Can Relationality be Distinguished from Abstractness in Noun Mutability?

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Abstract

Previous studies have suggested that relational concepts are more mutable—more prone to change meaning in context—than entity concepts even when both relational and entity concepts are denoted by nouns (Asmuth & Gentner, 2005; Feist & Férez, 2007). However, relationality is a complex dimension, and is highly correlated with other factors such as imageability and abstractness. In the current research, we compared the mutability of entity nouns and relational nouns while controlling for imageability (as well as frequency). People read these nouns in a given context and then had to recognize them in either the same or different context. We found that (1) participants showed greater recognition sensitivity for entity nouns than for relational nouns; and (2) recognition of relational nouns was more impaired by a change in context than was recognition of entity nouns. We conclude that the encoding of relational nouns is more influenced by context than the encoding of entity nouns and discuss parallels with encoding patterns for verbs and nouns.

Keywords: relational language; mutability; context sensitivity

Introduction

Most psychological research on concepts has focused on *entity* concepts, such as *cat* or *tomato*, which are defined by common properties and belong to taxonomic hierarchies. However, recently there has been increased interest in *relational* concepts (Jones & Love, 2007; Feist & Férez, 2007; Gentner, 2005; Gentner & Kurtz, 2005; Anggoro, Gentner & Klibanoff, 2005; Barr & Caplan, 1987; Markman & Stillwell, 2001). Relational categories are those whose membership is determined by common relational structure (such as extrinsic relations to other entities), rather than by common properties (see Gentner & Kurtz, 2005). For example, for X to be a *carnivore*, X must *eat* animals; for X to be a *bridge*, X must *connect* two other points or entities. The members of relational categories may share few or no intrinsic properties: e.g., sharks, eagles, tigers, and spiders are all carnivores. Relational categories thus contrast with entity categories like *bird*, whose members share large numbers of intrinsic properties.

Interestingly, both entity concepts and relational concepts can be denoted by nouns (e.g., *person* versus *enemy).* This makes them an apt arena in which to compare the psychological properties of these two kinds of concepts. Nouns can often be categorized as entity or relational according to whether they take arguments (To be an *enemy*, you have to be an enemy of someone or something, but you can be a *person* without further ado.) For relational nouns like *carnivore* that don't need arguments, Asmuth and Gentner (2005) proposed the *fetch test* as a way of distinguishing entity and relational categories: if you are asked to find a member of the category, how do you know one when you see it? For an entity category like *wolf*, you need only consider the entity itself—its intrinsic properties suffice to identify it. But for a relational category like *carnivore*, intrinsic properties are not enough: you need to verify its relations to other entities (namely, that it eats animals). You can tell which items in the room are *apples* just by looking at them, but you can't tell which things are *gifts* or *weapons* without knowing about their relations to other entities.

Apart from the intrinsic interest of relational and entity concepts, relational nouns are important in that they figure strongly in adult discourse. Our informal ratings of the 100 highest frequency nouns in the British National Corpus revealed that close to half were relational nouns. For example, consider the following sentences:

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

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

Sentences like (1)—which contains mostly relational nouns—are more likely to occur in adult conversation than are sentences like (2). To understand the importance of relational nouns in our everyday discourse, try to express the meaning of (1) without using relational nouns.

Relational nouns are similar to verbs and prepositions, in that their meanings are centered around extrinsic relations with other concepts[1]. Like verbs, relational nouns take an

[1] The extent of this extrinsic structure varies across different types of relational nouns. A distinction can be made between two kinds of relational nouns: *schema* nouns, such as *robbery*, denote relational systems and are defined by internal relational structure; *role* nouns, such as *thief*, are defined by extrinsic relations to the other entities in a relational schema (see Markman & Stillwell

argument (not always obligatorily) and assign 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 of relational nouns is more akin to the behavior of verbs than of entity nouns. We have suggested that one way to better understand differences between entity nouns and relational nouns is to consider some known contrasts between nouns and verbs. Indeed, the following analogy can be a useful way to generate predictions about relational nouns (Asmuth & Gentner, 2005; Gentner & Kurtz, 2005):

