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Resolving the Ambiguity of "In" and "On" Across Spatial and Abstract Contexts

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Abstract

The prepositions "in" and "on" are used in a wide variety of concrete, spatial contexts as well as abstract, non-spatial contexts. Previous research suggests that the meanings of these prepositions when used in abstract, non-spatial contexts might be grounded in the meanings these same prepositions have when they are used in concrete, spatial contexts; however, few studies have attempted to empirically test for evidence of these connections directly. The current study attempted to conceptually replicate Feist and Breaux (2013): No evidence of priming was observed. It could be that our prime stimuli did not adequately activate the meanings of "in" and "on" or that our participants' linguistic habits obscured any impact of the prime stimuli. Further research is needed to truly understand the role that grounded connections might play in the lexical semantics of words that are used in both abstract and spatial contexts.

Keywords: lexical semantics; polysemy; metaphor; prepositions; ambiguity

Introduction

The prepositions "in" and "on" are highly polysemous: They are each associated with a variety of spatial arrangements (e.g., a plant on a shelf, a painting on a wall, a ring on a finger) and can each be used to refer to non-spatial relationships (e.g., a person who is on time; a shirt that is on sale; an action that was taken on purpose). When prepositions are used in abstract contexts, the result is often referred to as an indirect metaphor (e.g., "on time," "on sale," "on purpose"). This is because there is often the underlying assumption that the non-spatial, abstract meanings of prepositions are derived from their spatially-based counterparts (e.g., Brugman & Lakoff, 1988, 2006; Kuteva & Sinha, 1994; Navarro i Ferrando, 1998; Tyler & Evans, 2001, 2003).

Proponents of Conceptual Metaphor Theory (CMT) propose one way in which this could occur: They argue that indirect linguistic metaphors are the result of conceptual metaphors (Lakoff & Johnson, 1980). According to Lakoff and Johnson (1980), the reason people can talk about time in the same ways they talk about space (e.g., "I finished the race in 32 minutes") is because underlying conceptual metaphors (e.g., TIME IS A CONTAINER) allow us to use our experiential knowledge of source domains (e.g., our everyday experience of being enclosed by a physical space such as a room or a house) to understand abstract concepts. Of particular interest is the directionality inherent in the CMT proposal such that our understanding of abstract domains is grounded in our understanding of physical domains but not vice versa.

Even though this compelling proposal is strongly supported by linguistic evidence, cognitive researchers have argued that the theory is not precise enough to be tested empirically (e.g., Boroditsky, 2000; Murphy, 1996, 1997; Valenzuela & Soriano, 2005). In response to such claims, Gentner (2001) outlined four broad theoretical approaches concerning the psychological status of these conceptual connections: system-mapping, cognitive archaeology, structural parallelism, and local lexical relations.

Both system-mapping and cognitive archaeology are compatible with CMT's grounded connections assumption but differ in what they predict is happening when people are actively processing indirect linguistic metaphors. When applied to indirect linguistic metaphors involving "in" or "on," system-mapping contends that grounded, source-to-target connections are actively used by speakers during processing (Gentner, 2001). Cognitive archaeology assumes that metaphor processing can change over time and that even though grounded connections were used in the past during online processing, they are no longer needed because the information that was once actively mapped from source to target is now a part of the target domain (e.g., TIME).

Unlike system-mapping and cognitive archaeology, structural parallelism and local lexical relations are incompatible with CMT's grounded connections assumption. According to the structural parallelism perspective, indirect linguistic metaphors are not the result of conceptual metaphors and, subsequently, are not the result of grounded connections. Proponents of structural parallelism, such as Murphy (1996), argue that conceptual domains (e.g., TIME and CONTAINER) are separate and do not interact with one another. The use of lexical items, such as "in" and "on," across spatial and abstract contexts is explained, then, by the idea that there were similarities that already existed across the domains (e.g., the concept of control) and the lexical items

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are being used because of the similarity. Interestingly, similarity does not even play a role in the local lexical relations proposal. In the context of indirect linguistic metaphors involving "in" and "on," proponents of this perspective would argue that that the lexical item of interest (e.g., "in") is the only thing connecting spatial meanings (e.g., spatial enclosure; "the cat is in the box") to abstract meanings (e.g., temporal inclusion; "in the morning").

