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Person-centered cognition: The presence of people in a visual scene promotes relational reasoning☆,☆☆

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ABSTRACT

How do people make sense of the world they encounter? In the current research, we suggest that a primary way people understand the external world is by engaging in “person-centric cognition:” they mentally organize the world in terms of how its various objects and elements relate to people. As a result, we propose that the mere presence of other people in a visual scene fundamentally shapes how observers make sense of that scene, leading observers to increase their focus on abstract relations between objects and people as opposed to just the concrete features of objects themselves. Across four studies using a picture mapping task, we found that people were more likely to process visual scenes in terms of underlying relational structure when the scenes involved another person as opposed to only non-human objects. In a fifth study, we demonstrate that other people are unique in their primacy such that observers are more likely to construe other animate entities (i.e., animals) in terms of their relationship to humans than they are to construe humans in terms of their relationship to animals. Overall, we propose that these findings reflect a tendency for person-centric construals in making sense of the external world, wherein the unique and distinctive features of various objects are construed in terms of their relationship with people.

1. Introduction

One of the most basic questions in the study of human cognition is: how do people make sense of the external world? That is, how do people organize and interpret the vast amount of information available to them at any moment? In the current research, we suggest that a primary way people understand the external world is by engaging in “person-centric cognition:” they mentally organize the world in terms of how its various objects and elements relate to people. As a result, we propose that the mere presence of other people in a visual scene fundamentally shapes how observers make sense of that scene, leading observers to increase their focus on abstract relations between objects and people as opposed to just the concrete features of objects themselves.

Consider the experience of looking at photographs from a friend's ski trip. Suppose one photo shows an empty, snow-covered mountain filled with trees, cliffs, and ledges. When looking at the photo, an observer may focus on the various objects; their features like size, shape, and color; or how they contribute to the overall beauty of the mountain. Now imagine that same photo, but with a skier in it. The presence of a person in the scene gives the mountain and those same objects a new meaning. The trees and cliffs that were processed as interesting objects in their own right may now be thought of primarily in terms of how they impact the skier—as hazards and obstacles.

In this article, we posit that when another person is present in the external environment, observers tend to structure their mental representation of the environment around that person and construe other objects within it in terms of how they relate to that person. As a result, we expect that observers will engage in more relational thinking (e.g., representing a tree in terms of its relationship to a skier rather than in terms of its perceptual features) when processing scenes that contain people within them than scenes that do not.

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1.1. The primacy of people in mental representation

Other people represent central figures in the mental processing of the world beyond the self (see Heider, 1944; Jones, 1990). The first visual attention studies to use non-invasive eye-tracking found that people exhibit a strong attentional bias towards other people. In these studies, Buswell (1935) found that when looking at pieces of art, participants spent a hugely disproportionate amount of time fixating on depictions of people over other non-human objects. Further evidence for the primacy of other people in visual attention comes from research showing that reliable patterns of fixation on the faces and bodies of other people are detectable as early in perceptual processing as 100–150 ms within stimulus onset (Fletcher-Watson, Findlay, Leekam, & Benson, 2008). Taken together, this research shows that when processing a visual scene, humans preferentially direct attention towards other people, who quickly and overwhelmingly become the central object of focus.

In the current research, we posit that other people are not only central figures in visual attention but are also central figures in the conceptual organization of a scene. When another person is identified as the central object of interest in a given scene, the rest of the environment becomes construed as the context in which that person's actions occur. Importantly, it is not that the background and peripheral objects are left unattended or unrepresented, but rather that their meaning becomes defined by their relation to the central person. As a result, we propose that the presence of a person in a scene leads observers to view the distinct qualities of objects as secondary to how those objects relate to and interact with the person.

1.2. Relational reasoning

Once a person is identified as primary, the process of subordinating *what* other objects in the environment are to *how* that person interacts with them is an example of relational reasoning. In relational reasoning, people represent the various elements of an event as a system of relations wherein the meaning of specific objects is defined by the role they occupy in relationship to other objects (Gentner, 1983; Goldwater & Markman, 2011; Holyoak, 2012). Whereas more surface level, or object oriented, processing focuses on the distinctive qualities of specific objects, relational processing extracts structured representations that render surface level qualities secondary to how entities relate to and interact with each other. Such relational processing enables observers to easily recognize distinct objects that occupy the same relational role as substitutable for one another.

For example, consider the scenes in the left panel of Fig. 1. Relational processing may lead an observer to focus on the highlighted umbrella's role of protecting the girl from rain; rather than considering the umbrella's size or shape, the observer defines the umbrella based on how it relates to the girl. As a result, an observer may consider the newspaper in the bottom scene as the same type of object as the umbrella in the top scene, given that it occupies the same relational role of protecting the girl from rain. In the right panel, relational processing would promote aligning the Earth in the top scene with the Moon in the bottom scene since both occupy the relational role of blocking sunlight. This contrasts with object-level processing, which would lead an observer to match the umbrella in the top picture with the umbrella in the bottom picture in the right panel and the Earth in the top picture with the Earth in the bottom picture in the left panel.

Relational reasoning plays a fundamental role in learning, generalization, problem solving and innovation as it enables analogical reasoning (e.g., Christie & Gentner, 2010; Gentner, Loewenstein, & Thompson, 2003; Gick & Holyoak, 1983; Ross & Kennedy, 1990). Analogical reasoning involves comparing two distinct scenes or events, identifying similarities between them, and using these similarities to transfer what is known about the more familiar target to the less familiar one (see Holyoak, 2012). Relational reasoning facilitates analogical transfer by extracting underlying structures that are applicable across variable contexts with variable surface level features.

For example, thinking to use a newspaper "as an umbrella" is an example of analogical reasoning. Here, an individual solves the problem of avoiding getting wet by substituting a newspaper into the relational role typically occupied by an umbrella (i.e., protecting one from rain), despite their differences in surface level appearance. Focusing on this relational similarity instead of the objects' surface level appearance allows the individual to transfer what she knows about how to use an umbrella (e.g., spread it out and hold it over one's head) to infer how to use a newspaper to serve the same purpose (analogical transfer). While this is a relatively simple example, the same basic process of using relational schemas to guide analogical transfer operates even in the most complex of problem solving, such as using a pump analogy to understand and reconstruct a healthy functioning heart.

Given its importance for learning, generalization and problem solving, theorists have sought to understand the various factors that promote relational reasoning (e.g., Christie & Gentner, 2010; Corral, Kurtz, & Jones, 2018; Gick & Holyoak, 1983; Goldwater, Don, Krushe, & Livesey, 2018; Kalkstein, Hubbard, & Trope, 2018a; Vendetti, Wu, & Holyoak, 2014). Our proposal identifies the presence of other people as one such factor that disposes people towards more relational processing.