Relational nouns : Entity nouns : : Verbs : Nouns

Gentner (1981; Gentner & Boroditsky, 2001) described a set of interrelated processing distinctions between verbs and nouns. Many of these contrasts apply also to relational nouns versus entity nouns. For example, verbs are acquired later than nouns in both first and second languages (Caselli et al., 1995; Gentner, 1982; Gentner & Boroditsky, 2001), and the same appears to be true for relational nouns relative to entity nouns. Developmentally, understanding the meanings of relational nouns occurs rather late in acquisition, as compared to children's early grasp of the meanings 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 (Clark, 1973; Gentner, 2005; Gentner & Rattermann, 1991; Keil, 1989; Waxman & Hall, 1993).

The similarity between relational nouns and verbs can be seen in other phenomena as well. Kurtz and Gentner (2001) compared relational categories (named by relational nouns such as *shield* and *surprise*) to relatively abstract entity categories (like *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 judged by independent raters as much more similar to each other than those generated for the relational categories.

In our previous research, (Asmuth & Gentner, 2005), we asked whether we could extend two important differences between nouns and verbs to entity nouns and relational nouns: (1) *memory*: verbs are less likely to be accurately remembered or recalled than nouns (Earles & Kersten, 2000; Gentner, 1982; Kersten & Earles, 2004;) and (2) *mutability*: 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."*

It seems likely that high mutability and poor memory are causally related: If verbs are more mutable in context than are nouns, then it follows that memory for verbs should be more vulnerable to changes in semantic context (Gentner, 1981; Kersten & Earles, 2004). (For example, had a memory task been administered in the Gentner & France study, participants would probably have been better able to remember *lizard* than *worshipped*.) Kersten and Earles tested this connection between mutability and recognition. In their experiment, participants were given a list of intransitive sentences and asked to study either the nouns or the verbs. In a later recognition list, memory for verbs was significantly better when the verb was paired with the same noun as at encoding. This effect of context was much smaller for nouns.

In our earlier studies, we asked whether this pattern—greater contextual mutability with concomitant lowering of recognition accuracy—held in the comparison between relational nouns and entity nouns (Asmuth & Gentner, 2005). The analogy with verbs would suggest that relational nouns are more mutable than entity nouns. That is, the interpretation of a relational noun would be more likely to be influenced by the context in which it appears. In a discussion about an essay, a relational noun like *bridge* would be understood as a transition between ideas, whereas if the topic moves to politics, *bridge* refers to a source of compromise or agreement. An entity noun like *truck*, however, will be relatively stable regardless of its context.

Our initial experiment looked at recognition sensitivity for whole noun-noun phrases. Participants were asked to interpret conceptual combinations made up of an entity noun and a relational noun. On a subsequent recognition test, participants were better able to recognize that a phrase was 'new' when the entity noun was new than when the relational noun was new. That is, they were more sensitive to a change in the entity noun than to a change in the relational noun. This is exactly what we would expect if a relational noun is more likely to shift meaning between the different contexts, whereas the meaning of an entity noun is encoded more stably across different contexts. These results provided support for our hypothesis concerning the greater mutability of relational nouns.

The next step was to compare memory for entity and relational nouns more directly, looking at recognition for single words rather than phrases. As in the first experiment, participants encoded conceptual combinations. At recognition, they saw phrases with one word indicated as the target word to be recognized. The target word could appear in the same context or a different context. Once again, participants showed greater recognition sensitivity for entity nouns than for relational nouns. In addition, relational nouns were more disadvantaged in different contexts relative to same contexts than were entity nouns.

(2001) and Gentner & Kurtz (2005) for more detailed discussions of these distinctions.

However, at this point an intriguing pattern began to emerge: there appears to be a strong association between relationality and abstractness. Of course, there are relational words that are very concrete, such as *father*, and entity words that are abstract, like *idea*. However, overall it is very likely that a relational word will also be abstract. For example, words like *contribution, advice,* and *majority* all denote important relational categories that have very few attributes available to the senses.