The question, then, is the extent to which there is empirical evidence of source-to-target connections for the prepositions "in" and "on." The most direct test of such grounded connections comes from Feist and Breaux (2013), who used a priming paradigm to determine whether processing of spatial meanings would affect the processing of abstract meanings and, alternatively, whether the processing of abstract meanings would affect the processing of spatial meanings. The researchers did this by creating stimulus pairs involving photographs of one object in or on another object and abstract phrases involving "in" and "on." They then collected the reaction times of participants as they categorized these photographs and phrases as either natural/expected (e.g., a flower in a vase; "in love") or unnatural/unexpected (e.g., a banana in a shoe; "in basis").

For the preposition "in," the researchers found evidence of priming such that processing in photographs facilitated processing of abstract "in" phrases but no evidence that processing abstract "in" phrases facilitated processing of in photographs. For the preposition "on," the researchers found evidence of priming such that processing abstract "on" phrases facilitated the processing of on photographs but no evidence that processing on photographs facilitated processing of abstract "on" phrases. Because the structural parallelism perspective would predict bidirectional priming for both prepositions under these circumstances, Feist and Breaux (2013) argue that the unidirectional connections they observed are consistent with CMT's grounded connections assumption and that the opposing directionality observed across the prepositions might be related to other differences. They point out that "in" is used more frequently, occurs across a wider variety of contexts, and can be more readily used to create novel combinations as compared to "on." These patterns combined with the results of their priming study suggest that grounded connections for "in" are still active and used by speakers but that grounded connections for "on" are not, which could be interpreted as the results for "in" supporting system-mapping and the results for "on" supporting cognitive archeology.

Other studies seeking to better understand the abstract meanings of "in" and "on" and whether source-to-target connections exist in the minds of speakers have focused less on priming and more on patterns of interpretation. For example, Kranjec, Cardillo, Schmidt, and Chatterjee (2010) found that adding the preposition "in" to a temporal metaphor (i.e., "The meeting in June has been moved forward 2 months. In what month is the meeting now that it has been rescheduled?") resulted in a later bias (i.e., participants more likely to respond "August") compared to when the preposition was absent (i.e., "The June meeting has been moved forward 2 months. What month is the meeting now that it has been rescheduled?"), adding "at" resulted in an earlier bias, and adding "on" did not change the later bias that was observed when the preposition was absent. Consistent with CMT's grounded connections assumption, Kranjec et al. (2010) argue that the differences in interpretations observed across the prepositions when used to describe time can be linked to the differences observed across these prepositions when used to describe space.

Similar to Kranjec et al. (2010), Jamrozik and Gentner (2015) explored the processing of prepositions when used in abstract contexts; however, they focused specifically on the concept of control. Just as physical containers constrain and control the movement of the objects or entities in them, Jamrozik and Gentner (2015) proposed that this same type of control might be found in the meanings associated with abstract uses of "in." In contrast, objects or entities located on physical surfaces have a significant amount of control over their movement in the world; therefore, this same type of control might be found in the meanings associated with abstract uses of "on." As predicted, Jamrozik and Gentner (2015) found evidence that the element of control differentiates the processing and production of "in" and "on" across a variety of abstract contexts. The researchers observed similar findings across participants' ratings, forced choice responses, and written interpretations. Even though these patterns of interpretation are consistent with CMT's grounded connections assumption and inconsistent with a local lexical relations explanation, they do not allow us to determine which of the remaining theoretical possibilities—system-mapping, cognitive archeology, and structural parallelism—is most likely. What is needed to distinguish between these possibilities is more empirical evidence, of the type collected by Feist and Breaux (2013), that explores the ways in which the spatial and abstract meanings of prepositions might be connected in the minds of speakers.

