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Infants' prosocial behavior is governed by cost-benefit analyses

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ABSTRACT

Cost-benefit analyses are central to mature decision-making and behavior across a range of contexts. Given debates regarding the nature of infants' prosociality, we investigated whether 18-month-old infants' (N = 160) prosocial behavior is impacted by anticipated costs and benefits. Infants participated in a helping task in which they could carry either a heavy or light block across a room to help an experimenter. Infants' helping behavior was attenuated when the anticipated physical costs were high versus low (Experiment 1), and high-cost helping was enhanced under conditions of increased intrinsic motivational benefits (Experiments 2 and 3). High-cost helping was further predicted by infants' months of walking experience, presumably because carrying a heavy block across a room is more effortful for less experienced walkers than for more experienced walkers demonstrating that infants subjectively calibrate costs. Thus, infants' prosocial responding may be guided by a rational decision-making process that weighs and integrates costs and benefits.

1. Introduction

Cost-benefit calculations are central to decision making: humans and animals consider not only the rewards associated with obtaining a particular outcome but also the costs required to achieve an outcome when selecting amongst alternatives (Bautista, Tinbergen, & Kacelnik, 2001; Croxson, Walton, O'Reilly, Behrens, & Rushworth, 2009; Kool, McGuire, Rosen, & Botvinick, 2010; Walton, Kennerley, Bannerman, Phillips, & Rushworth, 2006). Indeed, such calculations are so ubiquitous that some scholars have recently suggested that cost-benefit calculations not only guide individual choices and actions but may also form the basis for the inferences and evaluations that we make about other people and their behavior (Jara-Ettinger, Schulz, & Tenenbaum, in press). Strikingly, however, little is known regarding when, in the course of human ontogeny, the ability to compute costs and benefits, and integrate them to make decisions, first arises.

We investigated whether infants use cost-benefit calculations to guide their prosocial behavior. Prosocial behavior, such as helping individuals in need (Warneken & Tomasello, 2006), sharing objects with others (Brownell, Svetlova, & Nichols, 2009), and comforting those in distress (Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992), is present and prolific by the end of the second year of life. Yet, there is ongoing debate regarding the degree and nature of selectivity in infants' prosocial responding (Burns & Sommerville, 2014; Hay & Cook, 2007; Kuhlmeier, Dunfield, & O'Neill, 2014; Warneken & Tomasello, 2009; see Martin & Olson, 2015). One means of informing this debate is to investigate the impact of the costs associated with producing a prosocial response, and the impact of the benefits that coincide with acting prosocially, on infants' behavior.

Empirical work on the impact of costs on children's prosocial behavior has yielded mixed results. Some experiments have found that increasing personal costs diminishes prosocial behavior in children; for example, 2.5-year-old children are less likely to give up one of their own toys to help another individual than to give up someone else's toy (Svetlova, Nichols, & Brownell, 2010). Other research demonstrates that personal costs have no impact on prosocial responding: 4-year-old children are equally likely to help an adult retrieve a reward from a novel box when there is no cost to the self versus when choosing to help could lead to fewer rewards (i.e., jellybeans) for the self (Nielsen, Gigante, & Collier-Baker, 2014). Additionally, and critically, the impact of costs on prosocial behavior earlier in life, in the course of infancy, has been relatively unexplored.

We investigated the impact of physical or energetic costs, on infants' prosocial behavior in the context of an instrumental helping paradigm. Given the evolutionary importance of conserving energetic resources, physical or energetic costs may be one of the first costs that infants or young children are capable of recognizing or reasoning about. Considerable work has demonstrated that infants apply a principle of

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efficiency (which may or may not encompass notions of effort per se) to their expectations of others' actions (e.g., Biro, 2013; Gergely, Nádasdy, Csibra, & Bíró, 1995; Skerry, Carey, & Spelke, 2013), expecting agents to take the most efficient path to their goals and to minimize the costs of their actions (Liu & Spelke, 2017). Yet, little work has investigated whether or how infants use effort to guide their own actions, and, in particular their prosocial responses. In Warneken, Hare, Melis, Hanus, and Tomasello (2007), children who had helped in a previous experiment continued to help in a follow-up study where they had to navigate obstacles in their path to help another person, showing that children help when costs are raised. However, no prior study has directly compared low- and high-cost helping situations that allow us to quantify/assess the effect of cost on helping rates.

In addition to assessing the impact of physical costs on infants' helping behavior we also investigated whether infants' helping behavior was facilitated by motivational benefits associated with helping. Existing work has demonstrated that when there are concrete or explicit rewards associated with helping behavior – such as when infants receive praise, encouragement or material rewards (Warneken & Tomasello, 2013, 2014; Warneken et al., 2007) – helping behavior is unaffected or may even decrease. While these findings demonstrate that increasing *extrinsic motivation* does not facilitate helping behavior, it remains possible that factors that increase *intrinsic motivation* to produce a given response may lead to increased rates of helping behavior. Indeed, recent studies indicate that various interventions can increase infants' or children's intrinsic motivation to prosocially respond to others (Barragan & Dweck, 2014; Carpenter, Uebel, & Tomasello, 2013; Hepach, Vaish, & Tomasello, 2017; Over & Carpenter, 2009). Evidence suggests that infants are intrinsically motivated to interact with individuals that share ingroup characteristics over those that demonstrate outgroup characteristics (such as those that speak their native language; Kinzler, Dupoux, & Spelke, 2007). An intrinsic motivation to interact with ingroup over outgroup members may exist because interacting with ingroup members has functional consequences for development, including spurring social and cultural learning. Thus, we tested the impact of a subtle but important marker of ingroup versus outgroup status – shared toy preferences – on infants' prosocial responding. Critically, irrespective of whether shared preferences serve as an ingroup/outgroup marker, per se, evidence suggests that infants are more motivated to interact with those that share versus oppose their preferences.

