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Agency Drives Category Structure in Instrumental Events

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Abstract

Thematic roles such as Agent and Instrument have a long-standing place in theories of event representation. Nonetheless, the structure of these categories has been difficult to determine. We investigated how instrumental events, such as someone slicing bread with a knife, are categorized in English. Speakers described a variety of typical and atypical instrumental events, and we determined the similarity structure of their descriptions using correspondence analysis. We found that events where the instrument is an extension of an intentional agent were most likely to elicit similar language, highlighting the importance of agency in structuring instrumental categories.

Keywords: thematic roles; events; categorization; tools; language production; English

Introduction

Events have event participants – an eating event, for example, involves someone who eats and something that gets eaten. There is extensive evidence that such event participants are represented in terms of abstract event participant categories, sometimes called "thematic roles" (Hafri, Trueswell & Strickland, 2018; Kako, 2006; Lakusta, Spinelli & Garcia, 2017). The category Agent, for example, contains not only the person who eats in an eating event but also the person who cooks in a cooking event and the person who builds in a building event. Thematic roles have been argued to be cross-culturally universal and part of innate knowledge (Carey, 2009; Fillmore, 1968; Strickland, 2016). At the same time, thematic roles have been persistently difficult to define in terms of necessary and sufficient conditions (Cruse, 1973; Dowty, 1991; Levin & Rappaport-Hovav, 2005). For example, the person who sees in a seeing event has fewer agentive properties than the person who eats. The upshot of this prior research is that although humans represent event participants in terms of abstract categories, the structure of these categories is not well understood.

A prominent proposal is that thematic roles have prototype structure (Ackerman & Moore, 2001; Dowty, 1991; Lakoff & Johnson, 1980). Dowty (1991), for example, explains how the arguments of English verbs appear in Subject vs. Object position in terms of Proto-Role properties. The argument with the most Proto-Agent properties (e.g., being sentient, having intention, being a causer) surfaces as Subject, whereas the argument with the most Proto-Patient properties (e.g., undergoing a change of state, being causally affected) surfaces as Object. Ackerman and Moore (2001) argue that

being a bounded entity is another Proto-Patient property. Given these properties, the person who sees is a less prototypical Agent than the person who eats because it is sentient but not also a causer. While these proposals have made significant progress in understanding thematic role structure, they are limited in several ways. To fully understand how event participant categories are represented, we first need to investigate a more diverse set of categories beyond Agent and Patient, which have received the most attention. We also need to draw on more diverse forms of evidence, e.g. online psycholinguistic data. The present study achieves both of these goals: we investigate the structure of the English thematic role category Instrument, as in *Marnie sliced the bread with a knife*, using a language production task in which adult speakers described live action videos. We submitted this language description data to correspondence analysis (Greenacre, 2007), allowing us to identify similarity structure within a diverse set of instrumental events.

Within linguistics, thematic roles are often understood to be linguistic objects whose theoretical function is to explain linguistic behavior, such as argument realization. In this paper, we assume that while there may be such domain-specific role representations, there are also domain-general event participant categories that are relevant to both the syntax~semantics interface and non-linguistic event cognition. We take the more conservative position that speakers' descriptions of instrumental events reflect domain-general thematic roles.

Instrument as a Thematic Role

The Instrument role appears frequently in lists of thematic roles, dating back to the ancient Sanskrit grammarian Pāṇini. Like the roles Agent and Patient, Instrument has been characterized as having prototype structure. For example, Luraghi (2001: 388) characterizes a prototypical instrument as "an inanimate manipulable entity which occurs in a controlled state of affairs, where an agent acts intentionally." The prevalence of the Instrument role in linguistic analyses perhaps reflects the importance of tool use for building human culture. In the literature on how tool use differs across human and non-human animals (Plotnik & Clayton, 2015; Seed & Byrne, 2010; Vaesen, 2012), a tool is typically defined as a physical object distinct from the body, that an individual wields intentionally, causing a change in another object or person. We adopt this definition of tool use in the present study. Tools are important because they allow us to

extend the capabilities of our own body, allowing us to solve problems “for which evolution has not provided a rigid morphological or behavioral adaptation” (Seed & Byrne, 2010: R1032).