We sought to contribute to this literature by conceptually replicating Feist and Breaux (2013). The current study differed from Feist and Breaux (2013) in two important ways. (1) Instead of focusing on ease of processing, we chose to focus on interpretation. We were inspired by the ambiguity resolution task that was used in Boroditsky's (2000) Experiment 2 to test for evidence of grounded connections between movement through space and movement through time. Boroditsky (2000) presented participants with ambiguous spatial images in which objects could be perceived as moving toward or away from the viewer and ambiguous abstract scenarios involving time (e.g., "Next Wednesday's meeting has been moved forward two days. Which day is the meeting now that it's been moved?"). (2) Instead of only two priming conditions (i.e., space to abstract and abstract to space), we added two control conditions (i.e., space to space and abstract to abstract). We were inspired by the design of Boroditsky's (2000) Experiment 2, which was a between-subjects priming experiment involving four stimulus combination types: space-to-abstract, abstract-to-

space, space-to-space, and abstract-to-abstract. Boroditsky (2000) found evidence of priming in every condition except when the prime stimuli involved participants thinking about moving through time and the target stimuli involved participants resolving a spatial ambiguity. This pattern of findings is best explained by system-mapping.

Stimulus Development

To explore the potential of grounded connections as they relate to the polysemy of the lexical items "in" and "on" using Boroditsky's (2000) method, we needed to develop four different types of stimuli that aligned with the stimuli used in Experiment 2.

Prime Stimuli

All prime stimuli in Boroditsky's (2000) Experiment 2 required participants to determine whether a statement was true or false, so our goal was to develop prime stimuli that also utilized a dichotomous response option. To encourage participants to process information about the spatial relationships of interest while avoiding the lexical items used to label those spatial relationships, our strategy was similar to that used by Feist and Breaux (2013) in that participants were asked to consider the naturalness and/or expectedness of the stimuli.

Spatial Prime Stimuli Boroditsky (2000) created spatial prime stimuli using static cartoon images involving a person and several objects in which an arrow was used to indicate motion, either of the person (ego-moving) or of the objects (object-moving). Sentences—describing the location of different objects as being either in front of or behind the person or other objects—accompanied the images, and participants were asked to indicate whether these sentences were true or false.

Our lab had previously conducted a study in which undergraduate students from the same population as the current study answered questions about photographs depicting objects in or on other objects that were either natural/expected or unnatural/unexpected combinations (e.g., a pencil in a pencil pouch vs. a toilet paper roll on a tennis racket; Breaux et al., 2022). Relevant to the current study were three questions we asked participants about these photographs: the extent to which they (1) thought the larger object (i.e., the ground) controlled the movement of the smaller object (i.e., the figure), (2) would use "in" or "on" to describe the relationship between the objects, and (3) thought the relationship between the objects was natural and/or expected.

Based on this data, we selected ten stimuli for use in our current study: three natural/expected in photographs, two unnatural/unexpected in photographs, three natural/expected on photographs, and two unnatural/unexpected on photographs (see Figure 1 for example photographs). The in photographs we selected were those with high perceived ground control that were most likely to be described using the lexical term "in," but the on photographs we selected were those with low perceived ground control that were most likely to be described using the lexical term "on." Importantly, our natural/expected photographs had high mean naturalness/expectedness ratings and our unnatural/unexpected photographs had low mean naturalness/expectedness ratings. In the current study, participants were asked whether the photograph being shown was natural/expected or unnatural/unexpected.

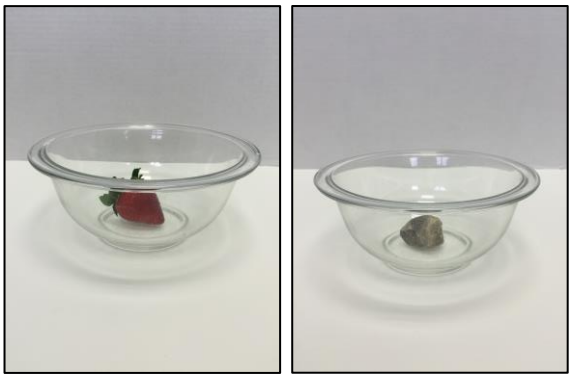

Figure 1: On the left is a natural/expected photograph of a strawberry in a bowl. On the right is an unnatural/unexpected photograph of a rock in a bowl.