Experiment 1 investigated whether infants' helping behavior was affected by physical costs by contrasting conditions that required high versus low physical effort: infants could choose whether or not to carry a heavy block (high effort condition) or a light block (low effort condition) across a room to help a recipient. Experiment 2 investigated whether infants' willingness to engage in high effort prosocial behavior was affected by whether the experimenter shared or opposed infants' toy preferences; Experiment 3 provided a direct replication of Experiment 2 in order to provide a highly-powered sample to investigate condition differences as well as how these behaviors play out over time. Across all experiments we measured infants' months of walking experience via parent-report. Personal costs are not only defined by objective situational characteristics (such as the weight of the block that infants carry) but also by subjective characteristics that influence the degree of effort required by individual infants to produce a particular response, such as degree of walking experience. Although all infants in our sample were experienced walkers, infants varied in their amount of walking experience which in turn could influence the degree of effort required to carry a block across a room particularly when it is heavy; carrying a heavy block is more challenging for a less versus more experienced walker. Thus, we predicted that walking experience would predict infants' helping behavior either uniquely or more strongly under conditions of high physical costs and/or reduced interpersonal benefits.

2. Materials and methods

2.1. Participants

Forty-eight 18-month-old infants (27 girls; $M = 17$ months, 28 days; range = 17 months, 15 days to 18 months, 18 days) participated in the experiment. The sample size ($n = 24$/condition; $N = 48$) was decided a priori based on similar paradigms with same age infants; the stopping rule involved cessation of data collection at $n = 24$ usable infants per condition. An additional 3 infants were tested but excluded from subsequent analyses because they did not complete the test phase of the experiment due to becoming fussy and crying ($n = 1$), or because English was not their native language ($n = 2$). Infants were recruited from a university-maintained database at a large university in the Pacific Northwest. According to parent report, 38 infants were Caucasian, 9 infants were of mixed race/ethnicity, and 1 infant was Black/African American.

Infants were randomly assigned to the low effort condition ($N = 24$; 14 girls, $M = 17$ months, 28 days) or the high effort condition ($N = 24$; 13 girls, $M = 17$ months, 28 days).

2.2. Set-up and materials

Infants were tested in a room measuring roughly 4.4 m wide by 3.4 m long. Two black blankets (roughly 125 cm by 125 cm) were placed at opposite sides of the room, 2.34 m apart; for each blanket an outer edge was aligned with the room wall. During the familiarization phase, infants and parents began the procedure on one blanket (henceforth the familiarization blanket). During the test phase the experimenter moved to the second blanket (henceforth the test blanket).

The warm-up toys consistent of 3 typical size bath toys: a plastic penguin and two different colored plastic fish. During the familiarization phase, the experimenter used 5 vinyl blocks, each a different color (green, red, purple, yellow and orange; all 14 cm by 14 cm by 14 cm). One of these blocks was unaltered and of typical weight (139 g; henceforth the light block). The remaining 4 blocks were surreptitiously weighted by opening two sides of the block, inserting a round fishing weight (each a different weight) and re-stitching the block, in order to create 4 blocks of increasing weight: 1970 g, 2220 g, 2470 g and 2720 g. The experimenter also used a transparent container (16.5 cm high by 31 cm wide, by 27 cm deep) as a receptacle to encourage infants to lift each block and place it into the bin. A multi-colored, opaque striped bin (32 cm high by 31 cm wide by 31 cm deep) was used during the test phase in order to occlude the target block from the primary experimenter's view.

2.3. Procedure

Fig. 1.

2.3.1. Warm-up

During the warm-up the primary experimenter presented infants with 3 plastic bath toys and spent roughly 1 min drawing infants' attention to the toys and commenting on them. The purpose of the warm-up phase was to acclimate infants to the test room. During the warm-up infants sat on the caregiver's lap while the primary experimenter interacted with the infant.

2.3.2. Familiarization phase

The purpose of the familiarization phase was to ensure that infants had the opportunity to learn the weight of each block, and also to determine the heaviest block each infant was capable of lifting. The familiarization phase was identical in both the high and low effort conditions.

During familiarization, infants sat on the familiarization blanket between their caregiver's legs. The experimenter sat on the same

