguish between entity and relational categories is the *fetch test*: if asked to find a member of the category, how do you know one when you see it? For an entity category like *tulip*, all you have to do is locate the entity itself—its intrinsic properties suffice to identify it. But for a relational category like *thief*, intrinsic properties are not enough: you need to verify its relations to other entities. Specifically, you need to check that there are other entities that serve as *victim* and *purloined goods*.

While there has been considerable work on entity nouns and taxonomic categories, the study of relational nouns and categories is relatively new (Gentner & Kurtz, 2005; Anggoro, Gentner & Klibanoff, 2005; Jones & Love, in preparation; Barr & Caplan, 1987; Markman & Stillwell, 2001). This is surprising, given their frequency and importance. Our informal ratings of the 100 highest frequency nouns in the British National Corpus revealed that roughly half showed extrinsic relational structure in adult discourse. For example, consider the following sentences:

*(1) This goal has priority until the submission deadline has passed.*

*(2) The dog chased the ball across the field.*

We suggest that the first sentence—which contains mostly relational nouns—is more likely to occur in adult life than the second, with its concrete entity nouns. The importance of relational nouns in our everyday discourse becomes clear if we try to express the meaning of (1) without using relational nouns.

Relational nouns have some commonalities with verbs and prepositions, in that their meanings are centered around extrinsic relations with other concepts. Relational nouns are also similar to verbs in that they are semantically unsaturated (i.e., they take arguments). A relational noun takes an argument (often not obligatory) and assigns a thematic role. For example, *barrier* implies three arguments, not all of which need be explicit: a figure, something that blocks access, and a goal. This greater syntactic complexity more closely approximates the behavior of verbs than of entity nouns.

This similarity between relational nouns and verbs can be seen in other phenomena as well. As with verbs (Gentner, 1982; Gentner & Boroditsky, 2001), a rich understanding of relational nouns occurs later in acquisition than that of entity nouns. Relational nouns such as *uncle* are typically understood first as object reference terms (e.g., *friendly man with a pipe*) before evolving to a more relational interpretation (Gentner & Rattermann, 1991; Keil, 1989; Waxman & Hall, 1993). Kurtz and Gentner (2001) compared relational categories (named by relational nouns like *shield* and *surprise*) to superordinate entity categories (such as *furniture* and *vegetable*). Productivity and response fluency were much higher for entity categories than for relational categories. In addition, exemplars generated for the entity categories were rated as much more similar to each other than those generated for the relational categories by independent raters.

One way to begin exploring the differences between entity nouns and relational nouns is to consider some known contrasts between nouns and verbs. To clarify this proposal, we offer the following intriguing analogy:

relational nouns : entity nouns : : verbs : nouns

Gentner (1981; Gentner & Boroditsky, 2001) described a set of interrelated processing distinctions between verbs and nouns. For example, verbs are acquired later than nouns in both first and second languages (Caselli et al., 1995; Gentner & Boroditsky, 2001), paralleling the pattern noted above. We focus here on two interrelated differences: (1) verbs are less likely to be accurately remembered or recalled than nouns (Kersten & Earles, 2004; Earles & Kersten, 2000) and (2) verbs are more context-sensitive and semantically mutable than nouns (Gentner, 1982; Gentner & France, 1988). By *mutability* we mean a word's propensity to take on a different encoding in different contexts. Gentner and France (1988) compared nouns and verbs along this dimension by asking participants to paraphrase semantically strained intransitive sentences such as *The lizard worshipped.* The results showed greater semantic change for the verbs than for the nouns; for example, asked to paraphrase the above sentence, one participant wrote *"The small grey reptile lay on a rock and stared unblinkingly at the sun."*

Mutability and poor recognition and recall may well be related: memory for verbs may be more dependent on semantic context because their meanings are more variable in different contexts than are nouns (see also Gentner, 1981; Kersten & Earles, 2004). For example, had a memory task been administered in the Gentner & France study, it is likely that participants would have been more likely to remember *lizard* than *worshipped*. Kersten and Earles tested this connection between mutability and recognition. In their experiment, participants were asked to remember either the nouns or the verbs from a list of intransitive sentences and later given a recognition list. At test, memory for verbs was significantly improved when the verb was paired with the same noun as at encoding. This effect of context was much smaller for nouns.