Abstract Prime Stimuli Boroditsky (2000) created temporal prime stimuli using sentences that described days of the week as being either before or after other days of the week (e.g., "Tuesday comes before Friday"), and participants were asked to indicate whether the sentence was true or false.

Our lab had previously written a series of short vignettes about fictional people that differed in terms of the control the fictional people had over the situation being described and were similar to the vignettes developed by Jamrozik and Gentner (2015). We also conducted a study in which undergraduate students from the same population as the current study answered questions about these vignettes (Breaux et al., 2019). Relevant to the current study were four questions we asked participants about these vignettes: the extent to which they (1) thought the person had control over the situation (i.e., figure control), (2) would use "in" or "on" to describe the person relative to the situation, (3) thought the situation was natural and/or expected, and (4) thought the situation was likely to be a positive or negative event in the life of the fictious person.

Based on this data, we selected ten stimuli for use in our current study: three natural/expected in vignettes, two unnatural/unexpected in vignettes, three natural/expected on vignettes, and two unnatural/unexpected on vignettes (see Figure 2 for example vignettes). All the selected vignettes were perceived as positive events: This choice was made based on Breaux et al.'s (2019) finding that negative scenarios resulted in participants attributing more control to the fictious person as compared to positive scenarios. The in vignettes we selected were those with low perceived figure control where the fictious person was most likely to be described using the lexical term "in" relative to the situation. For our on vignettes, we selected those with high perceived

figure control where the fictious person was most likely to be described using the lexical term "on" relative to the situation. Importantly, our natural/expected vignettes had high mean naturalness/expectedness ratings and our unnatural/unexpected vignettes had low mean naturalness/expectedness ratings. To avoid presenting participants with similar stories, each selected vignette featured a unique character and situation. In the current study, participants were asked whether the scenario being described was natural/expected or unnatural/unexpected.

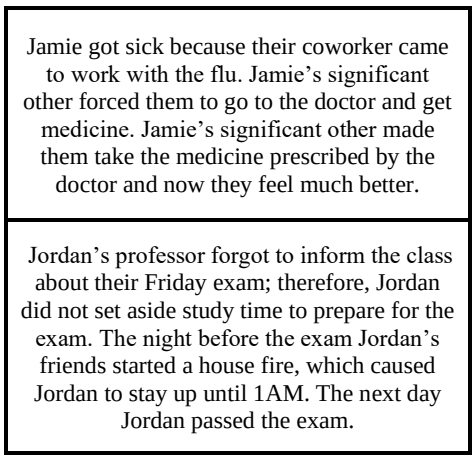

Figure 2: On the top is a natural/expected in vignette. On the bottom is an unnatural/unexpected in vignette.

Target Stimuli

Two types of target stimuli were presented to participants in Boroditsky's (2000) Experiment 2, and both types contained ambiguities that could be resolved in two ways. Our goal was to develop target stimuli that could also be resolved in two ways: with the lexical item "in" or the lexical item "on."

Spatial Target Stimuli Boroditsky (2000) created ambiguous spatial target stimuli by using spatial scenes that could be interpreted in two different ways (i.e., ego-moving vs. object-moving). One example is provided (p. 13): The spatial scene is a line drawing in which two oblique lines appear to converge toward a vanishing point and three faceless objects arranged such that the larger one appears between the oblique lines at the bottom of the image and the smaller one at the top of the image. It creates the illusion that the larger object is closer to the viewer and the smaller object is further away. Participants are asked to decide which widget is ahead, and they can resolve the ambiguity in two ways: by choosing either the smaller object or the larger object.