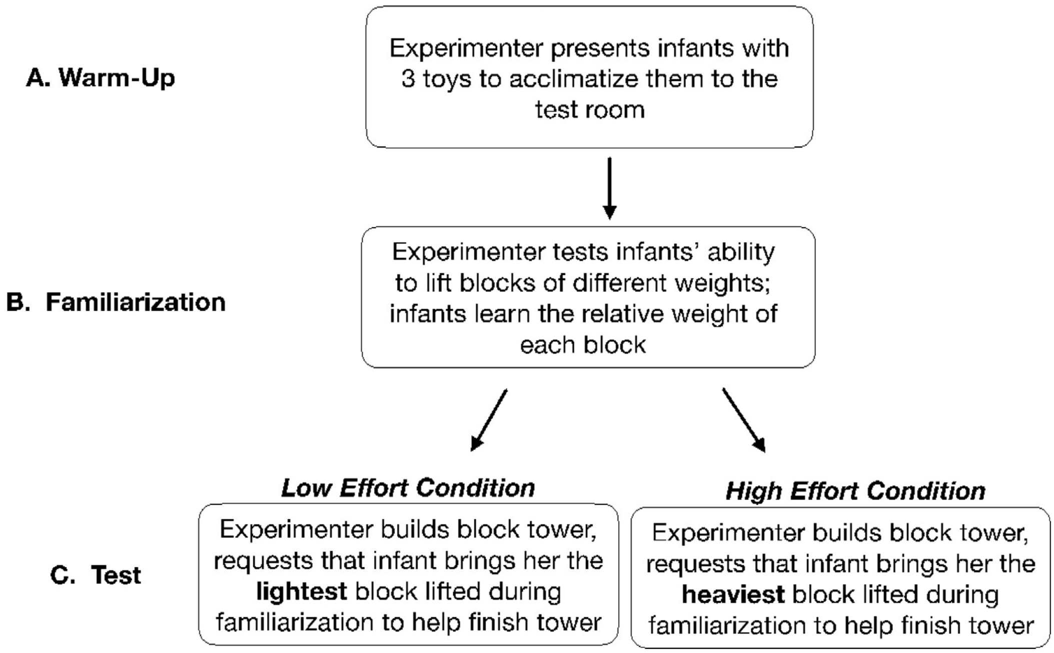

Fig. 1. Schematic of the procedure used in Experiment 1. Note that across both conditions, experimenters are blind to condition: the experimenter does not know whether infants are trying to bring them the heavy (High Effort Condition) or light block (Low Effort Condition).

blanket in front of the infant and parent. The experimenter presented a block and demonstrated lifting the block and placing it into a clear plastic bin twice. Then, the experimenter placed the block on the blanket in front of the infant and encouraged the infant to lift the block into the bin. If the infant did not reproduce the experimenter's actions, the experimenter repeated her request to place the object in the bin, and (if necessary) modeled placing the block into the bin again. The experimenter continued with this procedure for each block, one at a time, in order of increasing weight of the blocks. The familiarization period stopped after either, a) infants succeeded in lifting the heaviest block (2720 g) and placing it into the bin, or b) infants failed to lift (i.e., grabbed the block and tried to hoist it off the ground but failed to do so) a block of a given weight after being asked at least three times by the experimenter. The secondary experimenter recorded the heaviest block that the infant was able to lift during the familiarization phase.

2.3.3. Test phase

Following completion of the familiarization phase the primary experimenter got up and walked over to the test blanket and sat down beside a set of blocks similar to those used during training. In the meantime, the secondary experimenter approached the familiarization blanket and proceeded to clean up the familiarization blocks, by placing them into the transparent bin, while saying, "It's time to put the blocks back in the basket. I am going to clean up. It's important to put all the toys away." In the course of placing the blocks into the transparent bin, the secondary experimenter appeared to inadvertently push away the target block, such that it sat behind the striped bin, well within the infants' line of sight but out of the primary experimenter's line of sight. This ensured that the primary experimenter was unaware of which condition the infant took part in because she was unaware of which block was the target block.

For infants in the low effort condition, the lightest block (139 g) was the target block; for infants in the high effort condition the heaviest block that the infant was capable of lifting during the familiarization phase was the target block. We scaled block weight to the heaviest block that infants were capable of lifting for two reasons. First, given individual variability in strength, past work has scaled weight to the capabilities of the lifter (Proffitt, Stefanucci, Banton, & Epstein, 2003). Second, we wanted to ensure that infants were actually capable of lifting the block that they were required to bring across the room in the test phase to ensure that any differences between conditions arose from differences in associated effort, rather than sheer ability. For the majority of infants in the high effort condition the target block was the heaviest block (2720 g, $n = 15$). Of the remaining infants in the high effort condition, for 2 infants the 2470 g block was the target block, for 3 infants the 2220 g block was the target block, and for 4 infants the 1970 g block was the target block. By comparison, for infants in the low effort condition the heaviest block lifted was the 2720 g block for 15 infants, the 2470 g block for 3 infants, the 2220 g block for 1 infant, and the 1970 g block for 5 infants. Thus, the number of infants lifting the heaviest block during familiarization was identical across conditions, and each of the remaining blocks were lifted at similar frequencies across conditions. The median maximum block weight was identical across conditions: 2220 g.

After the blocks were picked up and the target block pushed behind the bin, the secondary experimenter removed the transparent bin with the other blocks. At this point, the primary experimenter, now seated on the test blanket, began stacking the blocks into a tower formation while narrating her actions, saying, "I am going to use the blocks to make a tower. These blocks will go on the bottom (while building the base of the tower). These blocks will go in the middle (while building the middle portion of the tower). Oh no, I am missing the block to complete the tower! (Primary experimenter holds the tower, so it looks like it may fall without the needed block.) Oh, there it is, baby. The block was left on your blanket (points in direction of the striped container that is occluding the target block). Can you bring me that block, so I can finish my tower?"

At this point the secondary experimenter tapped the caregiver on the shoulder, as a cue to release the infant. The primary experimenter continued to issue a series of requests, at 10-s intervals; these requests continued to occur until the infant brought the experimenter the block or until the experimenter had provided 5 requests and 1 min had elapsed. During the requests the experimenter alternated between saying, "(Baby's name), can you bring me the block?" and "Could you bring me the block, so I can finish my tower?" while sitting in the exact same location on the test blanket. Prior to the fifth and final request, the experimenter walked toward the familiarization blanket and sat down approximately 1.5 m from the baby and parent and produced the final request.

2.3.4. Walking experience

Parents were asked how long their infant had been walking, directly prior to the experimental session. The primary experimenter recorded infants' walking experience (in months and weeks).

2.4. Coding and Reliability

The key dependent variable was whether or not the infant brought the block to the experimenter during the test phase online (*block retrieval*). A primary coder, unaware of the secondary experimenter's codes, coded infants' block retrievals from videotape. A secondary coder, unaware of both the secondary experimenter and primary experimenter's codes, coded infants' block retrievals from videotape for 50% of the sample (12 infants from each condition). All three coders agreed on 100% of trials.

To ensure that infants understood the experimenter's request and understood it to refer to the block, we coded the proportion of infants that visually referenced the block (*block reference*) in response to the experimenter's request: a primary coder coded all infants, and a secondary coder, unaware of the primary coder's responses, coded 50% of the sample. Reliability between the primary and secondary coder was 100%.