While this connection between abstractness and relationality raises some fascinating theoretical issues (might there be a link between our capacity for relational thinking and our capacity for abstract thought?), on a methodological level, it makes the results of the studies more difficult to interpret. It has been well established that imageability and concreteness influence recognition of nouns (Morris & Reid, 1974; Gorman, 1961); if abstractness and relationality are correlated, what seemed to be a relationality mutability effect may in fact be due to abstractness. This called for further scrutiny.

When we examined our stimuli set, we found striking differences between the entity nouns and relational nouns that might account for the reported effects. A comparison of norms retrieved from the MRC2 database (Coltheart, 1981) showed that the entity noun stimuli were reliably more concrete than relational nouns, $F(1,42) = 87.71$, $p < .01$, as well as more imageable, $F(1,42) = 43.76$, $p < .01$.

In order to isolate the effect of relationality alone on mutability, we designed a set of relational and entity nouns that were matched for concreteness/abstractness.

Present Experiment

In our current study, we adapted the recognition paradigm from Kersten and Earles' (2004) investigation of noun and verb recognition. The experiment had two parts. First, participants saw a list of conceptual combinations consisting of a host noun (H) paired with either an entity noun (E) or a relational noun (R) (e.g., *marigold sister*) Host nouns belonged to one of three categories: animal, plant, or geological formation (e.g., *meadow* or *geyser*).

The participants were asked to think about what each phrase might mean, and to rate how difficult it was to understand. Later, a memory task tested their recognition of the entity nouns and relational nouns in new and old contexts. That is, participants saw entity and relational nouns that were paired with either the same host noun as at study or a different host noun. They were also presented with novel entity and relational nouns that had not been in the earlier ratings task.

For example, if a participant saw *marigold sister* during the ratings task, she would see one of the phrases in Table 1 during the recognition test. (Only the first phrase is an original phrase; the others are new.)

Previously seen nouns were always combined with novel nouns except when they appeared in their original phrase. That is, if both *marigold sister* and *albatross citizen* were seen at encoding, then *marigold citizen* would never be seen at test. We expected high hit rates for the original combinations ($H_{old}R_{old}$ and $H_{old}E_{old}$), since participants have actually seen the phrase before. Likewise, $H_{new}E_{new}$ and $H_{new}R_{new}$ combination should elicit a very low false alarm rate since both words are entirely new.

Table 1. Example Relational Recognition Combinations

Encoding combination: marigold sister			
Phrase at test	**Phrase type**		**'Yes' response**
marigold sister	$H_{old}R_{old}$	old context	Hit
marigold victim	$H_{old}R_{new}$	old context	False alarm
albatross sister	$H_{new}R_{old}$	new context	Hit
albatross citizen	$H_{new}R_{new}$	new context	False alarm

The key predictions are as follows. 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. 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 is given the entity noun item *marigold sister* at encoding and instantiates it as "a small, multi-petalled yellow flower that resembles a marigold." If, at recognition, the same participant sees the $H_{old}R_{new}$ phrase *marigold signal* at test and interprets it as "a bouquet of cheap flowers indicating lukewarm romantic interest," she might feel a sense of recognition based on the common concept of flower, thus she may be more likely to false alarm to the phrase. In contrast, a participant who sees the entity noun combination *marigold palace* at study may interpret it as "a glowing, gold castle." However, if she sees the $H_{old}E_{new}$ combination *marigold magazine* and interprets it as "a publication about flowers", it should be less similar to her prior encoding of "gold castle" and therefore less likely to trigger a false alarm.

Using A' (a non-parametric analog to discriminability measure d') as the measure of sensitivity, we predict (1) that A' should be higher overall for entity nouns than for relational nouns; (2) that A' for relational nouns should be lower in the different context than in the same; and (3) that there should be an interaction between type of noun (entity or relational) and recognition context (same or different).

Participants

Two hundred and seventeen Northwestern University undergraduates participated for either partial course credit or monetary compensation.

