Providing explanations shifts preschoolers' metaphor preferences

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Abstract

In order to learn from metaphors, children must not only be able to understand metaphors, but also appreciate their relative informativeness. Although functional metaphors based on abstract commonalities (e.g. "Eyes are windows") allow for more learning than perceptual metaphors based on superficial commonalities (e.g. "Eyes are buttons"), previous research shows that preschoolers prefer perceptual metaphors over functional metaphors. In the present studies, we ask whether providing additional context can shift metaphor preferences in preschoolers and adults. Experiment 1 finds that *pedagogical context* increases preferences for functional metaphors in adults, but not preschoolers. Experiment 2 finds that *providing explanations* for conceptual similarities in a metaphor increases preschoolers' preferences for functional metaphors. These findings suggest that providing explanations allows even preschoolers to appreciate the informativeness of functional metaphors.

Keywords: metaphor comprehension; relational reasoning; cognitive development

Introduction

A metaphor is a figurative utterance that directly compares a concept from one domain to another concept in an unrelated domain. Metaphors are ubiquitous in both poetry (e.g. Emily Dickinson's "'Hope' is the thing with feathers") and everyday speech (e.g. "the horror movie was a roller coaster of emotions"). By providing concrete frameworks for abstract concepts, metaphors influence how humans attend to, remember, and process information (Thibodeau et al., 2017). Historically, metaphors also facilitate creative change across disparate domains, for example by spurring the development of new scientific theories (Kuhn, 1993) and word meanings (Bowdle & Gentner, 2005; Holyoak & Stamenkovic, 2018). Thus, metaphor is a powerful cognitive tool, at least in adulthood.

In addition to investigating how metaphors influence adult cognition, psychologists have also explored metaphor comprehension in childhood. Some earlier research suggested that young children struggle to understand metaphors, reflecting a general inability to understand abstract relations (e.g. Silberstein et al., 1982; Winner et al., 1980). However, more recent work shows that preschoolers already possess both the ability to represent and reason about abstract relations (Christie & Gentner, 2014; Hochmann et al., 2017; Walker et al., 2016) and to comprehend metaphors (Pouscoulous & Tomasello, 2020; Zhu et al., 2020).

In particular, Zhu and colleagues (2020) demonstrate that preschoolers as young as four years of age can differentiate metaphors based on abstract functional similarities (e.g. "Roofs are hats"; "Tires are shoes") from nonsense statements (e.g. "Roofs are scissors"; "Tires are paintbrushes"). Moreover, some preschoolers were able to spontaneously provide explanations noting the functional similarities between concepts in the metaphors (e.g. "Roofs and hats both cover you"; "Tires and shoes help you go places"). Thus, children are able to understand metaphors based on abstract similarities earlier in development than previously assumed. Given this evidence for early metaphor *comprehension*, the present work asks how researchers might also encourage children to *use* metaphors to guide learning.

In order for metaphors to facilitate learning, children must not only understand metaphors, but also be able to appreciate the relative informativeness of the commonalities that metaphors highlight (Richland & McDonough, 2010). Two concepts can be the same or different along an infinite number of dimensions, but some dimensions are more informative and useful for learning than others. In particular, more abstract relations are often better for learning. For example, it is useful to know that dogs and cats are both animals, but less useful to know that both existed in medieval France. Both similarities are true, but the former similarity – both animals – facilitates category learning, while the latter similarity – both existing in medieval France – is mere trivia.