These clear differentiations between nouns and verbs provide a starting point for investigating the differences between relational nouns and entity nouns. In this paper, we ask whether this pattern—greater contextual mutability with concomitant lowering of recognition accuracy—will hold in the comparison between relational nouns and entity nouns. Suppose, as the analogy with verbs would suggest, that relational nouns are more mutable than entity nouns. Then we might expect that when relational nouns are combined with entity nouns, the relational nouns would be both less stable under paraphrase and less well-retained in a memory task.

To do this, we adopted the basic logic of the Kersten and Earles studies. We presented phrases containing a relational noun and an entity noun at study, and then compared recognition for the entity nouns versus the relational nouns given either the same (old) context word or a new context word. Our hypothesis is that the encoding of relational nouns is highly context sensitive, while the encoding of entity nouns is relatively context-independent; thus, entity nouns will retain their intrinsic character across the study and test situations (regardless of their relational partners). In this case, people should be more sensitive to a change in the entity noun than to a change in the relational noun.

The properties of noun–noun conceptual combinations have been well-studied and provide an appropriate arena in which to study the mutability of concepts (Costello & Keane, 2001; Murphy, 1988; Wisniewski, 1996).

## Experiment 1

In our first study, we employed a recognition paradigm from Kersten and Earles' (2004) investigation of noun and verb recognition. Participants were given a list of conceptual combinations consisting of an entity noun (E) and relational noun (R) (e.g., *a leg reference*) and asked to rate how difficult the sentences were to understand on a scale from 1 to 7.

After rating the phrases, participants were given an unrelated filler task, followed by a recognition test that included the old conceptual combinations ($E_{old}R_{old}$), combinations of old entity nouns and new relational nouns ($E_{old}R_{new}$), combinations of old relational nouns and new entity nouns ($E_{new}R_{old}$), and completely new combinations ($E_{new}R_{new}$). Their task was to say whether each phrase had been seen in the original ratings task. For example, if a participant saw *a truck limitation* during the ratings task, she would see one of the phrases in Table 1 during the recognition test. (Only the first sentence is old; the others are new.)

Table 1. Recognition Combinations

| **encoding phrase:** a truck limitation | |
|---|---|
| **phrase at test:** | |
| $E_{old}R_{old}$ | a truck limitation |
| $E_{old}R_{new}$ | a truck threat |
| $E_{new}R_{old}$ | a book limitation |
| $E_{new}R_{new}$ | a book threat |

Old items were always combined with new items except when they appeared in their original phrase. That is, if both *truck limitation* and *book threat* were seen at encoding, then *truck threat* would not be seen at test. This allowed us to distinguish between the false alarms triggered by the $E_{old}$ and those triggered by $R_{old}$ at recognition. We expected high hit rates for the $E_{old}R_{old}$ combinations, since participants have actually seen the phrase before. Likewise, an $E_{new}R_{new}$ combination should elicit a very low false alarm rate since both words are entirely new.

The key predictions are as follows. If relational nouns are more context sensitive than entity nouns, then we should see greater discrimination between the original combinations and the $E_{old}R_{new}$ phrases than between the original combinations the $E_{new}R_{old}$ phrases. This is because the meaning of the relational noun is more dependent upon its context and is therefore more susceptible to a shift in meaning between the different contexts. For example, suppose a participant instantiates the phrase *a truck*

*limitation* at encoding as "a vehicle that is hard to park." If, at recognition, the same participant sees the $E_{old}R_{new}$ phrase *a truck threat* and interprets it as "a runaway vehicle," she should feel a sense of recognition based on the common concept of *vehicle,* thus she may be likely to false-alarm to the phrase. However, if she sees the $E_{new}R_{old}$ combination *a book limitation* at test*,* she might think of "a boring story." This should be less similar to her prior encoding of "hard-to-park vehicle" and therefore less likely to trigger a false alarm.