Materials and Procedure

Materials. All relational nouns and entity nouns came from the MRC database (Coltheart, 1981) and fell within the frequency of 20-100, according to the Francis & Kucera (1982) norms. Nouns that were also used frequently as verbs

(e.g., *alert*) were excluded from the list. From this list we selected nouns that our expert raters agreed were either entity nouns or relational nouns (Asmuth & Gentner, in preparation). The study materials consisted of 118 conceptual combination phrases: 96 experimental items, formed by pairing a 'host noun' (an animal, plant, or geological formation) with an entity or relational noun, and 22 filler items, 10 of which were conventional combinations (e.g., *carrot cake* or *foot traffic*).

The recognition materials included four types of conceptual combinations for each type of noun (entity and relational): 12 original conceptual combinations seen during the ratings task ($H_{old}E_{old}$ or $H_{old}R_{old}$), 12 combinations of old host nouns with new entity or relational nouns ($H_{old}E_{new}$ or $H_{old}R_{new}$), 12 combinations of new host nouns and old entity or relational nouns ($H_{new}E_{old}$ or $H_{new}R_{old}$), and 12 completely new combinations ($H_{new}E_{new}$ or $H_{new}R_{new}$). Thus, there were 96 total phrases at test: 48 for entity nouns and 48 for relational nouns.

Our goal with entity and relational nouns in the recognition test was to control for two factors that are correlated with recall and recognition performance: imageability and concreteness/abstractness. This proved challenging, as relational nouns tend to be more abstract than nouns denoting entities, decreasing the range of nouns from which we could choose.

The imageability and concreteness ratings from the MRC2 database (Coltheart, 1981) have a correlation of .85 for the nouns that were identified as relational by both raters. Given the difficulty of controlling for multiple factors, it made sense to use imageability as a proxy for both. We constructed a list of entity and relational nouns, ensuring that the distributions were as equivalent as possible with respect to imageability. The imageability of entity nouns (M = 458.80, SD = 69.73) did not differ from that of relational nouns (M = 447.54, SD = 63.92), $p>.20$.

In addition, we also wanted to control for any effects that the particular host noun—the noun with which the entity or relational noun was paired in the conceptual combination—might have on recognition. Therefore, we created two sets of stimuli, such that host nouns that were paired with relational nouns in one stimuli list were paired with entity nouns in the other list. Thus, host noun pairing became a between-subjects factor. For example, half the participants would see the conceptual combinations *sea barn* and *spider outcome* while the other half would be presented with *sea outcome* and *spider barn*.

Finally, as in previous experiments, we controlled for the frequency of the two types of nouns. Mean log frequency was the same for entity nouns and relational nouns (2.63).

In this way we controlled for imageability (also our proxy for concreteness/abstractness), frequency, and effects of noun pairing.

Procedure. First, participants completed the computer-based ratings task for the 118 conceptual combinations. 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 to 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. After rating the encoding phrases, participants were given an unrelated filler task for 20 minutes, followed by the recognition test. At test, participants saw 96 conceptual combinations with one word in each pair indicated as the target to be recognized. Their task was to say whether each word had been seen in the original ratings task.

There were three independent variables: noun type (entity or relational), recognition context (old or new), and host noun list. Noun type and recognition context were manipulated within participants, while host noun list was manipulated within participants.

Results

Data from 2 of the 217 participants were excluded from analysis because they answered 'no' to every item at test. Two measures of recognition sensitivity were computed for each participant: one for entity nouns and one for relational nouns. To measure recognition sensitivity for targets in an old context, we computed the proportion of hits to previously encountered phrases and the proportion of false alarms to new target nouns that were presented with a familiar host noun (see Table 2). These proportions were used to compute A' for each participant, a measure of recognition sensitivity that takes individual bias into account, for old context phrases.

Likewise, to measure recognition sensitivity for targets in a new context, we computed the proportion of hits to previously encountered phrases and the proportion of false alarms to new target nouns that were presented with a familiar host noun (also in Table 2). These results were used to compute A' for the new context.