This definition of tool use does not directly correspond, however, to the event participant categories carved out by human language (Koenig, Mauner, Bienvenue & Conklin, 2008; Lakoff, 1968; Rissman & Rawlins, 2017). English, for example, has two primary morphosyntactic devices for talking about instruments: prepositional *with* (*Remi cut the cake with a knife*) and periphrastic *use* (*Remi used a knife to cut the cake*). In these examples, the knife is an example of a tool. When an object is being used as a tool, both *with* and *use* are appropriate to describe its role. Neither *with* nor *use*, however, is restricted to only the set of tools. *With* is possible for unintentional events (e.g., *Remi tripped and cut her dress with the scissors*). In addition, *use* is possible for instruments that play only a causally indirect role (e.g., *Remi used a stepladder to paint the ceiling*). Both *with* and *use* are also possible for body parts, where no external object extends the reach of the human body (*Remi was eating with her hands*; *Remi was using her hands to eat*). Rissman and Rawlins (2017) ultimately do not use the role Instrument in their analysis of the meanings of *with* and *use*. Thus the boundaries and structure of the Instrument category have been difficult to identify, as with other thematic roles. There is also little empirical evidence that the notion of a tool, as defined above, is a central reference point within this category.

Event Categories and Instruments

Neither *with* nor *use* map onto the category of a tool, and current analyses of the meanings of these words suggest that Instrument is not part of the grammar of English.

Nonetheless, there may still be an instrumental category that speakers represent when viewing actual events in the world, and tools may be prototypical members of that category. Events can be construed in multiple ways (DeLancey, 1991). An event of someone pouring orange juice into a glass, for example, can be construed as a caused change of the orange juice from one location to another, or as a caused change to the glass by means of the orange juice. Language provides a window into the construal that is chosen by a speaker at a particular time: the description *Tito poured the orange juice* emphasizes the change of location of the juice. By contrast, *Tito filled the glass with orange juice* emphasizes the change of state of the glass and the causal role of the juice. These two descriptions reflect different ways of construing the event and thus different ways of categorizing the event participants. In this study, we take advantage of this variability to investigate semantic similarity across different types of instrumental participants. To the extent that speakers favor a particular construal of an event, as evidenced through their language, this indicates a dominant way of categorizing the participants in the event. To the extent that speakers use similar language for tools and quasi-tool participants (such as body parts), this suggests that tools and quasi-tools are represented as relatively similar semantically, and may be part of a single event participant category.

We showed adult English speakers videos of tool use as well as seven types of events in which one of the participants shares some but not all of the properties of a tool. These event conditions are displayed in Table 1. For each video, there was a Target participant: we compared linguistic encoding of the Target across all conditions. The Target participants for the example videos are underlined in Table 1. In the No State Change condition, the patient is minimally affected – this contrasts with tool use, where tools bring about a specific

Table 1: Experimental conditions. Target participants are underlined.

	Condition	Description of example video
	Tool	A woman slices a baguette with a <u>knife</u>
Quasi-tool actions	No State Change	A woman hits a box with a <u>pen</u>
	Body Part	A man knocks over a music stand with his <u>hand</u>
	Accidental Agent	A woman sweeps the floor with a <u>broom</u> , accidentally knocking over a bottle
	Causally Indirect	A woman climbs a <u>ladder</u> to open a window
	Locatum	A woman fills a glass with <u>orange juice</u>
	Means of Transit	A trip on Google Maps from Rome to Moscow by <u>plane</u>
	Inanimate Agent	A train rolls down a track, which bumps a <u>red car</u> , which moves a truck
Non-tool actions	Put Theme	A man puts a <u>box</u> on a shelf
	Give Theme	A woman gives a <u>mug</u> to another person

change in an object. In the Body Part condition, the Target is not external to the agent's body. As described above, Accidental Agent events can be described with *with* but not *use*, and Causally Indirect events, where the Target is peripheral to the force exerted on the patient, can be described with *use* but not *with*.

Locatum events are of theoretical interest because some researchers have analyzed such events (e.g., filling a glass with orange juice) in terms of a schema where a substance crosses space, rather than a tool use schema (Jackendoff, 1990). By contrast, Koenig et al. (2008) analyze such events as instrumental, as both a locatum (the orange juice) and a tool are used by an agent to achieve a goal. Similarly, Means of Transit, such as taking a trip by plane, are used by an agent to achieve a goal but are not physically manipulated. Finally, the property of being a causal intermediary has been argued to be essential to instrumentality (Croft, 1991; Talmy, 1976). In Inanimate Agent events, the Target is a causal intermediary but is not manipulated by an animate agent.