## Participants

Fifty-three Northwestern University undergraduates participated for course credit.

## Materials and Procedure

The encoding materials consisted of 96 conceptual combination phrases: 64 entity noun–relational noun combinations, and 32 conventional combination (e.g., *noodle casserole* or *football stadium*) filler items. To encourage naturalistic encoding, the participants were instructed to interpret each phrase as if it had been overheard while passing through the dining hall and rate the difficulty of constructing an interpretation on a scale from 1 to 7. The difficulty ratings of the conventional conceptual combinations served as a manipulation check to ensure that participants were paying attention to the rating scale throughout the task.

There were two independent variables: word order of the phrase (ER, entity noun followed by relational noun, or RE, relational noun followed by entity noun) and recognition context. Word order was manipulated between participants, while recognition context was manipulated within participants.

The recognition materials consisted of 32 conceptual combinations presented in the same word order as seen at study: 8 $E_{old}R_{old}$, 8 $E_{old}R_{new}$, 8 $E_{new}R_{old}$, and 8 $E_{new}R_{new}$ phrases. One of the $E_{new}R_{new}$ phrases and one of the $E_{new}R_{old}$ phrases was omitted from analysis due to a combination error.

The nouns were matched in frequency according to the norms of Francis and Kucera (1982). All nouns fell in the frequency range of 20-100. The average entity noun frequency was 48.43; average relational noun frequency was 47.00. There was no reliable difference in frequency between the two lists ($t<1$).

Participants completed the paper-based ratings task for the 96 conceptual combinations, participated in an unrelated filler task for 20 minutes, then completed the paper-based recognition task.

## Results and discussion

Data from three participants were excluded from analysis because their false alarm rate exceeded their hit rate; data from one participant was excluded because the hit rate fell below the criterion set by 1.5 x interquartile range. Two measures of recognition sensitivity were computed for each participant. To measure recognition sensitivity for $E_{new}R_{old}$ phrases, we computed the proportion of hits to previously encountered ER phrases and the proportion of false alarms to new entity nouns that were presented with a familiar relational noun (see Table 2). These proportions were used to compute d' for each participant, a measure of recognition sensitivity that takes individual bias into account, for $E_{new}R_{old}$ phrases.

Likewise, to measure recognition sensitivity for $E_{old}R_{new}$ phrases, we computed the proportion of hits to previously encountered ER phrases and the proportion of false alarms to new relational nouns that were presented with a familiar entity noun (also in Table 2). These results were used to compute d' for the $E_{old}R_{new}$ phrases.

As expected, participants were highly accurate in correctly recognizing old noun–noun combinations ($M$ = .86, SD=.13) and unlikely to false alarm to entirely new combinations ($M$ = .11, SD=.15). Clearly, participants had been attending to the task. Turning to the comparisons of interest, the mean false alarm rate to $E_{old}R_{new}$ combinations (old entity nouns paired with new relational nouns) was higher than that of $E_{new}R_{old}$ combinations (new entity nouns paired with old relational nouns) (.28 and .17, respectively) in both word orders. That is, people were more likely to incorrectly identify a new phrase as old when the entity noun was old than when the relational noun was old.