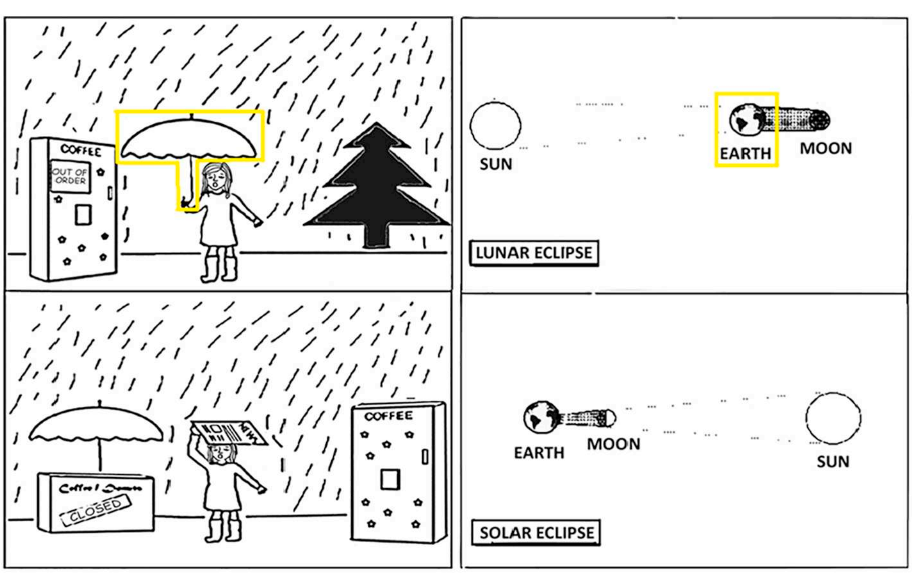

Fig. 1. Example of two pairs of scenes presented to participants in Studies 1a and 1b. The left panel shows an example of a pair of scenes containing a depiction of a person, while the right panel shows a pair with no one in it. Participants' task was to select the object in the target scene (the bottom picture) that "goes with" the highlighted object in the source scene (the top picture). In each pair of scenes, the target picture contains both an object match (the umbrella and earth) and a relational match (the newspaper and the moon).

1.3. Relational reasoning in social contexts

Our proposal joins a growing body of research exploring the general hypothesis that relational reasoning may be particularly prevalent in social domains (for reviews see Christie, 2017; Gentner, 2003). People perform better at deductive reasoning tasks (e.g., the Wason task) when they are framed in terms of social exchange than when they are framed in nonsocial ways (Cosmides, 1989). People reason more quickly and accurately about social relations (e.g., given that Janet likes Gary and Gary likes Courtney, will Janet like Courtney?) than non-social relations (e.g., given that Gold attracts Platinum and Platinum attracts Tin, will Gold attract Tin?) (Mason, Magee, Kuwabara, & Nind, 2010). Developmentally, children as young as 11-months old use goal inferences to predict the actions of human actors but not non-human entities (Cannon & Woodward, 2012). And in processing faces, people tend to process human faces configurally whereas nonhuman entities that resemble faces are processed more featurally (Maurer, Le Grand, & Mondloch, 2002). Taken together, this research suggests that people display enhanced relational reasoning in social contexts.

1.4. Present research

Whereas past research has focused on people's tendency to understand social systems in terms of relational structures (e.g., Cosmides, 1989; Mason et al., 2010), the present work focuses on people's tendency to understand the nonsocial world through relational structures when another person is present. We posit that when another person is present in a given environment, people use them as a primary source of meaning and construe the remaining elements of the environment in terms of how they relate to that focal person.

One result of this person-centric relational processing is that it should help observers identify correspondences across distinct objects that have similar relationships with a focal actor—for instance, identifying newspapers and umbrellas as corresponding objects when both shield a person from rain. While objects can have relationships to other inanimate objects (e.g., an umbrella can also shield a set of keys from the rain), we expect the relational meaning of objects to be particularly salient when that relationship is vis-à-vis another person. Hence, we predict that people will be more likely to establish correspondences between distinct objects that are based on common relational roles—as opposed to common object level identities—when the relationships involve another person (e.g., as in the left panel of Fig. 1) than when they do not (e.g., the right panel of Fig. 1).

2. Studies 1a and 1b

To test whether people are more likely to identify relational matches in a visual scene when those scenes involve another person, we reanalyzed data from two previously conducted studies using the picture mapping task shown in Fig. 1 (see Kalkstein et al., 2018a). Study 1b is a direct replication of Study 1a; both studies adopted the picture mapping materials and procedure from previous research (see Markman & Gentner, 1993; Tohill & Holyoak, 2000). Some of the picture pairs from these materials contained depictions of people while others did not (see Fig. 1).

In the task, participants are given pairs of pictures and are asked to identify correspondences across the two pictures in each pair. As discussed earlier, whether an individual processes a given event at a deeper relational level or more superficial object level can be inferred from the mappings they establish across distinct scenes. In reanalyzing this data, we predicted that people would be more likely to make relational matches for pairs of scenes that contained depictions of people than for pairs of scenes that did not.

2.1. Method

The two studies described below were originally designed to collect data for a separate project that is independent from the current investigation and is reported elsewhere (see Kalkstein et al., 2018a). In these experiments, participants were presented with five pairs of visual scenes and asked to identify correspondences across the two scenes for each pair. The original intent of these experiments was to explore the impact of sequential versus simultaneous presentation on the types of mappings people establish. Thus, the methods described below include a presentation style manipulation (sequential versus simultaneous presentation) that is irrelevant for the present study and sample sizes that were determined to achieve adequate power to detect this effect of presentation style on the picture mapping task.

2.1.1. Participants

One-hundred and forty participants (51% female; M_{age} = 37.44; range 19–70 years) and 144 participants (51% female; M_{age} = 38.08; range 18–73 years) were recruited online through Amazon's Mechanical Turk for Studies 1a and 1b, respectively. In all studies, sample size was determined before any data analysis.

2.1.2. Procedure

All procedures were approved by New York University's Institutional Review Board. The procedures for Studies 1a and 1b were identical. Participants began by learning that the study was about perceptions of pictures. After providing consent, participants were introduced to a picture mapping task adapted from Markman and Gentner (1993) and Tohill and Holyoak (2000). They were instructed that they would see several pairs of pictures. Their task was to identify the object in the second picture of each pair that corresponded to an object that was highlighted in the first picture.