Because we were interested in whether infants' block retrievals varied as a function of the *anticipated* effort associated with carrying the block across the room, and not because they tried to carry the block and gave up or failed, we coded *aborted block retrievals* (instances in which the infant lifted the block and started to move toward the experimenter but then stopped and put the block down) for infants who did not ultimately retrieve the block. A primary coder coded aborted block retrievals from videotape; a secondary coder, unaware of the primary coder's code, coded aborted block retrievals for 50% of the sample (12 infants from each condition). Reliability between the primary and secondary coder was 100%.

3. Results

3.1. Test phase

3.1.1. Block retrievals

Our primary hypothesis was that infants in the high effort condition would be less likely to bring the block to the experimenter than infants in the low effort condition. A chi-square test of independence revealed a significant association between condition and infants' block retrievals, X^2 (1, N = 48) = 4.09, p = .043, ø = .29. Whereas 67% (SE = 9.0) of infants in the low effort condition brought the block to experimenter only 38% (SE = 10.1) of infants in the high effort condition brought the block to the experimenter (see Fig. 2).

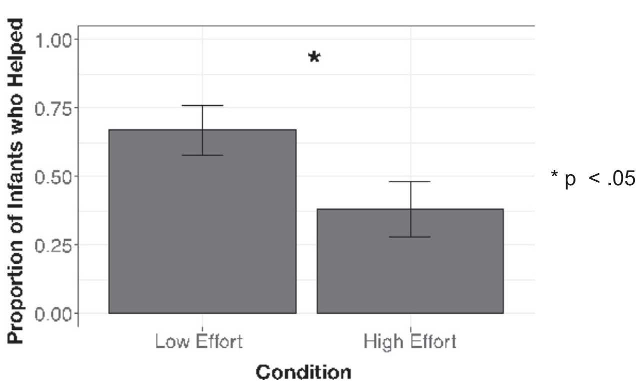

Fig. 2. Proportion of infants who helped as a function of high versus low effort (Experiment 1).

3.1.2. Block references

The majority of infants in both conditions (92% of infants in the high effort condition and 92% of infants in the low effort condition) visually referenced the block in response to the experimenter's request suggesting that infants recognized that her request referred to the block.

3.1.3. Aborted block retrievals

Only 1 infant (in the high effort condition) produced an aborted block retrieval. This suggests that infants' responses in the high effort condition were primarily a function of the *anticipated* effort associated with carrying the block across the room.

3.1.4. Walking experience

Our secondary hypothesis was that, because walking experience contributes to the relative ease or difficulty of carrying heavy loads, parent-reported walking experience would uniquely or more strongly predict infants' block retrievals in the high effort condition than in the low effort condition. On average, parents reported that infants had been walking for 6.0 months (SE = .32; range = 1.0 to 10.0 months); reported walking experience did not differ as a function of condition; low effort condition M = 6.44, SE = .34, high effort condition M = 5.56 months, SE = .52; p = .17. Separate binary logistic regression analyses were conducted on the low effort condition and the high effort condition to determine whether parent-reported walking experience predicted infants' block retrievals. Walking experience significantly predicted infants' block retrievals in the high effort condition, OR = 2.12, p = .016, (95% CI 1.15–3.90), indicating that each additional month of walking experience was associated with twice the likelihood of retrieving the block. However, walking experience was unrelated to block retrievals in the low effort condition, OR = 1.10, p = .72, (95% CI .67 – 1.81).

4. Experiment 2

The results of Experiment 1 suggest that infants' willingness to help the experimenter was significantly influenced by the degree of effort, or physical costs, associated with producing the prosocial response. Helping behavior was more frequent when physical costs were low versus high, and under conditions of high physical costs infants' prosocial responding was predicted by factors that either exacerbate or diminish physical costs at an individual level (i.e., amount of walking experience).

Experiment 2 investigated whether infants' willingness to engage in high effort prosocial behavior was influenced by intrinsic motivational benefits as defined by whether the experimenter either shared or opposed their toy preferences, given past work establishing that infants are motivated to interact with those that share versus oppose their preferences (Mahajan & Wynn, 2012). In Experiment 2 we examined infants' helping behavior in the first half of the response period as well as throughout the response period. We predicted that infants may be more likely to help the experimenter when she shared versus opposed the infants' toy preferences, particularly early in the response phase. Early in the response phase the importance of prior preference information (i.e., that the experimenter either shared or opposed the infant's preferences) is likely stronger, as the majority of what the infants have learned about the experimenter comes from this phase of the experiment. As infants receive additional exposure to, and requests from, the experimenter, infants gain equivalent information about the experimenters. This may either counteract or weaken the earlier distinguishing preference information. In addition, later in the response period more time has passed since infants received the differentiating preference information. Put another way, the differences between the experimenters, is both weaker, and more distant, as the response period goes on. Note that we did not have this prediction for Experiment 1 because the nature of the interaction/infants' relationship with the experimenter did not change across the response period: a heavy block