Table 2. Experiment 1: Hits, False Alarms, and d'

| | **ER** | | **RE** | | **total** | |
|---|---|---|---|---|---|---|
| | mean | SD | mean | SD | mean | SD |
| Hits $E_{old}R_{old}$ | .88 | .12 | .84 | .15 | .86 | .13 |
| FA $E_{old}R_{new}$ | .26 | .20 | .32 | .27 | .28 | .23 |
| FA $E_{new}R_{old}$ | .16 | .17 | .20 | .20 | .17 | .18 |
| FA $E_{new}R_{new}$ | .08 | .16 | .15 | .12 | .11 | .15 |
| d' $E_{old}R_{new}$ | 2.30 | 1.27 | 2.04 | 1.49 | 2.20 | 1.35 |
| d' $E_{new}R_{old}$ | 2.79 | 1.17 | 2.43 | 1.18 | 2.65 | 1.17 |

Participants were better able to discriminate between the old phrases and $E_{new}R_{old}$ combinations (mean d' = 2.65) than old phrases and $E_{old}R_{new}$ combinations (mean d' = 2.20), $F(1,47) = 10.60$, $p<.01$. To put this more simply, people were more sensitive to a change in the entity noun than to a change in the relational noun. This is consistent with the idea that the entity nouns were encoded in a relatively context-independent way during study (as well as during test); thus, entity nouns retained their intrinsic character across these two situations, regardless of their relational partner. In contrast, relational nouns were interpreted so as to fit the entity nouns with which they were paired, both at study and at test. Thus, seeing an old relational noun paired with a new entity noun did not trigger a sense of familiarity, since the relational noun would now have a slightly different interpretation.

The results of this study bore out the predictions. However, two concerns led us to carry out a second study. First, we wished to isolate the effect of encoding mutability to a greater degree than was permitted by the whole-phrase recognition method. Our goal is to discover whether entity nouns are encoded in a more context-independent manner than relational nouns. Although the results of Experiment 1 are consistent with this prediction, the interpretation is somewhat clouded by the fact that in the whole-phrase recognition test, each word acted both as cue and target. In Experiment 2 we conducted a cleaner recognition test by asking participants about only one of the words—either the relational noun or the entity noun.

Our second concern was that one of our two word orders—the RE order—was perceived as quite difficult by participants. Phrases in the RE order (e.g., *barrier peanut*) were judged more difficult ($M$ = 5.21) than the same combinations in ER order (e.g., *peanut barrier*) ($M$ = 4.8), $t(126) = 2.82$, $p<.01$. This difference is consistent with discussions of word order in conceptual combination (Murphy, 1988; Gerrig & Murphy, 1992; Wisniewski, 1996). Conceptual combinations are often understood by using the modifier to fill a slot in the head noun schema. In entity noun–relational noun combinations, the relational noun has a salient, established relational structure with arguments to be filled. Therefore the combination is most natural if the relational noun occupies the head position, where its well-established relational structure provides slots that can be filled by the entity noun in the modifier position. Thus, a *peanut barrier* would be something that blocks peanut(s) from reaching some location or goal; in contrast, while *barrier peanut* can be interpreted (e.g., as a stubbornly unmoving peanut), it seems less natural.

Although the major results of Experiment 1 did not appear to be affected by word order, we were concerned that the perceived awkwardness might compromise the naturalness of the interpretations. Therefore in Experiment 2, we decided to use only the more natural ER combination order.

## Experiment 2

In order to isolate the encoding mutability effect, in Experiment 2 we adapted Kersten and Earles' (2004) noun–verb recognition paradigm to test recognition sensitivity for words within noun–noun phrases. Participants first viewed conceptual combination phrases as in Experiment 1. At recognition, they saw phrases with one word indicated as the target word to be recognized. The target word could appear with an old or new context word.

If the encoding of relational nouns is more influenced by context than that of entity nouns, we should expect entity nouns to be more stable across different contexts. That is, we expect recognition sensitivity for relational nouns to be more impaired by a new context than that of entity nouns. Using d' as the measure of sensitivity, we predict (1) that d' should be higher overall for entity nouns than for relational nouns; (2) that d' for relational nouns should be lower in the new context than in the old; and (3) that there should be an interaction between noun focus (entity or relational) and recognition context (old or new).

### Participants

Seventy-two Northwestern University undergraduates participated in this study in exchange for course credit.