For each pair of pictures, participants saw an initial presentation phase that lasted 10 s, where the two distinct scenes were shown to participants for the first time. Next, they completed a mapping phase where they saw an object become highlighted in the first picture and were asked to map it onto a corresponding object in the second picture. Fig. 1 provides examples of what the mapping phase looked like for two pairs of pictures. During this mapping phase, participants were given as much time as they wanted to study each picture in the pair and establish a mapping. As mentioned above, the presentation of the two scenes within each pair was manipulated between participants in both Experiments 1a and 1b. Thus, half of the participants saw the scenes presented simultaneously on the same screen—i.e., both scenes were present on the same screen during the initial presentation (10 s) and during the mapping phase. The other half saw the first and second scene presented sequentially on consecutive screens—i.e., the two scenes appeared one at a time first (5 s each) in the initial presentation phase and then one at a time in the mapping phase (see Kalkstein et al., 2018a for additional details on the presentation manipulation). Note, however, that this factor was not of interest for the present analysis and will be discussed only minimally.

After studying the pictures, participants clicked to proceed to the response page where they were asked to type into an open-ended response box the name of the object in the second picture that "corresponds to the object that was highlighted" in the first picture.[1]

2.1.3. Independent variable

Of the five pairs of pictures presented to participants, three of the pairs depicted a person in the scenes while two of the pairs did not. Whether or not each pair of scenes contained depictions of a human was

[1] In this and all subsequent studies, participants completed several demographic and debriefing questions at the end of the survey. Participants were asked for their age, gender, whether they were fluent in English, how difficult they found the task, how much they were paying attention, whether the instructions were clear, whether all the pictures displayed properly, what device they completed the survey on, whether anything strange happened while they were taking the experiment, whether they had a guess as to what the experiment was about, and for any additional comments they had. Other than the demographic information, we did not include (nor intend to include) these measures with any of the analyses we report in this paper and they will not be discussed further.

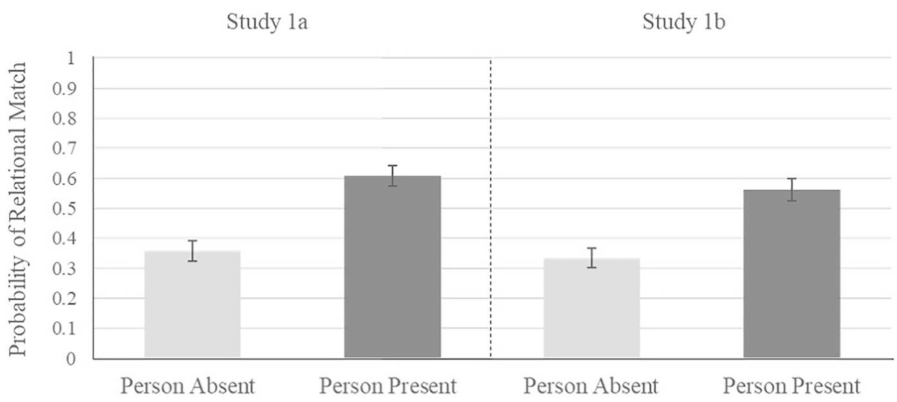

Fig. 2. Estimated probability of making a relational match for each type of scene. In both Studies 1a and 1b, participants were more likely to make a relational match (vs. an object match) between two scenes when the scenes contained a depiction of a person within them than when they did not. Error bars represent one standard error above and below the expected probability.

thus manipulated within participants. An example of a pair of scenes that contain a human is shown in the left panel of Fig. 1, while an example of a scene that did not contain any humans is shown in the right panel of Fig. 1.

2.1.4. Dependent variable

Our main dependent measure was whether participants provided a relational match or an object match to the question asking them what in the second picture corresponded to the object highlighted in the first picture. This measure was obtained by coding participants' text responses for whether they identified an object occupying the same relational role (coded as 1) or an object that had the same surface form (coded as 0) as the corresponding object. For example, for the pair of pictures shown in the right panel of Fig. 1, the response "the moon" would be coded as 1, while "Earth" would be coded as 0. Any response that could not easily be categorized as a relational or an object match was left uncoded and was not factored into the subsequent analyses. Our final measure was the likelihood that participants provided a relational match for a given picture.

2.2. Results

Data for these and all subsequent studies is available at osf.io/8txwd. In this and all subsequent studies, all measures, manipulations, and exclusions are reported. One participant in Study 1a and one participant in Study 1b was excluded from the main analyses for failing to provide any response that could be coded as either a relational or an object match. Overall, only 10% of responses in Study 1a and 9% of responses in Study 1b were left uncoded and the average number of analyzable responses provided by each participant was 4.55 for Study 1a and 4.57 for Study 1b (out of 5). Importantly, the likelihood of a response being left uncoded did not significantly differ as a function of whether the scenes depicted a human or not (Study 1a: $p = .52$; Study 1b: $p = .79$; see Table S1 in Supplemental Materials).

Our key hypothesis was that participants would make more relational matches in images that depicted a human. Since our variable of whether or not a human was present in each pair of scenes occurred within subjects, we used generalized estimating equations (GEE) to adjust for interdependence within participants' responses (Zeger, Liang, & Albert, 1988). Using a binary logistic GEE model with an exchangeable working correlation matrix, we found, across both studies, that participants were more likely to provide a relational match for scenes with a human (coded as 1) than for scenes without (coded as 0). As shown in Fig. 2, in Study 1a, the estimated probability of providing a relational match for pictures with people in them was 61% compared to 36% for pictures without people ($b = 1.03$, $se = 0.12$, $Wald\ \chi^2(1) = 77.28$, $p < .001$, $OR = 2.80$). In Study 1b, the estimated probability of providing a relational match for pictures with people in them was 56% compared to 33% for pictures without people ($b = 0.94$, $se = 0.12$, $Wald\ \chi^2(1) = 60.54$, $p < .001$, $OR = 2.56$). We do not report a measure of standardized effect size because, to our knowledge, such measures have not been well-developed for GEE.

We next sought to rule out the possibility that our results were driven by participants spending more time on the person-present scenes than the person-absent scenes, which in turn may have led to greater relational processing (see Goldstone & Medin, 1994). To analyze response times, we first log transformed the response time variable and used a linear GEE model with an exchangeable working correlation matrix where log transformed response time was predicted by whether the picture contained a person in it or not. We found that participants were quicker in responding to the pairs of pictures containing people than to the pictures without people (Study 1a: $b = 0.33$, $se = 0.05$, $Wald\ \chi^2(1) = 48.52$, $p < .001$; Study 1b: $b = 0.34$, $se = 0.05$, $Wald\ \chi^2(1) = 44.90$, $p < .001$). Moreover, the effect of condition on likelihood of making a relational match remained significant when adjusting for response time (Study 1a: $b = 1.11$, $se = 0.12$, $Wald\ \chi^2(1) = 79.77$, $p < .001$, $OR = 3.03$; Study 1b: $b = 0.91$, $se = 0.12$, $Wald\ \chi^2(1) = 60.06$, $p < .001$, $OR = 2.48$). These analyses suggest that our findings are not the result of differences between conditions on response times.

