Title: PREPRINT Infants choose those who defer in conflicts

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Summary: For humans and other social species, social status matters: it determines who wins access to contested resources, territory and mates [1–11]. Human infants are sensitive to dominance status cues [12,13]. They expect conflicts to be won by larger individuals [14], those with more allies [15], and those with a history of winning [16–18]. But being sensitive to status cues is not enough; individuals must also use status information when deciding whom to approach and whom to avoid [19]. In many non-human species, low-status individuals avoid high-status individuals, and in so doing avoid the threat of aggression [20–23]. In these species, high-status individuals commit random acts of aggression toward subordinates [23] and even commit infanticide [24–26]. However, for less reactively aggressive species [27,28], high-status individuals may be good coalition partners. This is especially true for humans, where high-status individuals can provide guidance, protection and knowledge to subordinates [2,29,30]. Indeed, human adults [31–33], human toddlers [34], and adult bonobos [35] prefer high-status individuals to low-status ones. Here we present 6 experiments testing whether 10- to 16-month-old human infants choose high-or low-status individuals—specifically, winners or yielders in zero-sum conflicts—and find that infants choose puppets who yield. Intriguingly, toddlers just six months older choose the *winners* of such conflicts [34]. This suggests that although humans start out like many other species, avoiding high-status others, we shift in toddlerhood to approaching high-status individuals, consistent with the idea that for humans, high-status individuals can provide benefits to low-status ones.

RESULTS

Experiment 1: Infants choose the puppet who yields the right-of-way over one who is yielded to.

We began by operationalizing social status as a zero-sum, right-of-way conflict. This paradigm, which has been used in several previous studies [1,5,14,15] relies on the fact that in both prestige-based hierarchies and dominance-based hierarchies, status determines who is deferred to in conflicts [1,6,20]. Human toddlers [34] and adult bonobos [35] both prefer the winners of such conflicts, whom they presumably see as having higher social status. A preference for high-status individuals is likely adaptive in both species: for bonobos, high-status individuals provide coalitional support; for humans, they can also provide protection, knowledge and guidance [2,13,30,36]. In contrast, it is likely adaptive for individuals in more reactively aggressive species [37] to avoid high-status others. Among baboons and macaques, for example, high-status individuals commit random acts of violence against others [23]; high-status individuals of many species commit infanticide [24,25,38] and low-status wolves and chimpanzees often avoid or withdraw from high-status others to avoid provoking aggression [8,20,21].

In Experiment 1, infants watched a puppet show where two puppets faced off in a right-of-way conflict like those used in previous studies [14,15,34]. In previous studies, infants who watched this kind of puppet show expected the behavior of the puppets to reflect the logic of dominance hierarchies that are found across species—they expected smaller individuals to yield the way for larger ones [14], and individuals with fewer allies to yield the way for those with more allies [15].

The puppet show began with a familiarization phase, whose purpose was to show that each puppet had the goal of crossing the stage. In this phase, one puppet crossed the stage alone from right to left; then the other puppet crossed alone from left to right. Next came the action phase, in which the two puppets tried to cross the stage in opposite directions at the same time. The puppets met in the middle and bumped into each other repeatedly. Finally, one puppet yielded to the other by making a 'bowing' motion (rotating to face downward) and moving upstage, out of the other puppet's way. The other puppet then continued past the bowing puppet and across the stage (see Figure 1 and STAR Methods for details). After the puppet show ended, an experimenter who did not know which puppet had yielded held out both puppets toward the infant; the dependent measure was which puppet the infant reached for (See Figure S1). This is a common way of measuring preferences in human infants and non-human primates [34,35,39–44].