### Materials and Procedure

The encoding materials were drawn from our stimuli list for Experiment 1. They consisted of 96 conceptual combination phrases in ER order: 64 relational noun–entity noun combinations and 32 conventional combinations (e.g., *noodle casserole* or *football stadium*) as filler items. Participants were instructed to imagine what the phrase might mean and to rate the difficulty of this task on a scale of 1 to 7. The conventional conceptual combinations served as a manipulation check to ensure that participants were paying attention to the rating scale throughout the task.

There were two independent variables: noun focus (whether the participant was tested on entity nouns or relational nouns) and recognition context (old or new). Noun focus was manipulated between participants, while recognition context was manipulated within participants.

The recognition materials consisted of 32 conceptual combinations: 8 $E_{old}R_{old}$, 8 $E_{old}R_{new}$, 8 $E_{new}R_{old}$, and 8 $E_{new}R_{new}$ phrases. On the recognition test, participants saw noun–noun phrases, and were instructed to say whether the target word (in red) was old or new. Individuals participated in a computer-based ratings task for the 96 conceptual combinations. Then they received an unrelated filler task for 20 minutes; finally, they completed the computer-based recognition task.

### Results

Data from seven participants were excluded because their false alarm rate exceeded their hit rate. Two measures of recognition sensitivity were computed for each participant. The first measured a participant's ability to detect a word when it was presented in the same semantic context as that at encoding. For this "old context" measure, we calculated the proportion of hits to old words presented with the (same) old context word as at encoding and the proportion of false alarms to new words presented with an old context word (as reported in Table 3). These proportions were used to compute the d' for an old context.

The second measure represented a participant's ability to recognize a word in a new context. For this "new context" measure, we calculated the proportion of hits to old words that were presented with a new context word and the proportion of false alarms to new words that were presented with a new context word (Table 3). These proportions were used to compute the d' for a new context, as shown in Figure 1.

Table 3. Experiment 2: Hits, False Alarms, and d'

| | E | | R | |
|---|---|---|---|---|
| | mean | SD | mean | SD |
| **old context** | | | | |
| Hits | 0.75 | 0.19 | 0.75 | 0.18 |
| FA | 0.25 | 0.13 | 0.38 | 0.22 |
| d' | 1.53 | 0.62 | 1.26 | 0.89 |
| **new context** | | | | |
| Hits | 0.61 | 0.21 | 0.53 | 0.24 |
| FA | 0.13 | 0.15 | 0.26 | 0.17 |
| d' | 1.79 | 0.95 | 0.91 | 0.74 |

As predicted, participants tested on entity nouns showed greater recognition sensitivity ($M$ = 1.66, SD = .81) than those tested on relational nouns ($M$ = 1.08, SD = .84), $F(1,63) = 14.04$, $p<.01$) across old and new contexts. There was no main effect of context. Also as predicted, there was a significant interaction of noun focus and context, $F(1,63) = 5.66$, $p<.05$. The mean d' for relational nouns in a new context was less than the mean d' in an old context (significant by a planned comparison, $t(33) = 2.17$, $p < .05$, one-tailed). Although the mean d' for entity nouns in the new context was greater than that in the old context, the difference was not statistically reliable. These results suggest that the change of context had a more deleterious effect on recognition of relational nouns than on recognition of entity nouns.

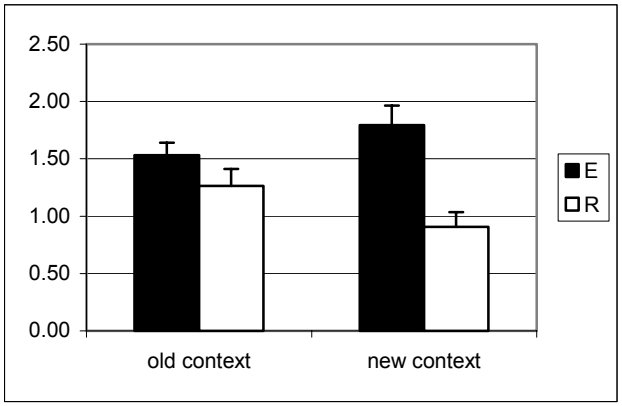


Figure 1. Experiment 2: Mean d' in old and new contexts

## General Discussion

Taken together, these experiments support two related claims: (1) that relational nouns are more mutable—that is, more context sensitive—than entity nouns during encoding; and (2) that recognition sensitivity for relational nouns is more disadvantaged in a new context than is recognition sensitivity for entity nouns.

