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Learning of role-governed and thematic categories

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A B S T R A C T

Natural categories are often based on intrinsic characteristics, such as shared features, but they can also be based on extrinsic relationships to items outside the categories. Examples of relational categories include items that share a *thematic relation* or items that share a common *role*. Five experiments used an artificial category learning paradigm to investigate whether people can learn role-governed and thematic categories without explicit instruction or linguistic support. Participants viewed film clips in which objects were engaged in similar actions and then were asked to group together objects that they believed were in the same category. Experiments 1 and 2 demonstrated that while people spontaneously grouped items using both role-governed and thematic relations, when forced to choose between the two, most preferred role-governed categories. In Experiment 3, category labels increased this preference. Experiment 4 found that people failed to group items based on more abstract role relations when the specific relations differed (e.g., objects that prevented different actions). However, Experiment 5 showed that people could identify them with the aid of comparison. We concluded that people can form role-governed categories even with minimal perceptual and linguistic cues.

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1. Introduction

The psychology of concepts has primarily studied simple object categories, e.g., chairs and dogs, or their even simpler experimental stand-ins: colored shapes, dot patterns, or schematic animals (e.g., Posner & Keele, 1968; Rosch, 1973). Such categories are generally based on descriptive features *intrinsic* to category members, e.g., dogs have fur and four limbs, and that are organized into taxonomic classification hierarchies, e.g., dog, mammal, animal.

Recent research has given increasing attention to relational categories, whose membership is determined by *extrinsic* relationships among items (Gentner, Anggoro, & Klibanoff, 2011; Gentner & Kurtz, 2005; Goldwater & Markman, 2011; Goldwater, Markman, & Stilwell, 2011; Kittur, Hummel, & Holyoak, 2006; Markman & Stilwell, 2001; Rein, Goldwater, & Markman, 2010; Ross & Murphy, 1999; Tomlinson & Love, 2010). There are many kinds of relational categories, but they are similar in their dependence on context and extrinsic relations. For example, *thematic* categories contain objects that have a specific functional relationship, such as soup and bowl, or honey and bee. Here the items in the same category are not necessarily similar but have a complementary relationship: The soup is eaten out of the bowl; the bee makes the honey (Estes, Golonka, & Jones, 2011; Lewis, Poeppel, & Murphy, 2015; Lin & Murphy, 2001; Markman, 1989). *Script-based* categories group together objects that play the same role in a familiar

event structure. For example, desserts are all eaten at the end of the meal, as a treat; greetings are the things we say at the beginning of an interaction (Nelson, 1986; Nguyen & Murphy, 2003; Ross & Murphy, 1999).

Similar to taxonomic categories, some of these relational categories also have overlapping intrinsic features. For example, desserts are usually but not always sweet. However, category membership is more strongly determined by the extrinsic relational properties. A cookie eaten before the main course is not considered dessert, and cheese or an unsweetened biscuit eaten at the end of the meal can be considered dessert. Someone who only attended to the intrinsic properties of cookies or pancakes would not be able to identify when they occurred as desserts.

The present article focuses on one type of relational category, *role-governed* categories (Goldwater et al., 2011; Markman & Stilwell, 2001). In such categories, membership is determined by the kind of role that the object plays relative to others. For example, a guest is a person who stays in someone else's home; a teacher is someone who instructs someone else; and a barrier is something that prevents access to a goal. Although the members of these categories can be similar, the critical determinant of category membership is the exemplar's role in some larger event or structure. A wealthy, domineering person who orders everyone around is not a CEO unless she actually has the proper role relative to others within a corporate structure. Many homes are houses, but a house no one lives in is not a home. Goldwater et al. (2011) empirically demonstrated the link between role-governed categories and relational structures and differentiated them from taxonomic feature-based categories along a number of dimensions (see also

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Gentner & Kurtz, 2005; Rein et al., 2010). However, the initial formation of role-governed categories has been studied to a much lesser degree (see Gentner et al., 2011; Goldwater & Markman, 2011; Jones & Love, 2007, for how common roles affect categorization and similarity of familiar items). The initial formation of role-governed categories is the focus of the current work.

It will be important for our purposes to distinguish such role-governed categories from thematic categories. Thematic categories include two or more kinds of objects that are connected by a specific relation, such as leash-and-dog. Note that these two objects do not have a *common* role, but instead play *complementary* roles to one another: The leash holds the dog; the dog is held by the leash. In contrast, objects in role-governed categories have the same roles in relationship to other objects not in the category. For example, all barriers impede access to a goal; but goals are not in the barrier category.

This example points out that there is often a close relationship between thematic and role-governed categories: One half of a thematic category often forms a role-governed category with similar items. For example, a teacher and student might form a thematic pair. Teachers themselves form a role-governed category, because they all share the same relationship to their students. Students form a role-governed category, because they all share the same relationship to their teachers. Similarly, a barrier and goal are linked thematically, and they are also each a member of different role-governed categories. This linkage between the two types of categories does not always hold. Although leashes and dogs might form a thematic category, dogs cannot be said to form a role-governed category, because they are not primarily defined in terms of their relationship to other things.