Our lab had previously conducted a study in which undergraduate students from the same population as the current study responded to five cartoon images depicting figure-ground arrangements that could be described as the figure (i.e., the smaller entity or object) being either in or on the ground (i.e., the larger entity or object). We asked participants to complete short descriptions of the images using either "in" or "on." We considered a stimulus to be ambiguous if we found approximately equal "in" and "on" responses across participants. All our ambiguous images and the data we collected from native English speakers in response to these ambiguous images can be found on the Open Science Framework (https://osf.io/uxjga/). We chose the image of a woman in/on a bus because participants were evenly split (50%) between the two options. In the current study, participants were asked to make the same choice when completing the description.

Abstract Target Stimuli Boroditsky (2000) needed ambiguous temporal target stimuli that could be interpreted in two different ways (i.e., ego-moving vs. time-moving). One example was provided (p. 12): "Next Wednesday's meeting has been moved forward two days. Which day is the meeting now that it's been moved?" (i.e., a modified version of McGlone and Harding's [1998] ambiguous temporal statement). Participants can resolve the ambiguity in two ways: by responding either "Monday" (i.e., time-moving) or "Friday" (e.g., ego-moving).

Our lab had previously conducted a study in which undergraduate students from the same population as the current study responded to 11 sentences about fictious people containing a blank that could be completed using either "in" or "on." We asked participants to choose whether "in" or "on" best completed the sentence. Similar to the selection of our spatial target, we considered a stimulus to be ambiguous if we found approximately equal "in" and "on" responses across participants. All our ambiguous sentences and the data we collected from native English speakers in response to these ambiguous sentences can be found on the Open Science Framework (https://osf.io/uxjga/). We chose the sentence "I hope Riley gets there _____ time" because participants were almost evenly split (52% chose "in" and 48% chose "in") between the two options. In the current study, participants were asked to make the same choice when completing the sentence.

Experiment

Method

Participants Ethical approval for this study was obtained from the University of Louisiana at Lafayette's Institutional Review Board (IRB-23-100-PSYC). We collected data from 323 undergraduate students from a public university in the southern United States, but seven of these students did not complete the study. Students earned partial course credit in exchange for their participation. The mean age of our participants was 19 (SD = 2, MIN = 18; MAX = 40). The majority of participants identified as White (59%) and female (78%). They also overwhelmingly reported being native English speakers (97%) who were only fluent in English (95%).

Design, Materials, and Procedure Participants were pseudorandomly assigned to one of four conditions such that

each condition would end up with approximately the same number of participants. We used a 4-transfer type by 2 prime type fully crossed between-groups design for in and on separately. The four levels of transfer type were: (1) space-space (i.e., spatial primes and spatial targets), (2) space-abstract (i.e., spatial primes and abstract targets), (3) abstract-abstract (i.e., abstract primes and abstract targets), and (4) abstract-space (i.e., abstract primes and spatial targets).

Participants took part in this study via Qualtrics. They were presented with an electronic consent form followed by a series of five prime stimuli, consisting of either (a) spatial arrangements involving two objects (i.e., spatial primes) or (b) brief vignettes involving fictitious people (i.e., abstract primes). Participants were asked the extent to which the stimuli presented were natural and/or expected. Participants were then presented with one ambiguous target stimulus, consisting of either (a) an image of a woman and a bus along with the statement "The woman is ____ the bus" or (b) the statement "I hope Riley gets there _____ time." Participants were asked to complete the statement using either "in" or "on." The study ended with a series of demographic questions and a debriefing form.

Results

Data Preparation Data from the seven participants who did not complete the study, from the 24 participants who responded incorrectly to three or more of their five prime stimuli, and from the 22 participants who reported being native speakers of a language other than English and/or being fluent in one or more languages other than English were removed from further analysis. This left us with the data for 275 participants, representing those monolingual English speakers who completed the study and engaged with our prime stimuli. This is similar to Boroditsky (2000), who reported collecting data from 302 undergraduate students for Experiment 2.

Data Analysis We conducted the same analyses as Boroditsky (2000, pp. 14-16), but we did not find evidence to suggest that participants in the current study were influenced by spatial primes when thinking about abstract relationships (50.7% consistent) nor were they influenced by abstract primes when thinking about space (51.6% consistent).