We also tested two non-tool-use conditions. In Put Theme events, an agent moved an object to an inanimate location, and in Give Theme events, an agent transferred a physical object to another agent. The Target in both of these events was the theme: themes are intermediary between a source and goal and therefore provide a parallel with tools, which are intermediary between an agent and a patient. Nonetheless, based on prior research on thematic roles (Jackendoff, 1990) we did not expect that participants would use instrumental language to describe the themes in these events.

Method

Participants

43 native speakers of British English participated. An additional four participants were tested but excluded for being native speakers of American English. Participants were tested at Radboud University in the Netherlands and at the University of York in the UK and received either course credit or £5/€5.

Design and Materials

Participants described five videos from each of 10 conditions in Table 1. Each participant saw these 50 videos in a unique random order. The events were live-action videos each lasting 4-5 seconds, with the exception of Means of Transit events. For this condition, we asked participants to describe events in which the mode of transit (e.g., train, bicycle) was construed as a means of getting from one place to another. This construal is difficult to access if participants only see a live-action event of someone riding on a train, for example. We therefore showed a video of someone planning a trip on Google Maps, with a screen capture showing someone typing in a starting point, then a destination, then a means of travel (e.g., walking, driving).

Pilot studies showed that when speakers describe instrumental events, they often omit the instrument from their descriptions (e.g., an event of a man cutting bread with a knife would simply be described as *a man was cutting some*

bread). Given this tendency, we highlighted the event participants that we wanted speakers to mention by drawing red circles around them. Circles were drawn around the Target as well as around the agent and patient (or source and goal, as appropriate). A still image of the red circles appeared for two seconds prior to the beginning of the event, as in Figure 1. The circles disappeared as the video began. Means of Transit events did not include red circles.



Figure 1: Initial still image from a video of a woman slicing bread (Tool condition)

Procedure

Participants viewed each of the 50 events on a computer screen and described the events out loud. We gave participants four practice videos to familiarize them with the red circles and Means of Transit events. Speakers were told they could describe the videos in any way they liked, but they needed to mention the three objects in red circles. If a participant failed to mention one of the circled objects during a practice video, they were corrected and given another opportunity to describe the video. Participants were not corrected in the experimental trials. For the Means of Transit events, participants were told that they would see someone planning a trip on Google Maps, and they should describe the trip as if they took it themselves, as if it actually happened. The task itself took about 15 minutes.

Coding

We transcribed speakers' utterances and coded how speakers described the Target in each video (what "term" was used). In syntactic terminology, we coded the lexical item that the Target DP was a complement of. Example terms are shown in (1); these sentences are actual recorded descriptions. The Targets are underlined, terms are noted in boldface and Condition in parentheses. If a speaker described the Target in multiple ways, as in (1f), each of these terms was included. We included all terms to avoid making *a priori* assumptions about which linguistic devices would be relevant for categorizing instrumental events. As we describe below, low-frequency terms were excluded from analysis.

- (1) a. The lady smashed the plate **with a hammer**. (Tool)
- b. Unfortunately the man **placed his cup** onto the cupcake. (Accidental Agent)
- c. A sitting man passes a scarf over to a nearby lady **using his foot**. (Body Part)
- d. A woman **used a toy stick** to tap a cat on the head. (No State Change)
- e. A lady wrapped the baby **in the cloth**. (Locatum)
- f. A man is **holding a cardboard box**. He **lifts it** onto a shelf at about head height and **places it** on that shelf. (Put Theme)

We did not code tense and aspect markings on the verb (e.g. 1b and 1f both included the term *place*). We coded verb and verb-particle constructions as having the same term (e.g., for both *the man held the scarf* and *the man held out the scarf*, the coded term was *hold*).

We excluded trials in which the participant did not mention the Target (e.g., saying *the woman chopped up the carrot* when the Target was the cutting board). We also excluded trials in which the Target was only mentioned as the subject of a clause (e.g., saying *the woman juggled and the ball fell and knocked over the bottle* when the Target was the ball). A total of 4% of all trials were excluded for these reasons.