Thus, an outstanding question is whether preschoolers are able to appreciate which metaphors allow for the most learning, and to prefer those metaphors over others. Previous research suggests that the answer is no: while adults prefer functional metaphors (e.g. "Moons are lightbulbs"; "Eyes are windows") that highlight abstract features conducive to further learning (Gentner & Clement, 1988), preschoolers prefer perceptual metaphors (e.g. "Moons are cookies"; "Eyes are buttons") that highlight arbitrary, surface-level features and do not license additional inferences (Silberstein et al., 1982). Consequently, even though some preschoolers are able to understand functional metaphors (Zhu et al., 2020), they may not recognize that the comparisons drawn by functional metaphors provide more relevant information for learning than those drawn by perceptual metaphors. If children are simply unable to appreciate the greater relative informativeness of functional over perceptual metaphors (i.e. if they are insensitive to the benefits of abstract, functional commonalities over superficial, perceptual commonalities for learning), then the utility of metaphor as an early childhood learning mechanism is severely limited. If, however, we can *provide contexts* that allow children to correctly distinguish between the relative informativeness of functional versus

perceptual metaphors, then this would suggest that children have the skills to learn from metaphors far earlier than previously believed. It would also provide additional evidence to the growing body of research suggesting early competence in abstract relational thought (Christie & Gentner, 2014; Goddu et al., 2020; Hochmann et al., 2017; Walker et al., 2016), as well as suggest interventions that could allow children to learn from metaphors in the powerful ways that adults do.

The current paper asks whether preschoolers might *shift their metaphor preferences from perceptual metaphors to functional metaphors* when the metaphors are encountered in a pedagogical context (Experiment 1) and when explanations for the conceptual similarities in each metaphor are provided (Experiment 2).

Since previous metaphor preference paradigms (e.g. Silberstein et al., 1982) lacked context to help guide children's responses, we provide two kinds of experimental contexts which might facilitate preschoolers' performance. First, previous research suggests that preschoolers are sensitive to pedagogical contexts: for example, they flexibly select what information to teach others (Bridgers et al., 2019) and who to learn from (Gweon et al., 2018; Gweon & Asaba, 2018; Koenig & Harris, 2005; Sobel & Kushnir, 2013). Thus, Experiment 1 asks whether adults and preschoolers shift their metaphor preferences in a pedagogical context. Second, since preschoolers sometimes struggle to notice relations (Kroupin & Carey, 2021), Experiment 2 asks whether preschoolers shift their metaphor preferences when provided with explanations that highlight how two concepts in a metaphor are alike.

Experiment 1

In Experiment 1, we investigated whether preschoolers might be capable of shifting their preferences away from perceptual metaphors (e.g. "Eyes are buttons"), and towards functional metaphors (e.g. "Eyes are windows"), given a pedagogical context. We tested both adults and preschoolers in either the Pedagogical condition, in which participants helped teach a naïve person, or the Baseline condition, in which no context was given to guide participants' choices. We hypothesized that both adults and preschoolers would shift their metaphor preferences given a pedagogical context, such that both adults and preschoolers would be more likely to prefer functional metaphors over perceptual metaphors in the Pedagogical condition relative to the Baseline condition.

Methods

Participants. We adhered to a stopping rule of 24 participants per condition, leading to a total of 48 adult participants (M = 25.93 years; SD = 6.57 years; range = 18.83 – 48.61 years; 16 males) and 48 4- and 5-year-olds participants (M = 4.93 years; SD = .55 years; range = 4.02 – 5.91 years; 24 males). Researchers tested an additional child, whose data were excluded due to failure on the attention check. Adults were recruited and tested in-person, on a university campus. Most children (45 out of 48) were recruited and tested in-person, in a preschool or museum. Due to COVID-19, three children were recruited from a local database and tested online over Zoom. All experiments reported in this paper were approved by the university's Committee for the Protection of Human Subjects. All adult participants and parents of child participants provided informed consent. The preschooler component of Experiment 1 is preregistered at https://osf.io/erq9k/.

Stimuli and Procedure. The experimenter presented participants with stories on a computer. Participants were assigned to either the Pedagogical or Baseline condition.

Pedagogical Condition. In the Pedagogical condition, the experimenter showed a picture of an alien and said, "We're going to play with my friend Zorpa. I've got something special to tell you about Zorpa. Zorpa is actually an alien from Planet Meelee! So she doesn't know anything about the objects on Earth. We need your help teaching Zorpa about the objects here on Earth. In this game, Zorpa is going to ask two teachers about any object. One teacher will give her an answer. Then, another teacher will give her a different answer. Your job is to figure out which teacher Zorpa should learn from."