Within-domain consistency effects were not observed for either the space-space condition or the abstract-abstract condition (43.8 and 56.5%, respectively; see Figure 3).

When looking specifically at the space-space condition, 43.8% of the participants in this condition responded in a prime-consistent manner. When given spatial in primes (i.e., photos of objects in other objects), 41.7% of participants said that a woman is "in" the bus. When given spatial on primes (i.e., photos of objects on other objects), 45.9% of participants said that a woman is "on" the bus. There was no evidence of prime-consistency bias, χ^2 (1, N = 73) = 1.12, p = .291.

When looking specifically at the abstract-abstract condition, 56.5% of the participants in this condition responded in a prime-consistent manner. When given abstract in primes (i.e., stories with a high level of figure control), 25.8% of participants completed their ambiguous sentence with "in" (i.e., "I hope Riley gets there in time"). When given on primes (i.e., stories with a low level of figure control), 81.6% of participants completed their ambiguous sentence with "on" (i.e., "I hope Riley gets there on time"). There was no evidence of prime-consistency bias, χ^2 (1, N = 69) = 0.54, p = .461; however, there did appear to be a bias toward the "on" response in this condition with the majority of participants (77.9%) completing their ambiguous sentence with "on," which is not a pattern that was observed in our stimulus development data.

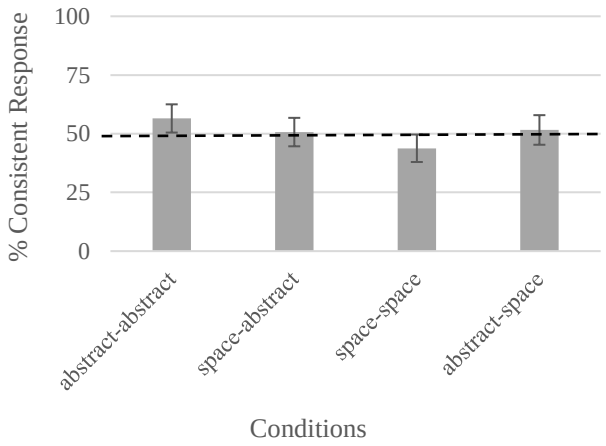

Figure 3: Results are shown in terms of % Consistent Response as a function of Transfer Type. Chance is represented by a dashed line at 50%. Error bars represent standard error.

Cross-domain consistency effects were not observed for either the space-abstract condition or the abstract-space condition (50.7 and 51.6%, respectively; see Figure 3).

When looking specifically at the space-abstract condition, 50.7% of the participants in this condition responded in a prime-consistent manner. When given spatial in primes (i.e., photos of objects in other objects), 25.7% of participants completed their ambiguous sentence with "in" (i.e., "I hope Riley gets there in time"). When given spatial on primes (i.e., photos of objects on other objects), 76.4% of participants completed their ambiguous sentence with "on" (i.e., "I hope Riley gets there on time"). There was no evidence of prime-consistency bias, χ^2 (1, N = 69) = 0.04, p = .833; however, there did appear to be a bias toward the "on" response in this condition with the majority of participants (75.4%) completing their ambiguous sentence with "on," which is not a pattern that was observed in our stimulus development data.

When looking specifically at the abstract-space condition, 51.6% of the participants in this condition responded in a prime-consistent manner. When given abstract in primes (i.e., stories with a high level of figure control), 54.8% of participants said that a woman is "in" the bus. When given on

primes (i.e., stories with a low level of figure control), 48.5% of participants said that a woman is "on" the bus. There was no evidence of prime-consistency bias, χ^2 (1, N = 64) = 0.07, p = .790.

Discussion

Unlike Boroditsky (2000), who found evidence consistent with CMT's grounded connections assumption, more generally, and system-mapping, more specifically, when exploring whether the way we conceptualize TIME can be influenced by our conceptualization of SPACE, we found evidence that appears—at least on the surface—to be incompatible with CMT's grounded connections assumption for the spatial and abstract meanings associated with the prepositions "in" and "on." We found no evidence of prime-consistent responding, even in our two control conditions (i.e., space-space and abstract-abstract). There are different ways to interpret the complete absence of priming in the current study. One possibility is that despite having adequately primed the concepts of "in" and "on," we found no evidence of priming because we took great care to avoid using the lexical items "in" and "on" when developing our prime stimuli and the lexical items are what connects all the disparate meanings together. This explanation is in line with the local lexical relations proposal.