Results

Descriptive statistics

Across all remaining trials, participants produced 2426 term tokens and 108 term types. Given the high number of term types produced, and the resulting complexity of correspondence analysis models of these data, we focus on only the most frequently produced terms here. We selected the top 16 terms: this was the smallest number of terms needed to ensure that data from all 50 videos were included in the analysis. These top 16 terms constituted 72% of all tokens produced. The 16 most frequent terms were, from most to least frequent: *with*, *use*, *put*, *pick-up*, *on*, *take*, *place*, *hit*, *using*, *knock*, *drop*, *in*, *throw*, *pass*, *by* and *into*.

Dimensions of variation

We used correspondence analysis (Greenacre, 2007) to analyze semantic similarity across the descriptions of the 50 videos. We constructed a 16×50 matrix in which each cell of the matrix contained a count of how often a particular term was used to describe a particular video. From this high-dimensional space, correspondence analysis extracts dimensions such that the majority of the variance in the data set can be captured using a relatively small number of dimensions. We used the *FactoMineR* package for R (Lê, Josse, & Husson, 2008; R Core Team, 2017). Figure 2 shows the eigenvalues of each of the dimensions in the correspondence analysis, as well as the cumulative variance accounted for with each dimension. Dimensions with higher eigenvalues are more important in interpreting the structure in the semantic space. Drawing on Figure 2, we interpreted

the first eight dimensions of the model, which collectively accounted for 86% of the variance.

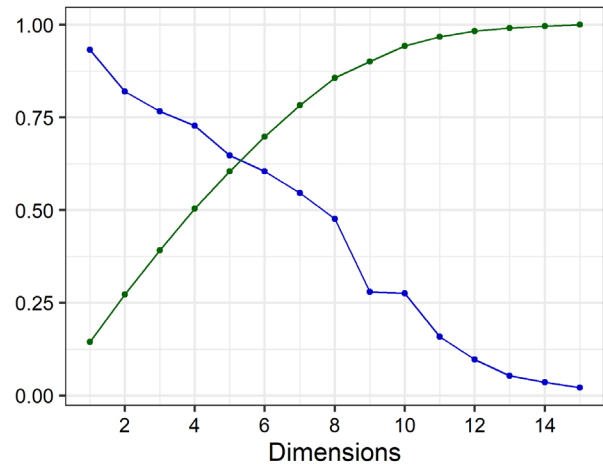


Figure 2: Eigenvalues (blue) and cumulative variance explained (green) for each of the dimensions in the analysis. The y-axis is the same for both values.

We explored how videos in the Tool condition were distinguished in this model from the other conditions. The first dimension distinguished Inanimate Agent videos from the other conditions. The most common terms for Inanimate Agent videos were *knock*, *hit* and *into*, terms which were rarely used for other videos. The second dimension distinguished videos involving ballistic motion, labeled with the terms *throw* and *drop*, from other videos. These ballistic motion videos came from the Put Theme and Give Theme conditions, as well as the Accidental Agent condition. In one accidental video, for example, a woman tries to juggle three balls but she accidentally drops one of them, knocking over a plastic bottle.

The third dimension grouped Give Theme and Means of Transit videos together, distinguishing them from other videos. The terms distinguished by this third dimension were *take* (e.g., *take a soda can from a woman* but also *take a train to Edinburgh*), *by* (e.g., *go to Paris by car*) and *throw* (e.g., *throw an apple to the man*). The fourth dimension distinguished two conditions from the others, but at opposite ends of the axis: Give Theme videos on one end (labeled by the term *pass*) and Causally Indirect videos on the other (labeled by the term *on*, as in *a woman chops a carrot on a cutting board*). Summarizing the first four dimensions, we see that Inanimate Agent videos are most distinct from Tool videos, followed by Give Theme, Accidental Agent and Means of Transit videos, followed by Causally Indirect videos.