In this experiment, 24 of 30 infants chose the puppet who yielded (two-sided binomial test p=.001; Bayes factor of 47.43, meaning that these data are 47.43 times more likely to arise when infants are choosing one puppet more than 50% of the time than when they are choosing both puppets equally. Results from all experiments are summarized in Figure 4.) We then replicated this finding with a different group of participants, using puppets of different shapes and colors (see STAR Methods). In the replication, 17 of 19 infants chose the puppet who yielded the way (two-sided binomial test p<.001; Bayes factor of 71.98 in favor of the hypothesis that infants chose one puppet more often than the other).

Experiment 2: Infants choose the puppet who yields, even when the winner does not reach its goal.

In Experiment 2 we investigated whether the 'winner' must go on to reach its goal in order for the infants to reach for the yielder. Experiments by Hamlin and colleagues [40]; but see [45,46] have shown that infants choose those who help others achieve a goal over those who hinder others from achieving goal. This raises the question of whether infants in Experiment 1 and its replication chose the yielding puppet not because they like low-status individuals, but because they like helpful ones. In other words, perhaps infants saw the bowing puppet as helping the other one by moving out of the way. Another possibility is that infants chose the bowing puppet because it failed to reach its goal. In Experiment 2, infants watched a puppet show with the same familiarization phase as in Experiment 1. The action phase differed from Experiment 1 in that the scene was stopped as soon as one puppet bowed and moved aside. Thus, neither puppet actually achieved its goal of crossing the stage (See Figure 1). Again, 17 of 20 infants chose the puppet that yielded (p=.003; BF=28.11 in favor of infants choosing one puppet over the other). In other words, the infants seemed to prefer one puppet as soon as it bowed down and moved aside. Neither puppet crossed the stage and both puppets failed to reach their goal, yet infants still chose the puppet who yielded the way. In this case, neither puppet helped the other reach a goal, and neither puppet was more ‘successful’ in reaching one. Infant apparently made their choice as soon as one puppet deferred to the other.

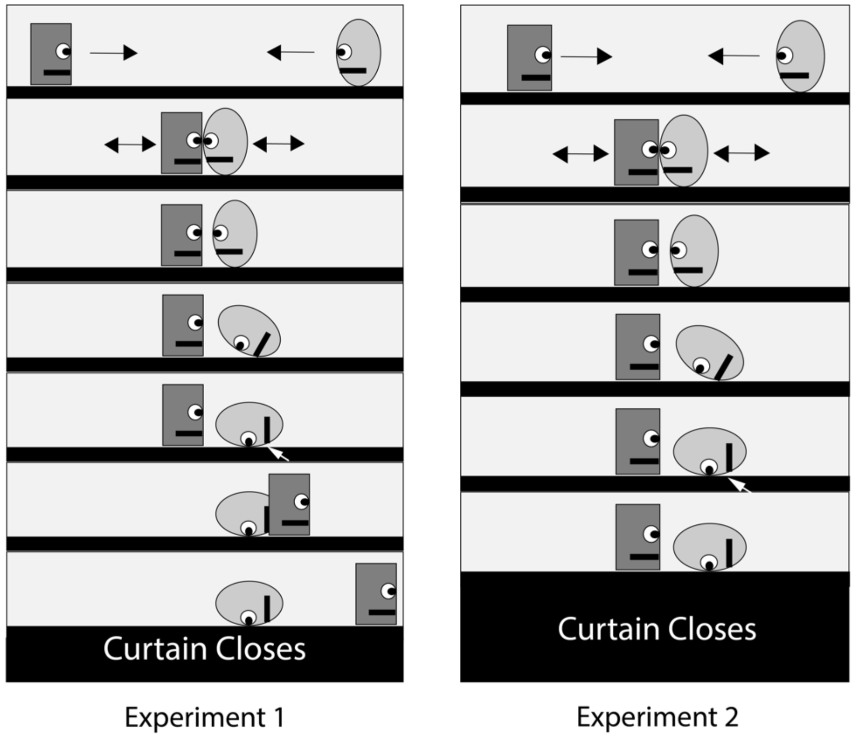

Figure 1. Movements of the puppets in Experiments 1 and 2. The rectangular puppet was red and the oval puppet was yellow. The white arrows in the fifth row indicate that the puppet moved upstage after it bowed, clearing the way for the other puppet. The roles of the puppets and the directions they traveled were counterbalanced across participants. See Figure S1 for choice procedure

Experiment 3: When both puppets reach their goals, infants show no preference or either puppet.