Alternatively, the complete absence of priming in the current study could mean that our prime stimuli did not adequately prime the concepts of "in" or "on." This explanation leaves open the possibility that the spatial and abstract meanings of prepositions are connected but that our methods did not allow us to detect them. To determine the likelihood of this conclusion, we conducted a follow-up study using 100 participants pulled from the same population as the current study. The only changes we made were to replace our spatial prime stimuli with images depicting objects in front of or behind other objects (rather than objects in or on other objects) and our abstract prime stimuli with vignettes that were designed to have a moderate level of figure control (rather than very high or very low). This follow-up study resulted in an almost identical pattern of results, including the "on" bias that we had previously found in response to our ambiguous abstract target sentence (i.e., "I hope Riley gets there _____time") but that was not present in our stimulus development data.

When choosing to use a temporal metaphor as our ambiguous abstract target stimulus, one thing we had failed to consider is the evidence collected by Duffy and Feist (2014), which suggests that individual differences can affect the interpretation temporal metaphors in predictable ways. More specifically, Duffy and Feist (2014) found that college students were more likely to respond to the ambiguous "Next Wednesday's meeting has been moved forward two days. Which day is the meeting now that it's been moved?" question with "Friday" and that professionals on a college campus were more likely to respond "Monday." The researchers explained that this pattern might be due to students tending to have more control over their schedules and professionals tending to have less control over their schedules. Interestingly, Jamrozik and Gentner (2015) found "on" to be associated with more figure control and "in" to be associated with less figure control. It might make sense, then, that college students resolved our abstract target statement using "on" significantly more often than "in." This would mean that participants' ambiguity resolution was influenced by their worldview and not by the primes we presented. We suspect that the small size (n = 26) of our abstract target stimulus development sample may have played a role in originally obscuring this bias.

The lack of priming that was observed in the current study does not align with the results of Feist and Breaux (2013), who found that the time taken to correctly categorize abstract uses of "in" as either natural/expected or unnatural/unexpected was faster following spatial "in" stimuli but not vice versa—which they argue is in line with system mapping—and that the time taken to correctly categorize spatial uses of "on" was faster following abstract "on" stimuli but not vice versa—which they argue is in line with cognitive archeology. The results of Feist and Breaux (2013) may provide more insight into automatic, unconscious processes that are more susceptible to priming whereas the ambiguity resolution task used in the current study might be less susceptible to priming.

The ambiguity resolution task used in the current study is also different from the types of interpretation tasks used by Jamrozik and Gentner (2015) and Kranjec et al. (2010). Even though these studies provide evidence of similarities across spatial and abstract meanings, their results—while consistent with system-mapping—do not completely rule out cognitive archaeology or structural parallelism as potential explanations for these findings. In fact, there is even the possibility that cognitive archeology could be used to explain our lack of significant findings. It could be that the ambiguous target stimuli selected for use in the current study are conventionalized in the language and that resolving their ambiguity relies heavily on participants' linguistic habits. One way to test this hypothesis would be to conduct a similar study in which novel ambiguous stimuli are used as targets. If the patterns observed by Boroditsky (2000) are found using this strategy, then it would suggest that spatial concepts are important in the development of indirect metaphors involving "in" and "on" but no longer need to be accessed following conventionalization of the metaphor.

Conclusion

This study was designed to empirically test CMT's grounded connections assumption. Focusing on the prepositions "in" and "on," we did not find evidence to support this assumption; however, we suspect that this is due to the method used in the current study and that our results might provide more information about the role of linguistic preferences in the resolution of this type of ambiguity. More empirical research is needed to determine whether CMT's grounded connections assumption is more than just an assumption.

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