Additionally, while we did not find evidence that the presentation style manipulation (simultaneous vs. sequential) interacted with the presence vs. absence of a person in the pictures on likelihood of making a relational match in Study 1a ($b = 0.20$, $se = 0.12$, $Wald\ \chi^2(1) = 2.65$, $p = .10$), we did find evidence for a marginal interaction between the two variables in Study 1b ($b = 0.25$, $se = 0.13$, $Wald\ \chi^2(1) = 3.88$, $p = .05$). Most importantly, however, across both studies, the effect of having people present vs. absent in the scenes on relational reasoning remained robust and significant in both presentation style conditions (all $ps < .001$; see Table S2 in Supplemental Materials).

3. Study 2

In Studies 1a and 1b, we found that people were more likely to construe scenes in a relational manner when the scenes contained depictions of people within them than when they did not. Because each pair of scenes was unique from the others, one limitation of these studies is that the two types of scenes differed not only in the presence of a person but also in the relationships displayed in the scene (see Fig. 1). In our next study, we sought to address this potential confound by constructing new stimuli where each pair of scenes had two versions—a person-present and a person-absent version. The relationships depicted in each version were the same and we only varied whether one entity in each scene was a person or an inanimate object. Here again, we tested whether people would be more likely to establish correspondences based on common relational roles when those relations are centered around a human actor than when they are not.

3.1. Method

3.1.1. Participants

Three-hundred and seventy-three participants (48% female; $M_{age} = 36.09$; range 18–73 years) were recruited online through Amazon's Mechanical Turk. The sample size for this study was

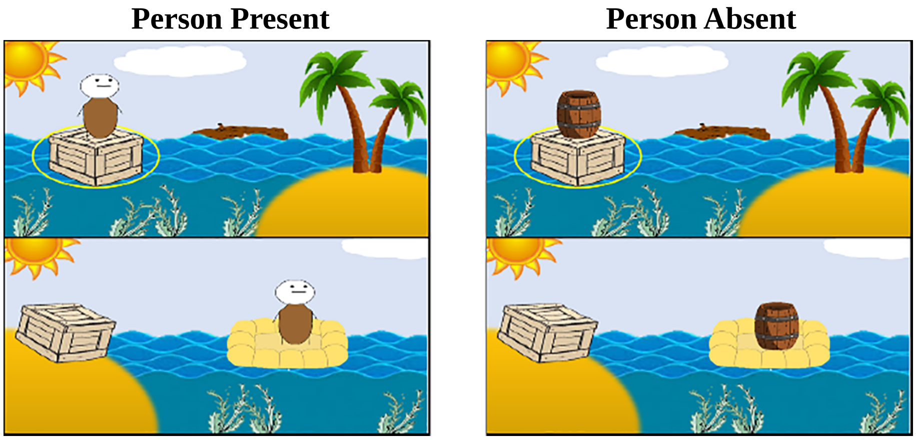

Fig. 3. Example of the two different versions of the scene pairs. The left panel shows an example of a scene containing a depiction of a person, while the right panel shows the version where the person was replaced with an inanimate object. As shown, the object to be mapped across scenes—the highlighted object in the top picture—was the same in both versions. Full stimuli for Study 2 can be found in supplemental materials.

determined to achieve approximately 80% power to detect an estimated small effect. The effect size was estimated based on a pilot test of the materials described below, and the power analysis was conducted using simulations that resampled the pilot data to construct bootstrapped samples of various sizes (ranging from 200 to 500) and identifying the sample size at which approximately 80% of tests were significant.

3.1.2. Procedure

The procedure for this study was similar to the previous two studies. After reading instructions explaining the picture mapping task, participants were presented with pairs of pictures one at a time. For each pair of pictures, the two scenes were presented simultaneously with one picture directly above the other. During the initial presentation phase, participants were given 10 s to study the pair of pictures. After the 10 s, the mapping phase began. Here an object in the top picture became highlighted and a question with a response box appeared below the two scenes that asked participants, "What in the bottom picture corresponds to the object that is highlighted in the top picture?" Participants were given as much time as they wanted during this phase to study the pair of pictures and to type their response into the response box. In total, participants saw four pairs of pictures. After completing this picture mapping task, participants then answered several demographic and debriefing questions.

3.1.3. Stimuli

The pairs of pictures used in this study modeled the underlying structure of those from the previous study. Each pair of scenes was designed to reasonably allow for either a relational or a perceptual mapping across the two pictures. Additionally, for each pair of pictures, we constructed two versions. One version contained a depiction of a person within the pictures, and the other version replaced that person with an inanimate object that was perceptually similar. Care was taken to try to match the perceptual appearance of the two versions (person present v. person absent) as closely as possible. Fig. 3 shows an example of these two different versions for one of the pairs of pictures. As can be seen in the right panel, the version without a person in it replaces the person with a barrel that occupies the same spatial position and has a similar visual appearance as the person in the left panel. Across the 4 pairs of pictures, we counterbalanced whether the object match or relational match was in the same spatial location (relative to the whole area of the scene) as the highlighted object. For two of the pairs, the object match appeared in the same location as the highlighted object; for the other two pairs the relational match appeared in the same location as the highlighted object. All of the stimuli used in this study can be found in the Supplemental Materials.

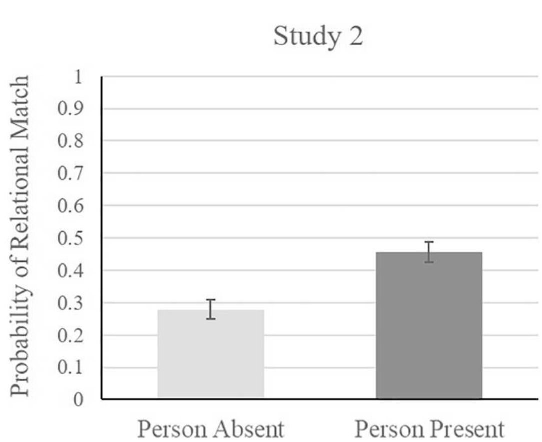

Fig. 4. Estimated probability of participants making a relational match for each version of scenes. Participants were more likely to make a relational match (vs. an object match) when the scene pair contained a depiction of a person within them than when they did not. Error bars represent one standard error above and below the mean.

3.1.4. Independent variable

The independent variable was whether participants saw the versions of the scene pairs that contained a depiction of a person or the versions that did not (see Fig. 3). This variable was manipulated between participants so that each participant either saw four pairs of scenes with people in them or four pairs of scenes that did not show any people.