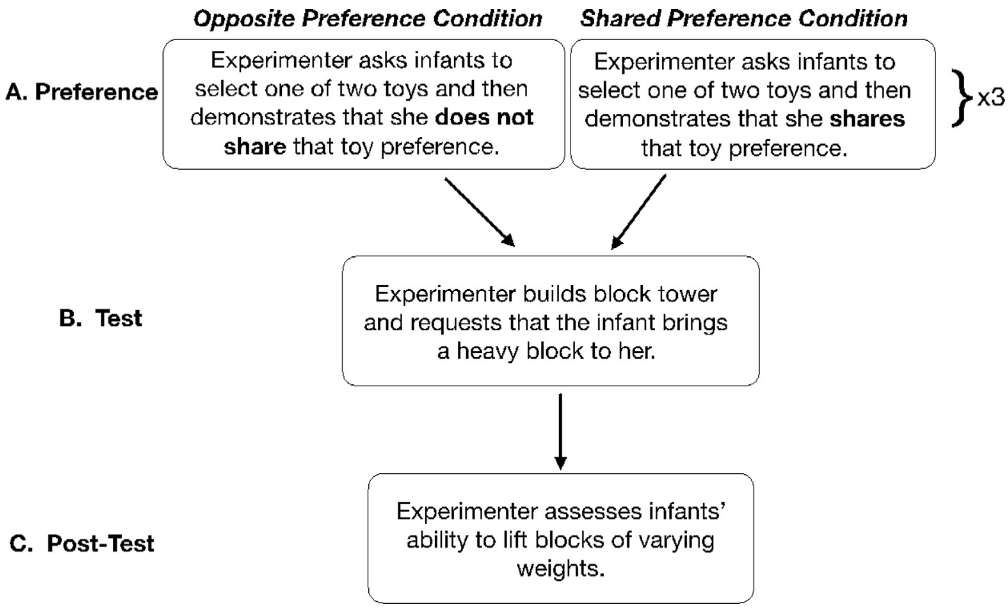

Fig. 3. Schematic of the procedure used in Experiments 2 and 3. Note that across the two conditions infants were asked to choose between one of two toys, the key difference between the conditions is that in the Shared Preference Condition the experimenter shared that preference whereas in the Opposite Preference Condition the experimenter liked the opposite toy as the infant.

was always a heavy block. This is in contrast to Experiment 2, in which the nature of the interaction *did* change across the response period: infants' relationship with the experimenter changes as the infant gains more experience with them.

Taking this general approach enabled us to rule out the possibility that differences in helping rates across conditions in Experiment 1 were driven by differences in infants' anticipated *ability* to help. That is, when infants in Experiment 1 chose not to help, this decision was not due to the fact that they were *incapable* of lifting and carrying the heavy block. If this were the case then infants' helping behavior should be unaffected by motivational variables and thus equivalent across the two conditions in Experiment 2. Moreover, differences in helping rates across conditions in Experiment 2 would not be expected to be greatest early in the response period and diminish over time. Instead, findings of differential helping rates as a function of whether the experimenter shared or opposed the infants' toy preferences would support the claim that it is effort, not ability, that drives the results of Experiment 1, and provide evidence that manipulating infants' intrinsic motivation can influence infants' high-cost helping behavior.

5. Materials and method

5.1. Participants

Fifty-six 17.5-month-old infants (26 girls; M = 17 months, 17 days; range = 16 months, 29 days to 18 months, 21 days) participated in the experiment. The sample size (n = 28/condition; N = 56) was decided a priori based on similar paradigms with same age infants; the stopping rule involved cessation of data collection at n = 28 usable infants per condition. An additional 13 infants were tested but excluded from subsequent analyses because they refused to choose any toys during the preference phase (n = 2), or because English was not their native language (n = 1), due to parental interference during the procedure (n = 2), or because they provided no evidence that they were capable of lifting the target block during the post-test phase (n = 8). Infants were recruited from a university-maintained database at a large university in the Pacific Northwest. According to parent report, 41 infants were Caucasian, 10 infants were of mixed race/ethnicity, 3 infants were Asian and 1 infant was Hispanic; 1 parent did not report their infant's race/ethnicity. The majority of primary caregivers reported education levels of college or higher (51 out of 56 infants)

Infants were randomly assigned to the shared preference condition (N = 28; 15 girls, M = 17;17) or the opposite preference condition (N = 28; 11 girls, M = 17;16).

5.2. Set-up and materials

Infants were tested in a room measuring roughly 4.4 m wide by 3.4 m long. During the preference phase the experimenter sat across from the parent and infant at a table measuring 38 cm by 92 cm. During the test phase, the experimenter sat on a blanket (roughly 125 cm by 125 cm) that was placed on the far side of the room aligned with two walls of the room; the parent and infant stood in the opposing corner of the room, 4 m away. During the post-test phase, the parent and infant moved to the blanket that the primary experimenter sat on, and sat down beside her.

During the preference phase, the infant was presented with three pairs of toys: a little people doctor doll and a green lego block, a toy cell phone and a white PVC pipe joint, and a Nickelodeon bath toy and a clear bowl. During the test phase the experimenter built a tower using multi-colored vinyl blocks from Experiment 1. The target block (the block that was left behind for the infant to bring to the experimenter) during the test phase was an orange vinyl block (14 cm by 14 cm by 14 cm) that was surreptitiously weighted with a fishing weight such that it weighed 2220 g. During the post-test phase the experimenter used a transparent container (16.5 cm high by 31 cm wide, by 27 cm deep) as a receptacle to encourage infants to lift each block and place it into the bin.

5.3. Procedure

See Fig. 3.

5.3.1. Preference phase

The purpose of the preference phase was to allow infants to select amongst sets of toys so that the experimenter could then demonstrate that she either shared or opposed infants' toy preference. Each preference phase consisted of 3 choice trials, and 3 demonstration trials; each choice trial was directly followed by a demonstration trial. The toys for the preference phase were selected on the basis of a pilot sample in which infants selected between a variety of different toys; toys that were selected 75% of the time or more by the pilot sample were paired with those that were selected 25% of the time or less by the pilot sample to yield object pairs for the current study.