The fifth dimension distinguished the terms *put* and *place* from other terms. These terms were used most often in the Put Theme condition, but also in the Locatum condition (e.g., *place groceries into a basket*) and for one of the Accidental Agent videos, as in (1b). Figure 3 shows a map of the spatial

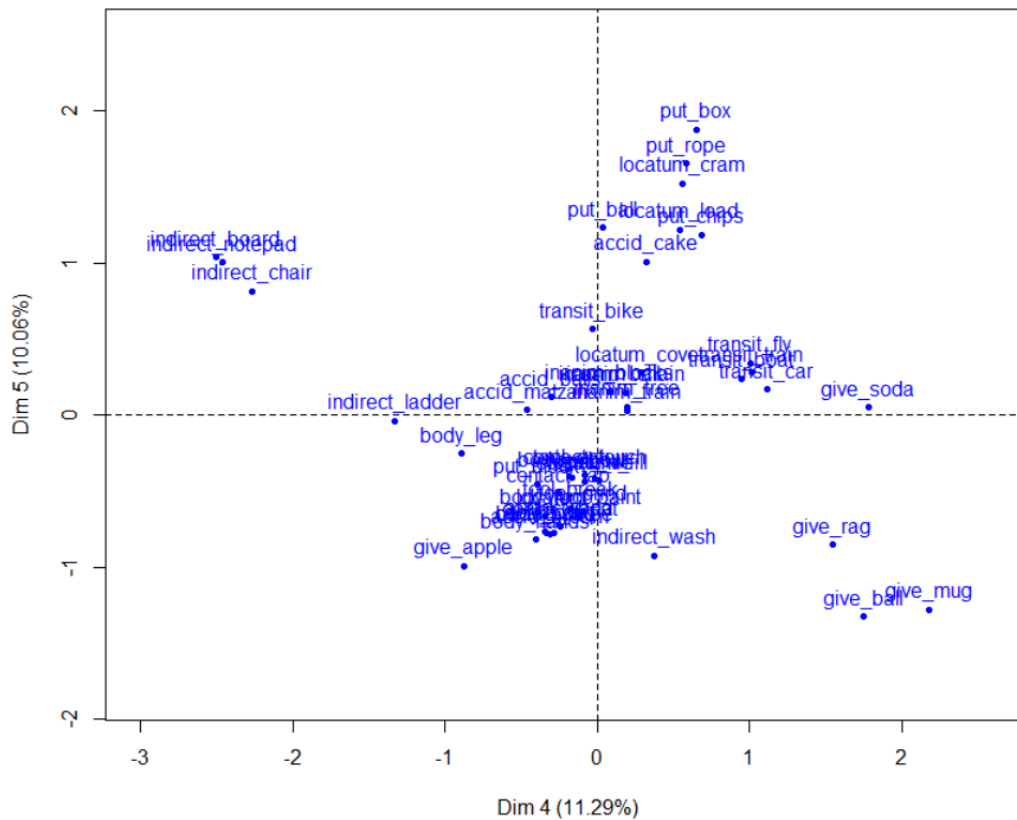


Figure 3: Individual videos plotted on Dimensions 4 and 5 of the correspondence analysis

arrangement of videos as plotted on the fourth and fifth dimensions of the correspondence analysis.

Through five dimensions, all conditions have been distinguished from the Tool condition except for No State Change and Body Part. These two conditions are not, however, distinguished by Dimensions 6-8. Dimension 6 separated transfer events in the Give Theme condition from Means of Transit events. Dimension 7 distinguished a single video in the Causally Indirect condition, where the most frequent term was *in* (e.g., *someone washed spinach in a colander*). Dimension 8 distinguished *throw* from *drop*. The correspondence analysis therefore indicates that No State Change and Body Part events have high semantic similarity to Tool events.

Focus on Tools

We further test this interpretation by analyzing in detail the data from Tool, No State Change and Body Part events taking into consideration the data which was omitted in the above analysis. As described above, 28% of the data was excluded in the correspondence analysis, and these data may reveal that English speakers do in fact categorize the Target in divergent ways across these three events. We calculated how often each term was used in each of these three conditions, as shown in Figure 4. For purposes of visualization, only the 16 most frequent terms are displayed, comprising 93% of all tokens

for these three conditions. Black boxes indicate those terms which were not part of the correspondence analysis.

Figure 4 shows that the distribution of terms is similar across Tool, No State Change and Body Part conditions, the most frequent terms being *with*, *use* and *using*. Smaller differences are also apparent: *pick-up* was relatively common in the Tool and No State Change conditions, but not the Body Part condition. *Over*, *against* and *elbow* were used for Body Part events but not the other two types of events. Despite these differences, the data in Figure 4 suggest that the similarity across these three conditions observed in the correspondence analysis is not an artefact of 28% of tokens being excluded.