Here we asked whether infants always choose a puppet who moves out of the way for another one, or whether they only make this choice in the context of a zero-sum conflict (i.e., a conflict where one individual wins and the other loses). This puppet show began like those in Experiments 1 and 2, with a familiarization phase where each puppet crossed the stage twice, followed by an action phase where two puppets attempted to cross at the same time and blocked each other's path. As in Experiment 1, one puppet bowed and moved aside, allowing the other puppet to cross in front of it. Then, unlike in previous experiments, the bowing puppet stood up (i.e., rotated back up to face forward) and continued across the stage. Thus the situation shown in this experiment was not a zero-sum conflict, but a win/win: Both puppets reached their goals, but only one puppet helped the other by bowing and moving out of the way (see Figure 2). In this case, only 12 of 30 infants chose the puppet who moved out of the way (two-sided binomial test $p=0.36$; Bayes Factor of 1.48, providing weak evidence in favor of the null hypothesis that infants had no preference; Bayes Factor of 7.31 against the hypothesis that children chose the 'bowing' puppet.) Thus, in a case where both puppets eventually reached their goals, we found no evidence that infants preferred the puppet who cleared the path. It seems that infants' preference for the yielding puppet in Experiments 1 and 2 requires that the puppet yield to another at its own expense, a mark of low status across species.

Experiment 4: In the absence of conflict, infants show no preference for either puppet.

Here we tested several non-social explanations for the findings in Experiments 1 and 2. For example, infants might choose a puppet who fails to reach its goal over one who achieves its goal; a puppet who stops halfway across the stage over one who continues all the way across; a puppet who is briefly occluded over one who is never occluded; a puppet who bows down and moves aside over one who remains upright; or a puppet who behaves differently during the test and familiarization phases. To test these explanations , we showed infants a scene in which the puppets moved as they had in Experiments 1-3, but without the face-to-face conflict. Instead, both puppets appeared at one side of the stage. Then, one puppet moved halfway across the stage before stopping to bow and move aside, repeating the motions of the yielding puppet in Experiments 1-3. Finally, the second puppet came from the same side of the stage as the first and moved all the way across the stage, and passing in front of the bowing puppet (see Figure 2). If infants' choice of the yielding puppet in Experiments 1 and 2 were due to reasons listed above, then infants should also choose the bowing puppet in this scene.