Table 2. Hits, False Alarms, and A'

	Entity		Relational	
	mean	SD	mean	SD
same context				
Hits	.75	(.17)	.69	(.18)
FA	.33	(.17)	.34	(.19)
A'	.78	(.13)	.75	(.14)
different context				
Hits	.50	(.21)	.43	(.18)
FA	.21	(.15)	.26	(.16)
A'	.72	(.16)	.64	(.16)

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Since there was no main effect of host noun pairing, we collapsed the two lists. The analysis revealed that, as predicted, participants showed greater recognition sensitivity for entity nouns (M = .75, SD = .15) than

relational nouns (M = .70, SD = .16), F(1,214) = 38.67, p<.01) across old and new contexts. Also as expected, recognition sensitivity was higher for nouns seen in an old context (M = .77, SD = .13) than in a new context (M = .68, SD = .16), F(1,214) = 94.15, p<.01. However, our primary interest was whether a new context would affect recognition for entity and relational nouns differently. Indeed, there was a reliable interaction of noun type and context, F(1,214) = 5.94, p<.05; recognition sensitivity for relational nouns in a different context suffered far more than that for entity nouns.

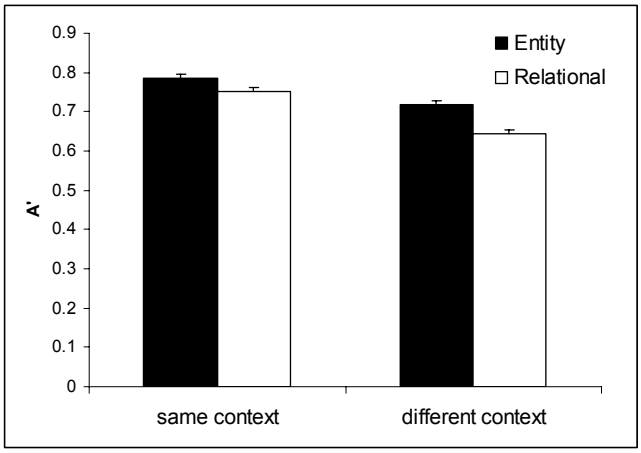

Figure 1. Mean A' for same and different contexts. Bars indicate standard error.

Discussion

The results from this experiment 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. Importantly, this experiment shows that the mutability of relational nouns does not depend on accompanying characteristics such as abstractness or imageability, but the core relational property itself.

Our hypothesis is that when people interpret a conceptual combination containing a relational noun, they tend to adapt the relational noun to fit the noun with which it is paired. While earlier studies (Asmuth & Gentner, 2005) have shown a difference between recognition sensitivity for entity nouns and for relational nouns, these studies did not take into account important factors which might contribute to the difference. By controlling for the abstractness of the entity and relational nouns of interest and for the role played by the host noun in the conceptual combination, we are better able to isolate the effect that relationality alone has in this phenomenon.

This pattern is markedly similar to that for nouns and verbs reported by Kersten and Earles (2004), who 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,

We believe this pattern may be the result of a shift in the encoded features of the relational noun; even though 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 depends largely 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.

These findings lend force to our starting analogy and invite us to ask what other characteristics relational nouns might share with verbs. Are they, like verbs, more variable cross-linguistically or more difficult to translate than entity nouns? Another extension might be to examine the differences within relational nouns. Markman and Stilwell (2001) discriminate between relational categories and role-governed categories. Similarly, Gentner and Kurtz (2005) distinguish between relational schema categories that convey a relational structure linking a set of arguments (e.g., robbery) and relational role categories, which convey one specific argument of a schema (e.g., thief). The distinction between these two categories of relational noun 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*.

Finally, although we have shown that relational effects such as mutability do not depend on greater abstractness, we believe the strong association between abstractness and relationality may indicate a connection between our ability for relational thinking and our capacity for abstract thought. For example, Zharikov and Gentner (2002) found that metaphors emerge from the extension of concrete physical concepts (e.g., the evolution of *bridge* from a concrete structure connecting two points above ground to a relational structure denoting a wide variety of connectors). Similarly, abstract ideas may arise from the process of turning entity concepts into relational concepts.

Finally, these results raise the question of whether many of the abstractness effects reported in the literature are, in fact, relationality effects. Perhaps it is not simply abstractness that gives rise to poor memory for terms like *contract* and *proportion* (relative to terms like *giraffe* and *tricycle*), but the more relational nature of the former categories that makes them difficult to grasp.

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