Throughout the procedure, parents sat on a rolling chair with their infant in their lap. Parents were asked to align the infant with a black piece of tape on the table that demarcated the mid-point of the table. To begin each choice trial, parents were instructed to turn their chair such that their back was to the table. While the table was obscured from view the experimenter placed two toys on the table each at an opposite end of the table, 54 cm apart. Once the toys were in place, the experimenter instructed the parent to turn their chair around to face that table. After 5 s elapsed, and the experimenter confirmed that infants had seen the placement of the toys, parents were instructed to roll their chair up to the table such that infants were centered between the two toys (as indicated by the black tape). Infants were then given an opportunity to select a toy. After the infant selected a toy, the infant was allowed to play with it briefly. Then the experimenter asked the parent to return the toy to the table, and the parent was instructed to move their chair back such that the toys and table were out of reach to the infant and to turn their chair around again.

During the demonstration trial, parents were instructed to turn their chair to face the table; both the table and toys were out of infants' reach. The procedure during the demonstration trial then varied as a function of condition. During the shared preference condition, the experimenter looked at each toy twice, and then picked up the infants' preferred toy (the toy the infant selected on the preceding choice trial), and said, "Ooh, I like this one. I like it," while smiling. The experimenter then placed the toy back down in its original location, and picked up the other toy, saying "Ugh. I don't like this one. I don't like it," while frowning. The opposite preference condition proceeded in the same manner as the shared preference condition except that in this condition the experimenter first selected and claimed she liked the infant's non-preferred toy, and then selected and claimed she disliked the infant's preferred toy. Otherwise all aspects of the two conditions were identical.

This choice trial followed by demonstration trial was repeated twice for a total of 3 trial pairs. The toy pairs used during the preference phase were administered in a fixed order: little people doctor doll versus lego block, followed by toy cell phone versus PVC pipe joint, then Nickelodeon bath toy versus clear bowl. The location (infants' left versus infants' right) of the more desirable toys (as determined by pilot testing: little people doctor doll, toy cell phone, bath toy) was counterbalanced across infants.

Following the preference phase the experimenter instructed the parent and infant to stand in the far corner of the room and moved to a blanket that was placed on the opposing side of the room.

5.3.2. Test phase

The test phase was identical to that of Experiment 1 with just two exceptions: first all infants received the 2220 g block as the target block (as this was the median maximum block weight lifted in Experiment 1), and second the response period was reduced to 4 requests over 45 s (as Experiment 1 revealed that if infants' were going to help the experimenter it typically happened in the first 45 s of the response period). The test phase otherwise proceeded in the exact same way as Experiment 1.

5.3.3. Post-test phase

The purpose of the post-test phase was to ensure that infants possessed the ability to lift the target block. The primary experimenter sat on the blanket in front of the infant and parent. Beginning with the target block, the experimenter demonstrated lifting the block and placing it into a clear plastic bin twice. Then, the experimenter placed the block on the blanket in front of the infant and encouraged the infant to lift the block into the bin. If the infant did not reproduce the experimenter's actions, the experimenter repeated her request to place the object in the bin, and (if necessary) modeled placing the block into the bin again. The experimenter continued with this procedure for the 2 remaining blocks. Blocks were presented in a fixed order. After the target block (2220 g) infants were presented with a 2470 g block, then a 2720 g block. Any infant that did not provide evidence that they could lift the target block, or a heavier block, were counted as failing the post test and thus were not included in the sample (because it could not be verified that the infant could lift the block). As indicated in the Participants section, 8 infants failed the post-test phase and were excluded from the final sample.

5.3.4. Walking experience

Parents were asked how long their infant had been walking, directly prior to the experimental session. The primary experimenter recorded infants' walking experience (in months and weeks). On average, parents reported that infants had been walking for 5.03 months (SE = .25; range = 1.0 to 10.0 months); reported walking experience did not differ as a function of condition; shared preference condition M = 5.25 months, SE = .34, opposite preference condition M = 4.81 months, SE = .36; p = .379.

5.4. Coding and Reliability

The key dependent variable was whether or not the infant brought the block to the experimenter during the test phase online (*block retrieval*). The secondary experimenter recorded infants' block retrievals online during the study. A primary coder, unaware of the secondary experimenter's online codes, coded infants' block retrievals from videotape. Coders agreed on 100% of block retrievals.

6. Results

6.1. Test phase

6.1.1. Block retrievals

Our primary hypothesis was that infants in the shared preference condition would be more likely to bring the block to the experimenter than infants in the opposite preference condition, particularly early in the response period. A chi-square test of independence revealed a significant association between condition and infants' block retrievals, X^2 (1, N = 56) = 4.67, p = .031, ø = .29, during the first half of the response period. Whereas 57% (SE = 9.5) of infants in the shared preference condition brought the block to experimenter only 29% (SE = 8.7) of infants in the opposite preference condition brought the block to the experimenter (see Fig. 2). By comparison during the overall response period 75% (SE = 8.3) of infants in the shared preference condition brought the block to experimenter whereas 57% (SE = 9.5) of infants in the opposite preference condition brought the block to the experimenter, X^2 (1, N = 56) = 1.91, p = .158, ø = .19. Thus, these findings suggest that infants in the shared preference condition were more motivated to bring the heavy block to the experimenter than infants in the opposite preference condition, particularly early in the response period.

6.1.2. Walking experience

We predicted that parent reported walking experience would predict infants' block retrievals, particularly in the opposite preference condition. Separate binary logistic regression analyses were conducted on the shared preference condition and the opposite preference condition to determine whether parent-reported walking experience predicted infants' block retrievals. Walking experience significantly predicted infants' block retrievals in the opposite preference condition, OR = 1.88, p = .033, (95% CI 1.05–3.36), indicating that each additional month of walking experience was associated with almost twice the likelihood of retrieving the block. However, walking experience was not significantly related to block retrievals in the shared preference condition, OR = 1.45, p = .151, (95% CI .87 – 2.41).