3.1.5. Dependent variable

Our dependent measure was again whether participants provided a relational match or an object match as the object that corresponded to what was highlighted in the first picture. Participants' responses were coded in the same manner as in Studies 1a and 1b, making the final variable the likelihood that participants provided a relational match for a given pair of picture.

3.2. Results

Five participants were excluded from the main analyses for failing to provide any response that could be coded as either a relational or an object match. Overall, 14% of responses were left uncoded and the average number of analyzable responses provided by each participant was 3.45 (out of 4). Importantly, the likelihood of a response being left uncoded did not significantly differ as a function of whether it the scenes depicted a human or not (p = .19; see Table S1 in Supplemental Materials).

Since participants provided multiple responses (one for each scene pair), we again used GEE with an exchangeable working correlation matrix to fit a binary logistic regression while adjusting for the interdependence within participants' responses. Replicating the findings of Studies 1a and 1b, we found that participants were more likely to provide a relational match for pairs of scenes with a person in them (coded 1) than for scenes without (coded 0). As shown in Fig. 4, the estimated probability of providing a relational match for pictures with people in them was 46% compared to 28% for pictures without people ($b = 0.78$, $se = 0.19$, Wald $\chi^2(1) = 16.54$, $p < .001$, $OR = 2.18$).[2] We did not find a significant difference between conditions in how long it took participants to respond ($b = 0.02$, $se = 0.06$, Wald $\chi^2(1) = 0.11$, $p = .74$) and the effect of condition on likelihood of making a relational match remained significant when adjusting for response time ($b = 0.78$, $se = 0.19$, Wald $\chi^2(1) = 16.59$, $p < .001$, $OR = 2.18$). Thus, once again, our results are not attributable to differences between conditions in response times.

4. Study 3

Study 2 extended the findings of Studies 1a and 1b by showing that the presence (vs. absence) of a person in a scene promotes relational processing even when all other aspects of the scene are identical. This finding supports the idea that people are more likely to notice underlying relationships in a scene when those relationships involve a person than when they do not. However, one limitation of Study 2 is that, in each scene pair, the relational match was closer in physical proximity to the person (or the replacement object in the person-absent scenes) than was the object match. For instance, in the bottom panels of Fig. 2, the raft is closer to the person (or barrel) than is the wooden crate. Given that observers tend to direct their attention towards people in visual scenes (Buswell, 1935; Fletcher-Watson et al., 2008), they may be more likely to attend to nearby stimuli as well. A critic may therefore argue that participants' tendency to choose the relational match in the person-present scenes was driven by this attentional shift and increased processing of the stimuli directly proximal to the person, rather than by a conceptual shift towards relational construals.

In Study 3, we sought to address this limitation. We designed stimuli in which the relational match is farther from the person (or its inanimate replacement in the person-absent scenes) than is the object-based match. Fig. 5 shows an example of one of these stimuli. The relationship depicted in the top scene is a safe falling on either a person or a cactus. In the bottom scene, the relational match for the highlighted safe (the rock falling on the person/cactus) is farther away from the person/cactus than is the object match (the safe). Here, we predicted that people would be more likely to match the safe in the top picture with the rock in the bottom picture in the person-present version of the scenes than in the person-absent version. This finding would imply that the presence of a person in the picture promotes a deeper relational processing that goes beyond merely matching stimuli that are most proximal to the person shown.

4.1. Method

4.1.1. Participants

Four-hundred participants (39% female; $M_{age} = 34.79$; range 18–74 years) were recruited online through Amazon's Mechanical Turk. The sample size for this study was determined to achieve approximately 80% power to detect an estimated small effect. The effect size was estimated based on a pilot test of the stimuli used in this experiment, and the power analysis was conducted using simulations that resampled the pilot data to construct bootstrapped samples of various sizes (ranging from 200 to 500) and identifying the sample size at which approximately 80% of tests were significant.

4.1.2. Procedure

The procedure for this study was identical to that of Study 2, with the exception that new scene pairs were used in this study. The stimuli used in this study are shown in the supplemental materials. The independent variable was again whether participants saw scene pairs that contained a person within them or scene pairs that were identical but replaced the person with an inanimate object (manipulated between participants). The dependent variable was whether participants made a relational match or an object match for each scene pair.

4.2. Results

Ten participants were excluded from the main analyses for failing to provide any response that could be coded as either a relational or an object match. Overall, 14% of responses were left uncoded and the average number of analyzable responses provided by each participant was 3.44 (out of 4). Importantly, the likelihood of a response being left uncoded did not significantly differ as a function of whether the scenes depicted a human or not ($p = .18$; see Table S1 in Supplemental Materials).

To test whether participants made more relational matches in the human scene, we again used GEE with an exchangeable working correlation matrix to fit a binary logistic regression while adjusting for the interdependence within participants' responses, given that participants provided multiple responses (one for each scene pair). We again found that participants were more likely to provide a relational match for pairs of scenes with a person in them (coded 1) than for scenes without (coded 0). As shown in Fig. 6, the estimated probability of providing a relational match for pictures with people in them was 40% compared to 20% for pictures without people ($b = 0.95$, $se = 0.19$, Wald $\chi^2(1) = 24.91$, $p < .001$, $OR = 2.59$). As in Study 2, we did not find a significant difference between condition on how long it took participants to provide a response to the pair of pictures ($b = 0.02$, $se = 0.07$, Wald $\chi^2(1) = 0.09$, $p = .76$) and the effect of condition on likelihood of providing a relational match remained significant when adjusting for response time ($b = 0.98$, $se = 0.19$, Wald $\chi^2(1) = 25.81$, $p < .001$, $OR = 2.66$).

5. Study 4

Our central thesis in this paper has been that human cognition displays a general tendency towards person-centric processing. Supporting this hypothesis, we have shown that people become more likely to construe objects in terms of their relational roles (as opposed to their object-level identities) when those relationships involve another person than when they involve other inanimate objects. A critic may question whether our effects are truly unique to other people. To be clear, our claim is not that other people are unique in evoking relational processing—perhaps the presence of any animate or agentic being in a scene would also promote relational reasoning relative to the presence of an inanimate object. Instead, we argue that other people are unique in their *centrality* in relational processing—or in other words, in their primacy in mental representation.

While our findings so far support our account of person-centric cognition, they do not yet demonstrate that other people are unique in their primacy. We have not ruled out the alternative possibility that observers are equally likely to structure their mental representations of the external world around any animate or agentic entity that has the capacity to interact with the external environment—an interesting possibility in its own right.