On each trial, Zorpa stated what concept she wanted to learn about (e.g. "I want to learn about eyes!"). A teacher appeared on the left side of the screen and provided a metaphor (e.g. a functional metaphor, such as "This teacher says, 'Eyes are windows!'"). As the metaphor was uttered, the two objects in the metaphor (e.g. eye and window) appeared on the screen. Then, a second teacher appeared on

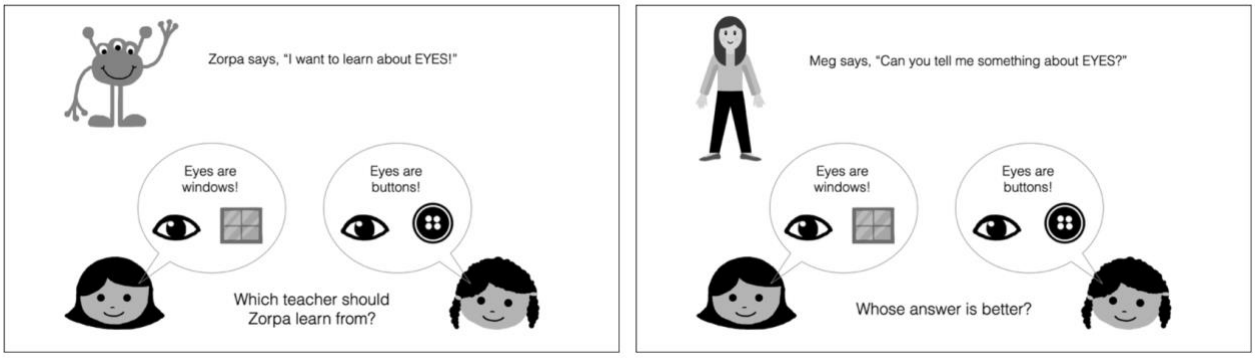

Figure 1. Example of an Experiment 1 trial, presented in either the Pedagogical condition (left) or Baseline condition (right).

the right side of the screen and provided another metaphor (e.g. a perceptual metaphor, such as "This teacher says 'Eyes are buttons!'"). Once again, as the metaphor was uttered, the two objects in the metaphor (e.g. eye and button) appeared on the screen. The experimenter then asked, "Which teacher should Zorpa learn from?" Once the participant answered by providing a verbal response (e.g., "buttons") or by pointing at one of the teachers, the experimenter began the next trial. No feedback was provided.

Finally, participants completed an attention check at the end of the study. In the attention check, the experimenter asked, "What is this animal called?" while a picture of a dog appeared on the screen. The person on the left provided the correct description (i.e., "The animal is a dog!") and the person on the right provided an incorrect description (i.e. "The animal is a fish!"). Participants needed to select the correct description in order to pass the attention check.

Each participant received eight metaphor preference trials. Each trial's structure followed the design described above, in which the participant had to select between a functional metaphor or a perceptual metaphor. The order of the eight trials was randomized and the left-right placement of the functional metaphors was counterbalanced.

Baseline Condition. In the Baseline condition, preschoolers participated in a very similar dichotomous-choice metaphor preference paradigm, but without any pedagogical framing. The experimenter introduced the task by saying, "We're going to play with my friend Meg. Meg is going to ask questions! One person will give her an answer to her question. Then, another person will give her a different answer to her question. Your job is to point at the person who gives Meg the better answer. Let's play!"

The Baseline trials were similar to the Pedagogical trials, with three exceptions. First, while the Pedagogical condition emphasized learning (e.g., "Zorpa says, "I want to *learn* about eyes"), the Baseline condition did not (e.g., "Meg says, "Can you tell me something about eyes?"). Second, while the Pedagogical condition emphasized that the respondents were teachers (i.e., "This *teacher* says..."), the Baseline condition did not (i.e., "This *person* says..."). Third, instead of selecting the teacher who should be learned from, participants were simply asked "Whose answer was better?"