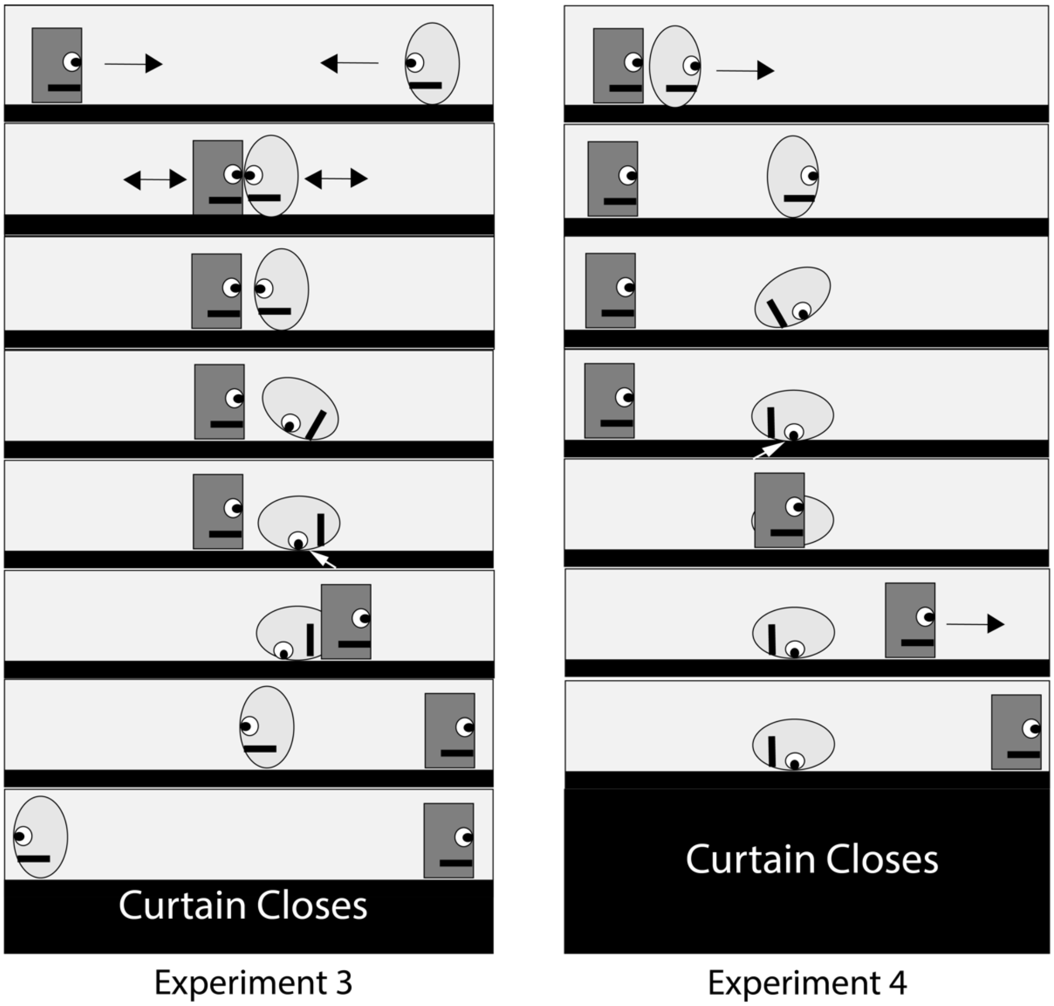

Figure 2. Movements of the puppets in Experiments 3 and 4. The rectangular puppet was red and the oval puppet was yellow. The white arrows in the fifth row indicate that the puppet moved upstage after it bowed, clearing the way for the other puppet. The roles of the puppets and the directions they traveled were counterbalanced across participants. See Figure S1 for choice procedure

However, 18 of 26 infants chose the second puppet, the one who crossed the stage without stopping, rather than the one who bowed and moved aside (two-sided binomial test *p*=.075; BF of 2.11 in favor of infants choosing the upright puppet; Bayes Factor of 12.31 against the hypothesis that children preferred the 'bowing' puppet.). This is weak positive evidence that when there is no social conflict, infants choose the puppet who stays upright, keeps moving, is never occluded, and so on.

Experiment 5: Infants choose a puppet who yields a rattle.

In Experiment 5, we asked whether infants choose a puppet that defers in a different type of zero-sum conflict. This experiment began with a familiarization phase showing two plush hand puppets, each alone on stage approaching and shaking a rattle. Then during the action phase, the two puppets struggled over the rattle until one deferred, moving away from the rattle and bowing its head, allowing the other puppet to pick up the rattle and shake it, unimpeded (See Figure 3). In this experiment, 15 of 17 infants chose the puppet who yielded (*p*=.002, BF=28.78). Thus, it seems that the choice for a yielder shown in Experiments 1 and 2 is not limited to clay block puppets in right-of-way conflicts, but generalizes to at least one other type of puppet (plush animals) and one other type of conflict—a dispute over a toy. (see Figure S2 for choice procedure).