At this point, some readers may be wondering whether all these groupings really are categories. Not only do they group things that are not at all similar, like leash and dog, they include a diverse set of relationships as the bases for classification—thematic relations, scripts, roles, and similarity. As discussed by Murphy (2010), identification of these kinds of categories is not just a theoretical claim but an empirical observation of the kinds of classifications that people actually make. People group items together in these ways when asked to form categories or to group together the same kinds of things (Estes et al., 2011; Gentner & Brem, 1999; Goldwater & Markman, 2011; Lin & Murphy, 2001; Ross & Murphy, 1999). They can influence memory performance (Rabinowitz & Mandler, 1983). Furthermore, relational categories provide a basis for category-based inferences (Rein et al., 2010; Ross & Murphy, 1999). Thus, such groupings share many of the functions of familiar taxonomic categories.

Another important connection to role-based categories is the creation or comprehension of analogies. Analogical inference is based on shared relational structure (Gentner, 1983; Holyoak & Thagard, 1989). The classic example of comparing the structure of the atom to the solar system works not because the sun and its planets are similar to the parts of the atom, but because the pattern of relationships between the sun and its planets is similar to that of the relations between an atom's nucleus and its electrons. However, analogies are not trivial to notice on one's own, and much research has focused on why analogical reasoning can be so difficult (e.g., Gick & Holyoak, 1980; Keane, 1997; Rottman, Gentner, & Goldwater, 2012). This difficulty suggests in turn that role-based categories may be difficult to identify as well. We explore this possibility in the next section.

1.1. Learning of role-governed categories

Much early work on role-governed categories and relational categories more generally has focused on distinguishing familiar role-governed categories from familiar taxonomic categories. Exemplars of role categories such as barrier are less similar to each other, e.g., wall and poverty, than are exemplars of taxonomic categories such as fruit (Gentner & Kurtz, 2005). Role-governed categories such as friends elicited extrinsic properties about how category members relate to

others, like "they are always there for you," while taxonomic categories such as knife, elicited properties intrinsic to category members, like "made of metal" (Goldwater et al., 2011). In addition, relational categories' meanings are more contextually mutable (Gentner & Asmuth, 2008).

These properties of role-governed categories seem likely to make them harder to learn than more familiar taxonomic categories. Just as people find it difficult to use the solution from one problem to solve another problem that is relationally identical but superficially different (Gick & Holyoak, 1980), they may find it difficult to identify a common role like *guest*. If one did not already know this word, would one identify people as being guests across all the different settings in which it is used? Would they identify houseguests, hotel guests (who pay for their services), people invited to a restaurant for dinner (who eat for free), guests at a wedding (who are not served food), or perhaps even a dragonfly visiting a garden (an attested example from Goldwater et al., 2011) all as being the same kind of entity, abstracting across their ages, genders, social classes, and even species? Could they identify the common role across very different events? In contrast to thematic categories, which often involve associated objects, identifying role-governed categories can require considerable abstraction. The fact that we already know the word *guest* makes the similarity of these different entities easy to detect, but we will shortly review literature that suggests that detection of novel role-governed categories is not so easy. That is, perhaps exposure to the word *guest* is important for our learning that category.

The category of guest co-occurs with another role-governed category, host, and the two form a thematic category. Much research now shows that many people will classify thematic pairs such as guests and hosts as being in the same category or as "the same kind of thing" (Estes et al., 2011; Goldwater & Markman, 2011; Lin & Murphy, 2001; Murphy, 2001). In light of that, it is not clear that people will reliably detect role-governed categories themselves in the absence of a linguistic label or an explicit search for commonalities. That is, they might think that a host and his guest go together but, prior to learning the word *host*, may not perceive that two different hosts are the same kind of person. The host bears a direct relationship to his or her guest but not to a different host.

Indeed, relational categories are not always correctly identified as such. For example, consider Keil and Batterman's finding (see Keil, 1989, ch. 4) that children misidentify the relational term *uncle* to be a feature-based category (a nice man who comes to visit and gives you presents) until they are in 4th grade. Clearly, these common features are easier to acquire than the familial relation that is the true basis of the word. Gentner and Kurtz (2005) point out that relational words are generally learned later, that it takes longer to produce examples of relational categories, and that people who view such examples (barriers, filters, guides, etc.) often have difficulty identifying what they have in common. Such results raise the question of whether people can identify and use relational categories as they do taxonomic categories, without instruction. Indeed, after considering this question, Gentner and Kurtz (2005 p. 165) propose that learning relational categories is at least in part "through cultural guidance: in particular, through linguistic labels." Gentner et al. (2011) showed that 4–5-year-old children identify relational categories based on a single example much better if they are given linguistic support, for example, "this knife is the *dax* for the watermelon." Such sentences not only label the category but use relational language that makes the nature of the category clear.

Another aid to role-governed category learning is comparison of category exemplars. Goldwater and Markman (2011), using linguistic stimuli, showed that without the support of a category label or explicit comparison, people were four times more likely to group thematic pairs, such as bodyguard and celebrity, than they were to group things that played the same role across domains, such as bodyguard and force-field (both are protectors) (see also Gentner et al., 2011; Jung &