Results

A between-subjects ANOVA with condition (Pedagogical, Baseline) and age (adult, preschooler) as independent variables yielded a main effect of Age, $F(1,92) = 111.40$, $p < .001$, and a main effect of Condition, $F(1,92) = 4.56$, $p = .04$.

Adults were significantly more likely to select functional metaphors over perceptual metaphors in both the Baseline condition, $M = 70.31\%$, $SE = 4.18\%$, $t(23) = 4.28$, $p < .001$, and the Pedagogical condition, $M = 85.42\%$, $SE = 3.89\%$, $t(23) = 9.12$, $p < .001$. Moreover, there was a significant effect of condition, such that adults in the Pedagogical condition were more likely to select functional metaphors than adults in the Baseline condition, $t(46) = 2.65$, $p = .01$.

In contrast, preschoolers were significantly more likely to select perceptual metaphors over functional metaphors in both the Baseline condition, $M = 31.25\%$, $SE = 4.05\%$, $t(23) = 4.63$, $p < .001$, and the Pedagogical condition, $M = 34.38\%$, $SE = 4.89\%$, $t(23) = 3.19$, $p = .004$. There was no difference in preschoolers' performance between the Baseline and Pedagogical conditions, $t(46) = .49$, $p = .63$. All the significant statistics reported above remained significant after correcting for multiple comparisons (Benjamini & Hochberg, 1995).

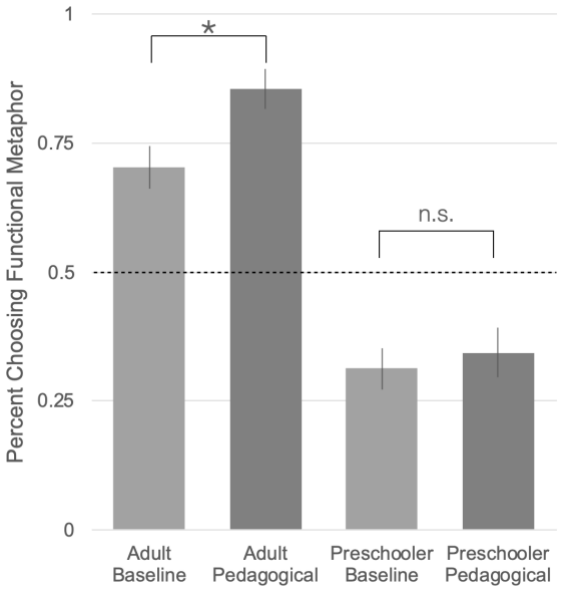

Figure 2. Experiment 1 results. Error bars show 1 standard error.

Discussion

Experiment 1 showed that adults', but not preschoolers', performance on the metaphor preference task benefited from pedagogical context. Specifically, while adults already preferred functional metaphors in a contextless baseline condition, they preferred functional metaphors *even more* in a pedagogical context. In contrast, preschoolers' performance on the metaphor preference task did not change across experimental contexts: preschoolers preferred perceptual metaphors over functional metaphors in both contexts.

These results demonstrate that adults are already able to select appropriate metaphors to learn from (i.e., functional metaphors) even without context, and this selection ability increases when a pedagogical context is introduced. However, preschoolers prefer shallow surface-level metaphors (i.e. perceptual metaphors) with or without a pedagogical context. These results suggest that preschoolers are not sensitive to the relative informativeness of functional over perceptual metaphors, even in a pedagogical context.

Experiment 2

Experiment 1 showed that pedagogical context improved adults', but not preschoolers', performance on a metaphor preference task. Although preschoolers are often sensitive to pedagogical contexts (Bridgers et al., 2019; Gweon et al., 2018; Gweon & Asaba, 2018; Koenig & Harris, 2005; Sobel & Kushnir, 2013), Experiment 1's results suggest that they are *not* sensitive to the relative informativeness of functional metaphors over perceptual metaphors when teaching others.