Thus, in Study 4, we sought to test whether other people occupy a

[2] The overall percentage of relational matches in Studies 2–4 (Study 2: 37%; Study 3: 30%; Study 4: 39%) is lower than that of Studies 1a and 1b (49% across the two studies) and lower than what has been reported in previous research using the same stimuli as Studies 1a and 1b (percentages ranging from 40% to 70%; e.g., Markman & Gentner, 1993; Tohill & Holyoak, 2000; Vendetti et al., 2014). We suspect that these differences are attributable to differences in the stimuli used. Studies 1a and 1b use a subsample of scenes that have been used in previous research, and thus have a relational match rate that falls within the typical range of previous findings. Studies 2–4 use novel scenes developed specifically for the present research. These scenes may have unique qualities that lead to differential rates of relational responding relative to previous research. Exploring these differences may be an interesting avenue for future research.

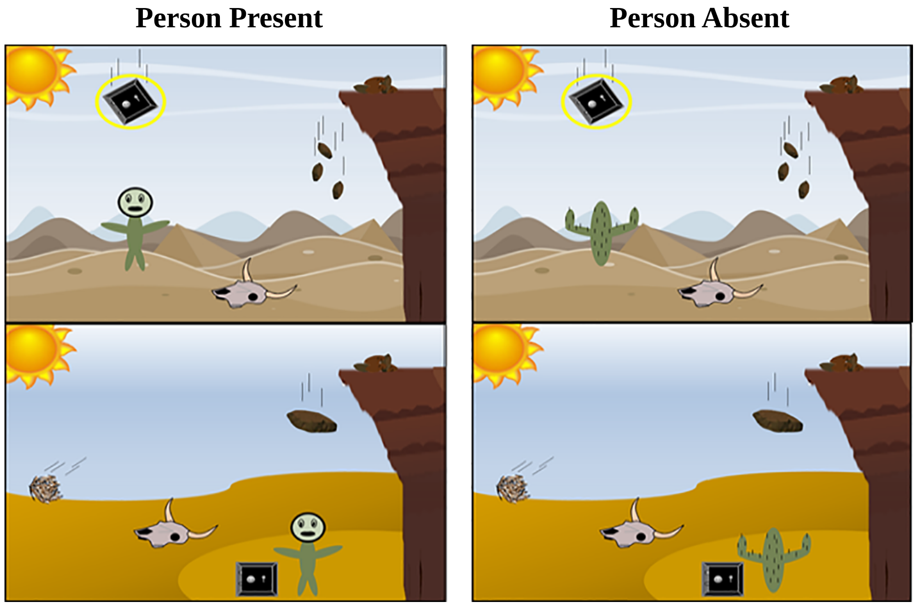

Fig. 5. Example of the two different versions of the scene pairs. The left panel shows an example of a scene containing a depiction of a person, while the right panel shows the version where the person was replaced with an inanimate object. In this set of stimuli, the relational match (here, the rock) was always located farther away from the person (or its replacement—the cactus) than the object match (here, the safe). Full stimuli for Study 3 can be found in supplemental materials.

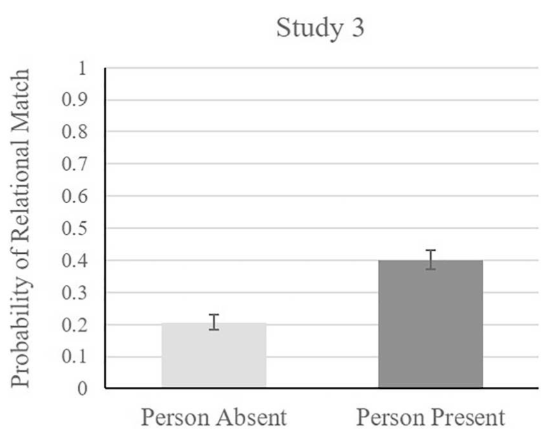

Fig. 6. Estimated probability of participants making a relational match for each version of scenes. Participants were more likely to make a relational match (vs. an object match) when the scene pair contained a depiction of a person within them than when they did not. Error bars represent one standard error above and below the mean.

position of primacy in mental representation relative to other non-human agents such as animals. One way to test whether other people are unique in their primacy is by testing whether people will preferentially structure their mental representations around other people even when other animals are present. If other people are unique in their primacy, then animals should be subordinated in mental representation and construed in terms of their relationship to a focal person. If other people are no more primary than animals, then observers should be equally likely to construe a person in terms of her relationship to an animal as they are to construe an animal in terms of its relationship to a person.

To test this, we constructed new stimuli that were designed to assess how people would mentally represent scenes that contain both people and animals. As exemplified in Fig. 7, we created two versions of each scene pair. In the person-centric version, shown in the left panel of Fig. 7, the relationship that is common across each scene centers around a human (e.g., a person being pulled by something) and an animal is highlighted as the object to be matched across scenes (e.g., the horse that is doing the pulling). In the animal-centric version, shown in the right panel of Fig. 7, the common relationship centers around an animal (e.g., a horse being pulled by something) and a human is the object to be matched across scenes. In both versions, making a relational match involves subordinating the object-level identity of the highlighted object to the role it occupies in relation to another agent (e.g., seeing the horse primarily as something that pulls the human or seeing the human primarily as something that pulls the horse). On the other hand, object level matches suggest that the highlighted object is represented as a focal object.

We predicted that people would be more likely to make a relational match for the person-centric version of the scenes than the animal-centric version. For instance, in person-centered scenes in which a horse or car pull a person (Fig. 7a), observers would match the horse with the car—a relational match that centers the person as the primary element of the scene. This would indicate that people are more inclined to subordinate animals to the role they occupy in relation to humans than the other way around (i.e., subordinate humans to the role they occupy in relation to animals). On the other hand, we expected people to be more likely to make object matches for animal-centric scene pairs where the person was highlighted. This would suggest that people processed the person as the focal object in both scenes and did not construe the person as substitutable with another entity that occupied a similar role. For instance, in animal-centered scenes in which in which a person or car pulls a horse (Fig. 7b), participants would match the person in one scene with the same person in the other scene—an "object-match" that again centers the person as the primary element of the scene. In short, we hypothesized that people would construe animals in terms of their relationships to humans in a scene but would be less likely to construe humans in terms of their relationships to animals in a scene.

5.1. Method

5.1.1. Participants

Four-hundred and four participants (42% female; $M_{age} = 35.97$; range 18–81 years) were recruited online through Amazon's Mechanical Turk. The sample size for this study was determined to achieve approximately 80% power to detect an estimated small effect. The effect size was estimated based on a pilot test of the stimuli used in this experiment, and the power analysis was conducted using simulations that resampled the pilot data to construct bootstrapped samples of various sizes (ranging from 200 to 500) and identifying the sample size at which approximately 80% of tests were significant.