Discussion and Conclusion

In this study, we investigated the structure of thematic roles, focusing on participants that have been classified as Instruments in previous linguistic analysis. We showed live action videos to English speakers, and inferred how participants categorized the events based on the language they used in their descriptions. Correspondence analysis revealed which types of Target participants were described in similar ways to Tools, and which were most distinct. Inanimate Agent events were least similar to Tool events. By contrast, Causally Indirect events were more similar to Tools,

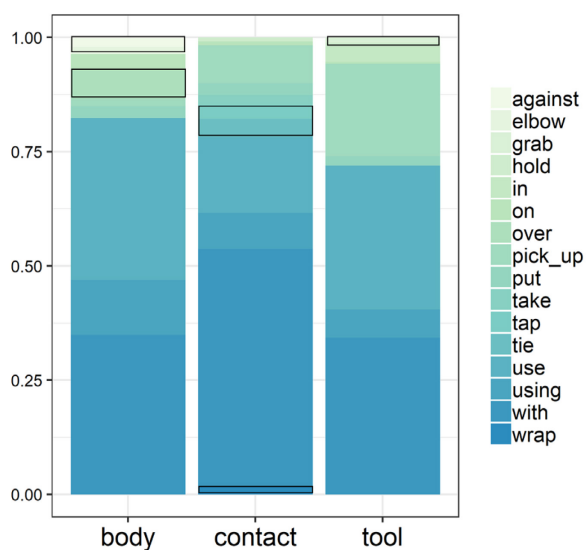


Figure 4: Distribution of the 16 most frequent terms across the Tool, No State Change and Body Part conditions. Black boxes show which terms were excluded from the correspondence analysis

distinguished only by the fourth dimension in the correspondence analysis. Although being a causal intermediary has been argued to be definitive for the Instrument category (Croft, 1991; Talmy, 1976), these results suggest that this property in fact plays a relatively weak role in shaping the categories formed by English speakers.

The results also showed that Put Theme events were more similar to Tools than Give Theme events were to Tools, although neither type of event was predicted to elicit instrumental language. This suggests a relationship between a change of location schema and a tool use schema. In an event of an agent breaking a plate with a hammer, the agent moves the hammer to the location of the plate. And although Tool events were predominantly described with *use* and *with*, not with the locative terms *put* and *place*, Locatum events formed a semantic bridge between Tool events and Put Theme events. Locatum events, such as someone putting a towel over a baby, alternated between locative encodings (e.g., *A woman picked up a towel and placed it onto a toy doll*) and Tool encodings (e.g., *The woman covered the baby with the blanket*). This semantic relationship between Instruments and Themes has been documented cross-linguistically (Bickel, Zakharko, Bierkandt & Witzlack-Makarevich, 2014), but has not been clearly noted for English before.

Previous studies of English have more often emphasized that an Instrument is an extension of an Agent (Rissman & Rawlins, 2017), and we see clear evidence for this relationship in our data. Surprisingly, the terms used for Body Part events were highly similar to the terms used for Tool

events. The idea that tools are external to our body, and can therefore extend our reach, is crucial to the role of tools in the development of human culture. *A priori*, we therefore expected that Tool and Body Part events would be categorized in different ways. We did not find a strong distinction between these events, however, suggesting the importance of conceptualizing Instruments as an extension of the Agent. The fact that No State Change events were also similar to Tool events supports this conclusion: the intention and actions of the Agent are more important than the actual outcome. To the extent that tools are prototypical instances of instrumental events, the instruments in Body Part and No State Change events are no less prototypical.

In the video stimuli in this study, we circled the Target participants, in addition to agents, patients, sources and goals, in order to prompt speakers to mention these participants. This likely did affect speakers' construal of the events – in fact, it was our goal to direct speakers to a construal where the Target had high prominence, high enough to be mentioned. We do make the assumption that the descriptions we elicited using these circles would not differ significantly from descriptions where speakers mention the Targets spontaneously, without prompting.

In conclusion, we find that agency plays a prominent role in determining similarity across instrumental events. These conclusions, however, only extend as far as English, and how English speakers conceptualize events. Future research can determine the extent to which similar principles guide categorization in other languages and other cultures.

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