However, it is not clear whether children's failure to select the more informative metaphors for the alien character in Experiment 1 derived from a difficulty with reasoning about which information would be useful to that character, or whether it stemmed from a general inability to appreciate the usefulness of functional over perceptual metaphors. In order to directly test the latter possibility, Experiment 2 investigated whether children were able to select functional metaphors over perceptual metaphors when given explanations for how the two concepts in the metaphors were alike. Earlier work shows that explanations can lead preschoolers to make broader and deeper generalizations, and attend to abstract relations (Walker et al., 2014; 2017). Although young children are capable of representing relations between objects (Christie & Gentner, 2014; Hochmann et al., 2017; Walker et al., 2016) and thus capable of understanding metaphors (Pouscoulous & Tomasello, 2020; Zhu et al., 2020), preschoolers also sometimes fail to spontaneously notice relations between objects (Kroupin & Carey, 2021). Thus, providing explanations of how two concepts in a metaphor are similar might help preschoolers notice and fully consider the relevant conceptual relations underlying metaphors, and thus facilitate their performance on a metaphor preference task. In Experiment 2, we replicate preschoolers' baseline performance, and investigate whether their performance shifts when 1) provided with explanations, and 2) provided with explanations *and* pedagogical context.

Methods

Participants. We adhered to a stopping rule of 24 participants per condition, leading to a total of 72 4- and 5-year-old participants (M = 5.04 years; SD = .60 years; range = 4.01 – 5.99 years; 44 females). Researchers tested six additional children, whose data were excluded due to failure on the attention check (four children), experimenter error (one child), and external interference (one child). All children were recruited from a local participant database and tested online over Zoom. Experiment 2's preregistration can be found at https://osf.io/erq9k/.

Stimuli and Procedure. The experimenter presented stories, which participants viewed on either a computer or large tablet. Participants were assigned to the Baseline, Explanation, or Explanation and Pedagogy condition.

Baseline Condition. Experiment 2's Baseline condition was identical to Experiment 1's Baseline condition, except that data was collected online rather than in person.

Explanation Condition. Experiment 2's Explanation condition was identical to Experiment 1's Baseline condition, except that data was collected online and the experimenter provided explanations for how the two concepts in the metaphors were alike (e.g. "This person says, 'Tires are donuts *because both have holes*'"; "This person says, 'Tires are shoes *because both help you go places*'").

Explanation and Pedagogy Condition. The Explanation and Pedagogy condition was identical to Experiment 1's Pedagogy condition, except that data was collected online and the experimenter provided explanations for how the two concepts in the metaphors were alike (e.g. "This teacher says, 'Eyes are windows *because you see through both of them*"; "This teacher says, 'Eyes are buttons *because both are round"*).

Results

In line with previous research and the results of Experiment 1, preschoolers in Experiment 2 were significantly more likely to select perceptual metaphors over functional metaphors in the Baseline condition, M = 34.38%, SE = 4.53%, t(23) = 3.45, p = .002. In contrast, preschoolers did not prefer perceptual metaphors over functional metaphors in the Explanation condition, M = 52.60%, SE = 4.82%, t(23) = .54, p = .59, and the Explanation and Pedagogy condition, M = 48.96%, SE = 4.32%, t(23) = .24, p = .81.

Compared to performance in the Baseline condition, preschoolers were significantly more likely to select functional metaphors in the Explanation condition, t(46) = 2.76, p = .008, and the Explanation and Pedagogy condition, t(46) = 2.33, p = .02. There was no difference in performance between the Explanation condition and the Explanation and Pedagogy condition, t(23) = .56, p = .58. All the significant statistics reported above remained significant after correcting for multiple comparisons (Benjamini & Hochberg, 1995).