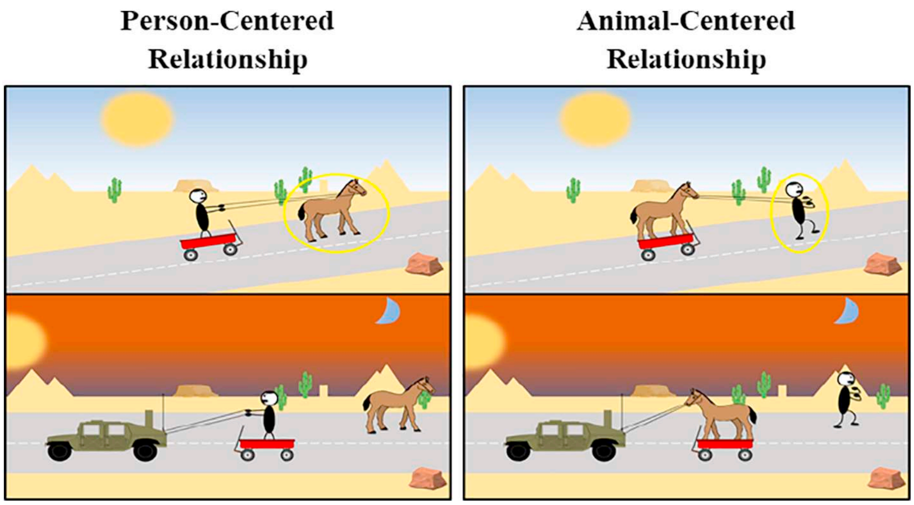

Fig. 7. Example of the two different versions of the scene pairs. The left panel shows an example of a scene pair where the relationship depicted in each scene revolves around a person. The right panel shows the version where the relationship in each revolves around an animal. As shown, The relationship depicted in each scene pair is the same, but the roles of the person and animal are switched. Full stimuli for Study 4 can be found in supplemental materials.

5.1.2. Procedure

The procedure for this study was identical to that of Studies 2 and 3, with the exception that new scene pairs were used in this study. In this study, participants saw two pairs of pictures and the order of presentation was randomized across participants.

5.1.3. Stimuli

As in the previous studies, the stimuli were designed so that each scene pair contained a plausible relational match and a plausible object match across the two pictures. For each scene pair, we constructed two versions: one where the relationship depicted in the two scenes involved the same human and one where the relationship depicted in the two scenes involved the same animal. These two versions of the stimuli correspond to our two conditions: the person-centered relationship condition and the animal-centered relationship condition. The left panel of Fig. 7 shows an example of the person-centered version of the stimuli. Here, the top scene shows a person on a wagon being pulled by a horse and the bottom scene shows that same person being pulled by a vehicle while the previously shown horse is off to the side. The right panel of Fig. 7 shows an example of the animal-centered version of the stimuli. In this version, the top scene shows a horse on a wagon being pulled by a person and the bottom scene shows that same horse being pulled by a vehicle while the person is shown off to the side. All stimuli used in this study can be found in the Supplemental Materials.

As can be seen in Fig. 7, the person-centered and animal-centered versions of the scenes are identical except that the roles of the person and the animal are switched across the two scenes. In the person-centered version of the stimuli, the animal in the top scene is highlighted and participants are asked to identify the object in the bottom scene that corresponds with the animal. In the animal-centered version, the person in the top scene is highlighted and participants are asked to identify the object in the bottom scene that corresponds with the human.

5.1.4. Independent variable

The independent variable was whether participants saw the person-centered version of the stimuli or the animal-centered version of the stimuli (see Fig. 7). This variable was manipulated between participants.

5.1.5. Dependent variable

Our dependent measure was whether participants provided a relational match or an object match to the highlighted object in the top picture. Conceptually, this can be thought of as whether participants subordinated the object-level identity of the highlighted object to the relationship to central figure.

5.2. Results

Nineteen participants were excluded from the main analyses for failing to provide any response that could be coded as either a relational or an object match. Overall, 8% of responses were left uncoded and the average number of analyzable responses provided by each participant was 1.83 (out of 2). Unlike the previous studies, there was a significant effect of condition such that participants in the person-centered condition were more likely to provide a codeable response (94%) than participants in the animal-centered condition (89%) ($b = 0.63$, $se = 0.32$, *Wald* $\chi^2(1) = 3.94$, $p = .05$; see Table S1 in Supplemental Materials).

Since participants provided multiple responses (one for each scene pair), we again used GEE with an exchangeable working correlation matrix to fit a binary logistic regression while adjusting for the interdependence within participants' responses. We found that participants were more likely to provide a relational match for person-centered pairs of scenes (coded 1) than for the animal-centered pairs of scenes (coded 0). As shown in Fig. 8, the estimated probability of providing a relational match when the relationship in each scene revolved around the same person 46% compared to 31% for when the relationship in each scene revolved around the same animal ($b = 0.65$, $se = 0.20$, *Wald* $\chi^2(1) = 10.61$, $p = .001$, $OR = 1.92$). There was also significant effect of condition on how long it took participants to respond to each question such that participants in the person-centered condition were faster to respond than participants in the animal-centered condition ($M_{person\text{-}centered} = 23.66$ s v. $M_{animal\text{-}centered} = 26.87$ s), ($b = 0.16$, $se = 0.07$, *Wald* $\chi^2(1) = 5.13$, $p = .02$). Importantly, the effect of condition on likelihood of making a relational match remained significant when adjusting for response time ($b = 0.62$, $se = 0.20$, *Wald* $\chi^2(1) = 9.71$, $p = .002$, $OR = 1.86$). Once again, these analyses suggest that our results cannot be attributed to participants spending longer on the person-centered scenes.

6. General discussion

Across four studies, we found that people were more likely to process visual scenes in terms of their underlying relational structure when that structure involved another person than when it involved only non-human objects. That is, umbrellas and newspapers were construed as equivalent rain-protectors when they served to keep a person dry. We argue that this reflects a tendency for person-centric construals in making sense of the external world.

In a fifth study, we found that other people are primary in mental representation relative to other animate entities like animals: people were more likely to construe animals in terms of their relation to a

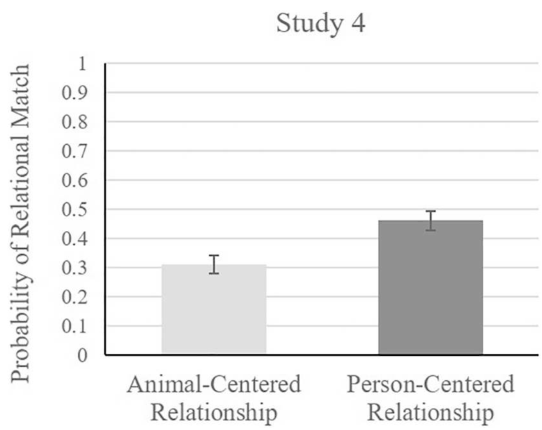

Fig. 8. Estimated probability of participants making a relational match for each version of scenes. Participants were more likely to make a relational match (vs. an object match) when the relational mapping was centered around a person than when the relational mapping was centered around an animal. Error bars represent one standard error above and below the mean.

central person in a scene than they were to construe people in terms of their relation to animals. Taken together, this research supports the assertion that when people are present in a visual scene, their primacy in mental representation prompts observers to construe the rest of the environment in terms of how its features interact with a focal actor.