Our hypothesis is that when people interpret an ER phrase, they tend to adapt the relational noun to fit the entity noun. Consistent with this hypothesis, in a whole-phrase recognition test (Experiment 1), people are more likely to judge a phrase to be "old" if the entity noun is old, (regardless of the relational noun). The results of Experiment 1 suggest that participants are more sensitive to the difference between old noun pairs and new pairs when the entity noun has been changed than when the relational noun has been changed. That is, people were able to recognize a change in entity noun regardless of its relational noun context. However, their recognition of relational nouns was influenced by its entity noun context.

In Experiment 2, participants showed greater recognition sensitivity for entity nouns than for relational nouns. In addition, relational nouns showed a greater disadvantage in new contexts relative to old contexts than did entity nouns. Both these results suggest that entity nouns were given a stable encoding that could later be recognized in a relatively context-independent way. In contrast, the encoding of relational nouns is influenced by the entity noun with which they occur.

This pattern parallels that for nouns and verbs reported by Kersten and Earles (2004). They found that people were better able to recognize old nouns across different verbs than old verbs across different nouns, and noted that this pattern could follow from the greater contextual mutability of verbs over nouns (Gentner, 1981; Gentner & France, 1988). Our findings invite an analogous conclusion for relational nouns as compared to entity nouns.

This pattern may be the result of a shift in the encoded features of the relational noun; while the defining extrinsic relations of the relational noun remain constant, the context may constrain and filter the properties of the relational noun. For example, *barrier* in the context of career advancement may refer to education or experience, while *barrier* in the context of athletic performance may be limitations of strength or endurance. Because the meaning of a relational noun is so dependent on its external relations, it is more likely to experience a shift in meaning in different contexts than an entity noun defined by primarily intrinsic relations.

*Further extensions.* An obvious direction is to ask what other verb characteristics may be shared by relational nouns. For example, are they more variable cross-linguistically and harder to translate than entity nouns? A second natural extension of this investigation is to examine the differences within relational nouns. One important distinction is between relational schema categories such as robbery, which convey a relational structure linking a set of arguments, versus relational role categories such as thief, which convey one specific argument of a schema. This distinction between relational role categories and relational schema categories may enter into the phenomena that characterize relational versus entity nouns. For example, are relational schema nouns more or less "verb-like" than relational role nouns? Another question is whether relational nouns that are morphologically derived from verbs (e.g., *betrayal* from the verb *betray* or *hindrance* from *hinder*)

differ from non-derived relational nouns such as *friend*, *sister*, or *carnivore*.

A final question is whether the relative abstractness/concreteness of the nouns plays a role in contextual mutability and recognition sensitivity. We are currently designing a study in which participant ratings will be used to create ER noun pairs controlled for abstractness.

Finally, although we have contrasted relational nouns with entity nouns, the contrast should probably be thought of as a continuum rather than a dichotomy. For example, Sloman and Malt (2003) have argued that artifact categories are characterized neither by essences nor by intrinsic sets of properties but at least in part by relational information such as the intended and actual function. Causal structure has also been shown to play an important role in the learning and processing of categories (Ahn, 1999; Rehder & Hastie, 2001) and in how people draw inferences from categories (Lassaline, 1996). As Murphy and Medin (1985) suggested, theory-like relational structure may be a prominent aspect of categories in general. If so, then the study of relational nouns and the categories they denote may shed light on phenomena of greater import.

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