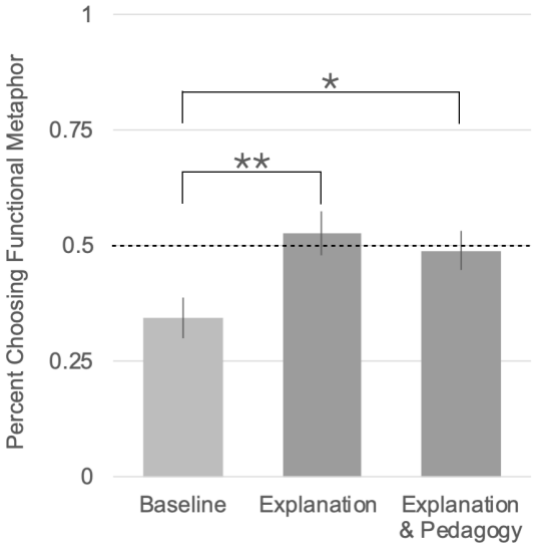

Figure 3. Experiment 2 results. Error bars show 1 standard error.

Discussion

Experiment 2's results suggest that explanations help preschoolers recognize the informativeness of functional metaphors. When they were provided with explanations for the comparisons between concepts drawn by the metaphors, children's preferences shifted away from perceptual metaphors, and towards functional metaphors. Notably, Experiment 2 demonstrated that preschoolers shifted their preferences towards functional metaphors in not one, but two, conditions involving explanations.

Replicating the results of Experiment 1, there was no effect of pedagogy, as preschoolers performed similarly in the two explanation conditions, with or without pedagogical context. Experiment 2 also replicated Experiment 1's finding that preschoolers prefer perceptual metaphors (e.g. "Tires are donuts") to functional metaphors (e.g. "Tires are shoes") in a contextless baseline condition.

Overall, the results of Experiment 2 show that preschoolers' metaphor preferences are not fixed. Given that providing explanations for the comparisons between concepts in the metaphors shifted preschoolers' metaphor preferences away from perceptual metaphors and towards functional metaphors, we can conclude that they are indeed sensitive to the informativeness of functional metaphors. This suggests that, in the right contexts, even young children are able to appreciate the abstract similarities that make metaphors conducive for learning.

General Discussion

The present findings suggest that preschool-aged children recognized the usefulness of functional metaphors (e.g. "Eyes are windows") when explanations for the comparisons drawn by those metaphors were made explicit. This suggests that, with the right kind of scaffolding, young children are indeed able to appreciate abstract comparisons that are conducive to learning. These findings also corroborate a growing body of work demonstrating that even preschool-aged children are able to understand and reason about abstract relations (Christie & Gentner, 2014; Goddu et al., 2020; Hochmann et al., 2017; Pouscoulous & Tomasello, 2020; Walker et al., 2016; Walker & Gopnik, 2017; Zhu et al., 2020). Critically, the results of the present experiments demonstrate that preschoolers *are able* to appreciate these abstract metaphors when the underlying commonalities are made salient. This is a new and different conclusion than those drawn in many earlier studies, which have interpreted children's preference for perceptual metaphors as evidence that children are *unable* to appreciate, reason with, and learn from the abstract relations expressed in functional metaphors. Moreover, the present findings demonstrate that providing explanations might help preschoolers fully consider the abstract similarities present in functional metaphors.

Experiment 1 demonstrated that, in a contextless baseline condition, adults prefer functional metaphors and preschoolers prefer perceptual metaphors. This result is consistent with previous findings (Gentner & Clement, 1988; Silberstein et al., 1982). Moreover, introducing a pedagogical context significantly shifted metaphor preferences in adults, but not preschoolers. Experiment 2, however, showed that preschoolers' metaphor preferences shifted away from perceptual metaphors, and towards functional metaphors when they were provided with explanations for the ways in which two concepts in a metaphor were similar (e.g. "Suns are oranges *because they're both the same color";* "Suns are candles *because they both light up*"). Thus, Experiment 2 shows that preschoolers' metaphor preferences are not fixed, but rather can shift when the underlying comparisons are made explicit. This finding suggests that children can not only to understand metaphors, but also appreciate the informativeness of different kinds of metaphors.