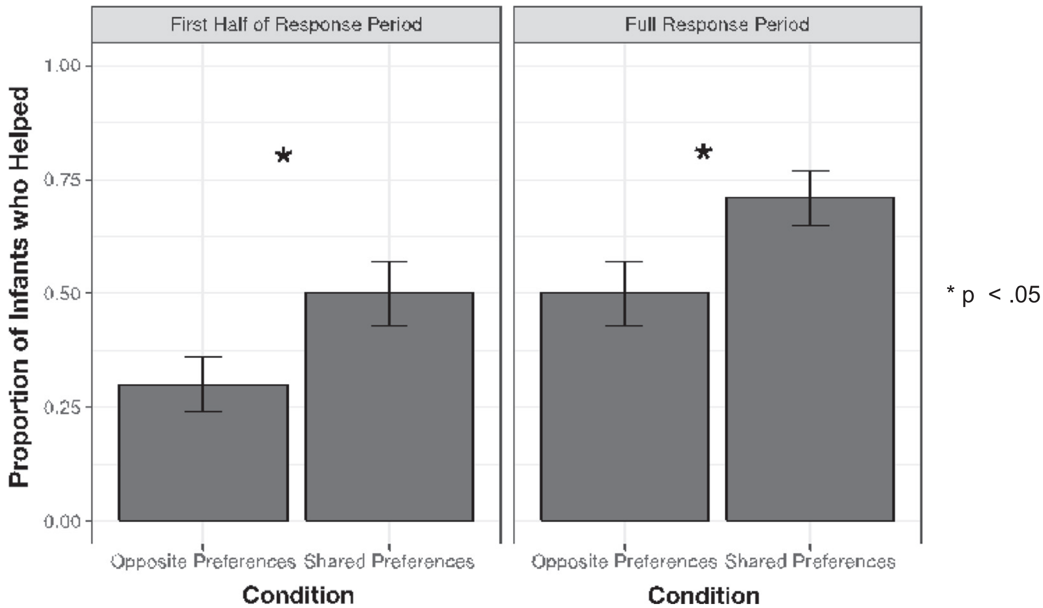

Fig. 4. Proportion of infants from Experiments 2 and 3 who helped as a function of shared versus opposite preferences. Data from the first half of the response period is presented in the left panel, data from the full response period is presented in the right panel.

7. Experiment 3

The findings from Experiment 2 suggest that infants vary in their high-cost helping behavior as a function of whether an experimenter shares or opposes their toy preferences. In particular, these differences emerged early in the response period but were attenuated by the response period. Given this pattern of findings, the goal of Experiment 3 was to attempt to replicate the results of Experiment 2. This provided us with the opportunity to assess infants' helping behavior at both time points in the experiment in a highly powered sample. Infants participated in the same procedure as Experiment 2.

8. Materials and methods

8.1. Participants

Fifty-six 18-month-old infants (23 girls; $M = 17$ months, 15 days; range = 17 months, 6 days to 18 months, 17 days) participated in the experiment. The sample size ($n = 28$/condition; $N = 56$) was decided a priori based on similar paradigms with same age infants; the stopping rule involved cessation of data collection at $n = 28$ usable infants per condition. An additional 11 infants were tested but excluded from subsequent analyses because they refused to choose any toys during the preference phase ($n = 4$), because English was not their native language ($n = 3$), due to parental interference during the procedure ($n = 1$), because they were not yet walking ($n = 2$) or because they provided no evidence that they were capable of lifting the target block during the post-test phase ($n = 1$). Infants were recruited from a university-maintained database at a large university in the Pacific Northwest. According to parent report, 35 infants were White, 15 infants were of mixed race/ethnicity, 4 were Asian, 1 was Hispanic, and 1 parent did not report. The majority of primary caregivers reported education levels of college or higher (53 out of 56 infants)

Infants were randomly assigned to the shared preference condition ($N = 28$; 11 girls, $M = 17$ months, 15 days) or the opposite preference condition ($N = 28$; 12 girls, $M = 17$ months, 15 days).

8.2. Set-up and materials

The set-up and materials were identical to Experiment 2.

8.2. Procedure

See Fig. 3.

8.2.1. Preference phase

The preference phase was identical to Experiment 2.

8.2.2. Test phase

The test phase was identical to that of Experiment 2.

8.2.3. Post-test phase

The post-test phase was identical to Experiment 2. As indicated in the Participants section, 1 infant failed the post-test phase and was excluded from the final sample.

8.2.4. Walking experience

On average, parents reported that infants had been walking for 5.65 months ($SE = .28$; range = 1.0 to 9.0 months); reported walking experience did not differ as a function of condition; shared preference condition $M = 5.5$ months, $SE = .34$, opposite preference condition $M = 5.8$ months, $SE = .37$; $p = .595$.

3.3. Coding and Reliability

The coding and reliability coding were identical to Experiment 2 for the overall response period. Coders also coded whether or not the infant helped within the first half of the response period. Coders agreed on 100% of block retrievals.

9. Results

9.1. Test phase

9.1.1. Block retrievals

As in Experiment 2, our primary hypothesis was that infants in the shared preference condition would be more likely to bring the block to the experimenter than infants in the opposite preference condition. We investigated both infants' responses during the first half of the response period, and infants' overall helping responses. A chi-square test of independence revealed a non-significant association between condition and infants' block retrievals, X^2 (1, N = 56) = .686, p = .408, ø = .11, during the first half of the response period. Whereas 43% (SE = .10) of infants in the shared preference condition brought the block to experimenter only 32% (SE = .09) of infants in the opposite preference condition brought the block to the experimenter (see Fig. 4). During the overall response period 68% (SE = .09) of infants in the shared preference condition brought the block to experimenter whereas 43% (SE = .10) of infants in the opposite preference condition brought the block to the experimenter, X^2 (1, N = 56) = 3.541, p = .06, ø = .25. Thus, at both time points infants were numerically more likely to bring the block to the experimenter, but only during the overall response period did this effect approach significance.