6.1. Functionality of person-centered cognition for learning and self-regulation

We posit that structuring one's mental representation of scenes around how another person interacts with various objects may provide a useful guide for organizing the external world. This is the case for two reasons.

First, person-centric processing results in cognition that represents the world according to how it can or should be interacted with. Functionalist theories of cognition have long posited that the goal of cognition is to figure out how to act and self-regulate—that "*thinking is for doing*" (e.g., Fiske, 1992; James, 1890/1983). If cognition does indeed function to plan and execute action, then other people would be particularly important figures in cognition. They are unique in their capacity to orient us to affordances and obstacles present in the external environment as well as potential ways of interacting with them. For example, an ordinary piece of driftwood becomes a life saver when it is observed in the same scene as an overboard sailor. In this way, the presence of others imbues the non-social world with meaning by leading observers to subordinate the distinctive features of various objects to their relationship with human actors. Thus, rather than "carving nature at its joints", the research reported here suggests the possibility that many of our internally held representations carve nature according to how it relates to humans (see also Greene, Baldassano, Esteva, Beck, & Fei-Fei, 2016; Kemler-Nelson, 1995; Nelson, 1974).

Second, person-centric cognition may operate as a major learning scaffold that helps people develop abstract relational schemas. It does so by providing a common conceptual anchor—humans—for mental representations of various objects and events. Having a common conceptual orientation to mental representations of diverse objects and events enables people to more easily compare them to each other and search for similarities and differences. Such comparison is a primary mechanism by which people develop abstract concepts. It initiates a process of structural alignment between distinct representations that elucidates higher-level commonalities between them, such as a common relational structure (Christie & Gentner, 2010; Gentner & Namy, 1999; Markman & Gentner, 1993). Thus, by providing a common conceptual orientation to distinct mental representations, person-centric cognition facilitates comparison and structural alignment, which in turn facilitates the discovery of abstract relational schemas.

Moreover, while any common object in distinct scenes or events could invite comparison and promote relational learning (Gentner, Ratterman, & Forbus, 1993; Ross, 1989), other people are uniquely functional as primary figures in mental representation due to their omnipresence in one's external environment and motivational relevance throughout development and daily life (see Atzil, Gao, Fradkin, & Barrett, 2018). Individuals are afforded a great number of opportunities to compare various person-centric mental representations. As people gain more and more experience comparing person-centric representations, they will develop deeper, more basic, and more systematic representations of relational structures that involve humans. And as these relational representations become more elaborated and accessible, they become easier to apply to novel circumstances.

Overall, we posit that the tendency for people to engage in relational reasoning about events involving other people is an adaptive feature of human cognition. It provides individuals with a knowledge base of relational representations that structure one's surroundings in terms of how to interact with it. These abstract representations are useful for understanding the external world and for guiding behavior as we navigate its variable conditions.

6.2. Mechanisms of person-centric cognition

The primary goal of this research is to document a person-centric bias in cognitive representation. We hypothesized that this person-centric processing bias would lead people to engage in more relational reasoning when presented with scenes that involved another person. Why does the presence of another person in a visual scene promote relational reasoning? In this section, we outline a few possible mechanisms for future research to explore.

First, people generally see other humans as motivationally relevant (Jones, 1990), and this motivational relevance may lead observers to structure their mental representations of the external world around people. If so, then any object that is as motivationally relevant may also assume centrality in mental representation and prompt relational reasoning. For example, a brand-new car may lead its owner to see a baseball and a rock as posing an equivalent danger to the car's windshield. However, even if motivational relevance is a major driver of the effect, other people may still be unique in the extent and primacy of their motivational relevance. There are few, if any, other targets that would be so relevant across as many situations as other people.

Second, people readily take the "intentional stance" when other humans are present, perceiving others' actions in terms of goals, beliefs, and intentions (Dennett, 1989; Malle & Holbrook, 2012; Rosset, 2008). For instance, people show spontaneous activity in neural regions linked to mental state inference when simply viewing social scenes (Wagner, Kelly, & Heatherton, 2011). Taking the intentional stance may, in turn, promote abstract construal of objects for two reasons. First, the intentional stance corresponds to an abstract mindset focused on why people take actions as opposed to how people take actions (Vallacher & Wegner, 1987). Indeed, people show overlapping neural activity when making abstract attributions about social or non-social scenes (Spunt & Adolphs, 2015). Second, when people represent another's goals, they may be more likely to represent how the environment interacts with those goals—like a tree that poses a danger to a skier's presumed goal of descending safely. Thus, taking the intentional stance might prompt other abstract construals or focus people on environmental affordances relative to an actor.

A third possibility is that the presence of people increases relational mappings across scenes because relations involving people are more familiar and accessible than relations that do not. For example, the relation "life saver" is one that is usually represented in relation to people. Because observers may have greater familiarity and more elaborated representations of relational concepts that involve humans, they may be more likely to draw on such abstract representations when processing social scenes. As previously discussed, the acquisition and use of abstract relational structures that are widely applicable may be a highly adaptive feature of person-centric cognition.

All-in-all, multiple mechanisms may contribute to the effects identified in the present research. And while it may be possible to promote relational reasoning through any one of these mechanisms without invoking another person in the scene, we argue that other people are unique in their propensity to engage all of these mechanisms chronically. Still, gaining conceptual clarity into the processes highlighted here will be an interesting avenue for future research.

6.3. Conclusion

The research reported here contributes to a broad theoretical perspective arguing that there is a fundamental link between abstract relational reasoning and social learning (see also Christie, 2017; Gentner, 2003; Hackel, Mende-Siedlecki, & Amodio, 2019; Kalkstein, Hubbard, & Trope, 2018b; Kalkstein, Kleiman, Wakslak, Liberman, & Trope, 2016). On one hand, relational reasoning enables social learning: by seeing ourselves and other people as interchangeable agents occupying similar roles, we can transfer lessons learned from others to ourselves. On the other hand, the research and theorizing here suggests that social observation promotes relational reasoning, which may facilitate the development of abstract relational schemas. Supporting this perspective, we showed that when another person is present in a visual scene, people tend to construct representations of that scene that focus on the relationships between that individual and the various elements of the environment. Overall, person-centric cognition may be an adaptive tendency that functions to help people represent the world in a way that is subsequently useful for guiding their own behavior.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesp.2020.104009.

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