While the current studies show that children *can* shift their metaphor preferences when provided with explanations, further research should investigate *why* explanations cause this shift in children's preferences. Previous studies have demonstrated that young children are capable of understanding metaphors based on abstract, functional similarities (Zhu et al., 2020). Thus, preschoolers' preference for perceptual metaphors over functional metaphors cannot be explained by a lack of representational ability (i.e. an inability to represent the abstract similarities between two concepts in a functional metaphor). Rather, providing explanations of how two concepts in a metaphor are alike might change the inductive biases that preschoolers bring to the experimental task (Kroupin & Carey, 2021).

Future research will be required to determine why exactly explanations are helpful. There are at least four possible accounts that might explain why preschoolers prefer perceptual metaphors in the baseline version of a metaphor preference task, but shift their preferences towards functional metaphors when provided with explanations.

One possibility is that without explanations, preschoolers fail to *spontaneously* notice how two concepts in a functional metaphor are similar. When presented with two metaphors (e.g. "Clouds are sponges"; "Clouds are ice creams"), preschoolers might immediately notice the surface-level similarities within the perceptual metaphor (e.g. how clouds and ice creams are alike) and not pause to consider whether there are also similarities within the functional metaphor (e.g. how clouds and sponges are also alike). Since the perceptual commonalities are more readily available, children may be more likely to spontaneously identify perceptual commonalities than abstract commonalities.

A second possibility is that preschoolers *do* notice similarities within functional metaphors, but not the correct kinds of similarities. For example, preschoolers might be interpreting functional metaphors in perceptual terms (e.g. thinking that clouds and sponges are alike because both are fluffy, not because both hold water). If this second possibility is true, explanations facilitate preschoolers' metaphor preferences because the explanations highlight the correct *kind* of similarity (i.e. same function) required to interpret the functional metaphors.

A third possibility is that providing explanations eases executive function demands on metaphor comprehension and relational reasoning (e.g. Ballestrino et al., 2016). Considering multiple speakers, concepts, and similarities between concepts within a single trial might tax preschoolers' attention and working memory; explicitly stating similarities between concepts might ease these difficulties.

Finally, a fourth possibility is that preschoolers' shift in preferences is caused by the process of explanation itself. Under this possibility, explanations might change the kinds of features or similarities that preschoolers notice or prefer (Walker et al., 2014; 2017). Thus, while the current work shows that preschoolers are capable of shifting their metaphor preferences, future work should explore the mechanisms underlying this shift.

A limitation of the current research is that while preschoolers were capable of shifting their metaphor preferences across experimental contexts, there were no contexts in which preschoolers consistently selected functional metaphors *over* perceptual metaphors. Rather, providing explanations helped preschoolers shift away from significantly preferring perceptual metaphors, towards preferring perceptual and functional metaphors equally. Thus, while providing explanations significantly improved preschoolers' performance on the metaphor preference task, preschoolers still did not perform as well as adults, who consistently preferred functional metaphors. Since the current research shows that preschoolers' preferences are flexible, future work might investigate whether there are additional contexts that might facilitate even greater shifts in preschoolers' metaphor preferences, such that preschoolers consistently prefer functional metaphors.

Overall, the current work shows that preschoolers are sensitive to the informativeness of functional metaphors, suggesting that they possess a critical initial requirement for understanding metaphors in a manner that is conducive for learning. The ability to select appropriate metaphors is important: in order to successfully learn from a metaphor, a child must not only understand metaphors, but also recognize which metaphors are useful for learning and additional inferential reasoning (Richland & McDonough, 2013). By demonstrating that providing explanations can change children's metaphor preferences, the current studies pave the way for future research on ways to use metaphor as a powerful learning mechanism early in human development.

Acknowledgments

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