To gain additional power, and given that Experiment 3 served as a direct replication of Experiment 2, we next collapsed across the two experiments and investigated infants' helping behavior (see Fig. 4). A chi-square test of independence revealed a significant association between condition and infants' block retrievals, X^2 (1, N = 56) = 4.495, p = .034, ø = .20, during the first half of the response period. Whereas 50% (SE = .07) of infants in the shared preference condition brought the block to experimenter only 30% (SE = .06) of infants in the opposite preference condition brought the block to the experimenter. With respect to the overall response period, 71% (SE = .06) of infants in the shared preference condition brought the block to experimenter whereas 50% (SE = .07) of infants in the opposite preference condition brought the block to the experimenter, X^2 (1, N = 112) = 5.390, p = .02, ø = .22). As a whole, these findings provide evidence that infants are more likely to engage in high effort helping when the experimenter shares, versus opposes, infants' preferences, both early in the response period, and overall.

9.1.2. Walking experience

We predicted that parent reported walking experience would predict infants' block retrievals, particularly in the opposite preference condition. Separate binary logistic regression analyses were conducted on the shared preference condition and the opposite preference condition to determine whether parent-reported walking experience predicted infants' block retrievals, collapsing across experiment. Walking predicted infants' block retrievals in the opposite preference condition, OR = 1.39, p = .031, (95% CI 1.03 – 1.875), indicating that each additional month of walking experience was associated with a 1.4 times the likelihood of retrieving the block. However, walking experience was not significantly related to block retrievals in the shared preference condition, OR = .89, p = .424, (95% CI .66 – 1.19).

10. Discussion

Experiment 1 demonstrated that infants' helping behavior varies as a function of the physical costs involved with helping a target recipient: infants were significantly less likely to help an experimenter when doing so involved carrying a heavy versus a light block across a room. The combined results from Experiments 2 and 3 demonstrated that infants' high-cost helping was influenced by whether the experimenter shared or opposed the infants' toy preferences. Together, these results indicate that infants' helping behavior is influenced by both the effort-related costs of the helping action, as well as the anticipated intrinsic motivational benefits of helping another person. Moreover, our findings suggest that infants not only consider costs at an "objective" level, but subjectively calibrate effort-related costs as a function of their own experience and abilities: infants with greater walking experience were significantly more likely to engage in high-cost helping than were infants with less walking experience.

Critically, in all experiments infants' responses were driven by the *anticipated* costs and benefits of a given action. In Experiment 1, infants based their decision of whether to help on the block weight as experienced during the earlier familiarization phase, not on the basis of lifting the block and straining to carry it across the room. Similarly, there were no concrete rewards associated with interacting with the experimenter that shared versus opposed their preferences during either the preference phase or test phase in Experiments 2 and 3; the experimenter acted equivalently toward the infants during the preference phase (the experimenter only differed in which toys she preferred across conditions) and the test phase across conditions. These results suggest that infants trade off *projected* costs and benefits to decide whether or not to help a recipient. Our results indicate that infants act to maximize the predicted utility of their helping behavior, as defined by weighing interpersonal benefits and energetic costs, as early as the second year of life.

Our findings that suggest that young infants appear to engage rational decision-making processes to guide selective prosocial responding raise the possibility that prosocial behavior is selective from early in development. Moreover, our results more broadly suggest that infants' prosocial behavior is influenced by multiple motives (Martin & Olson, 2015; Paulus, 2014), which include not only the motivation to provide assistance to someone who needs help, but also the motivation to interact with others, particularly those similar to the self, while curtailing costs incurred with doing so. Our findings, coupled with prior work, further indicate that factors that influence infants' intrinsic motivation may increase prosocial responding, whereas factors that influence infants' extrinsic motivation do not (Warneken & Tomasello, 2014; Warneken et al., 2007).

Understanding infants' and children's decision making and behavior across contexts first involves accurately identifying what constitutes costs and benefits. The fact that conserving metabolic resources is critical to survival, and interacting with ingroup members is central to social and cultural learning, may account for our findings that very young children can compute these costs and benefits and use them to guide their prosocial responding. In the current study, we manipulated ingroup/outgroup membership through shared or dissimilar toy preferences. However, it is important to consider that toy preferences may not have necessarily been interpreted by the infants as markers of group membership. More work is needed to determine whether toy preferences influence helping behaviors because they serve as markers of ingroup/outgroup status, or exert a motivational influence on infants' helping behavior through other means, such as perceived similarity to the self. This will help determine whether the differences across the two conditions in Experiments 2 and 3 are driven by an attraction to the experimenter that shares the infants' preferences or a distaste for the experimenter who opposes them. Another alternative explanation of the results from Experiments 2 and 3 could be that infants focused on shared communication rather than group membership. Infants who shared preferences with the experimenter may have felt they shared common ground and they understood her request for help. However, infants who did not share preferences with the experimenter may not have felt they understood her request for help because their past experiences of the world were different. Thus, shared communication, or lack thereof, could explain the differences across conditions.

These results also highlight the importance of conceptualizing costs not only in terms of objective costs, but also from the perspective of subjective, or agent-specific costs, and benefits. Additional critical questions, of course, remain for future work. What range of costs and benefits can infants compute? Is the ability to perform costs-benefit calculations innate or does it constitute a developmental achievement? What role does experience in infants' ability to compute particular costs and recognize particular benefits? When do infants recognize commonalities amongst different costs, and commonalities amongst particular benefits?

Identifying the computations that underlie decision making, including their developmental origins, is of critical importance to understanding human behavior. Our results show that cost-benefit calculations can be traced back to early in life and permeate infants' prosocial responding. Cost-benefit analyses may be fundamental to decision making across a range of contexts and across the developmental trajectory.

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