Experiment 6: When there is no conflict (over a rattle), infants show no preference

In Experiment 6, we tested a range of non-social explanations for the finding in Experiment 5. For example, infants might dislike the puppet who shook the rattle more often or shook it last; they might choose the puppet who gave up the rattle because it moved differently during the action phase than during the familiarization phase; they might dislike the puppet who moved last in the scene; and so on. To test these alternative explanations, we used a puppet show that was similar to the one in Experiment 5, but without the social conflict. During the action phase (when the puppets in Experiment 5 struggled over the toy), we placed a barrier at center stage. The rattle was on one side of the barrier, so only the puppet on that side could reach it (See Figure 3). Thus, there was no question about who would get the rattle, and no struggle between the puppets. Here, 16 of 29 infants chose the puppet that picked up the rattle (two-sided binomial test p=.458. BF of 2.11 in favor of the null hypothesis; BF=7.238 against infants choosing the yielder). In other words, this experiment provided positive evidence that when there is no conflict, children show no preference for the puppet that ends up without the rattle.

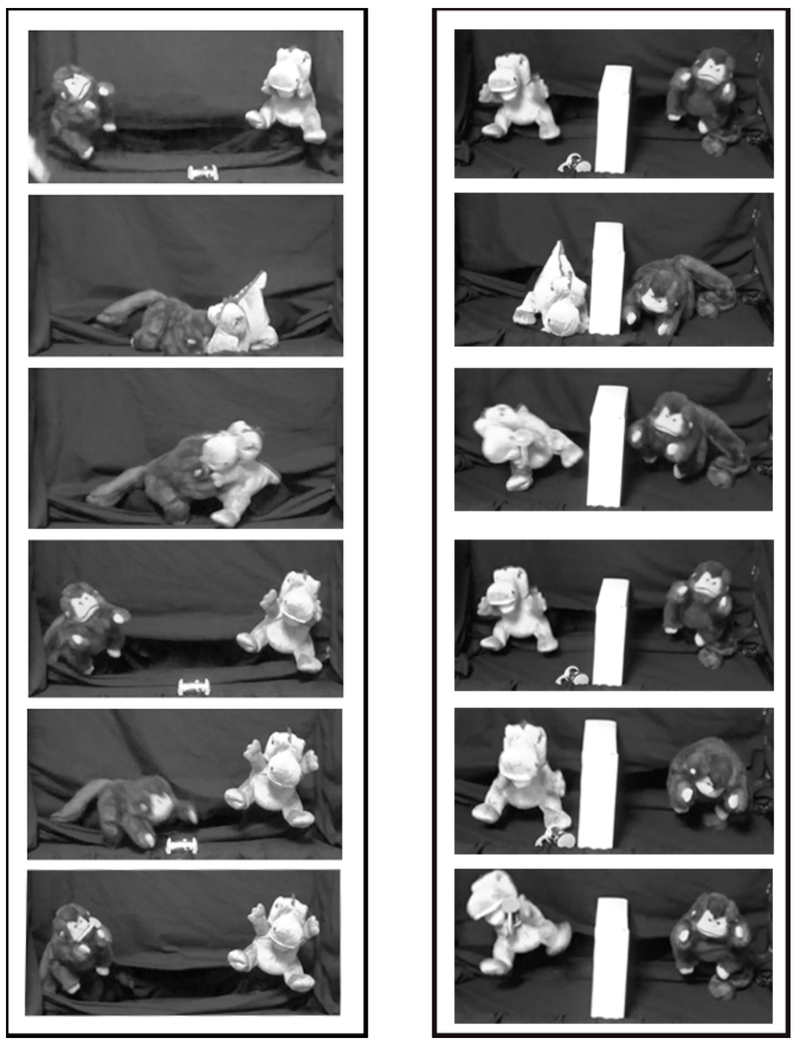

Figure 3. Movements of puppets in Experiments 5 and 6. The roles of the puppets and the side where they appeared were counterbalanced across participants. See Figure S2 for choice procedure

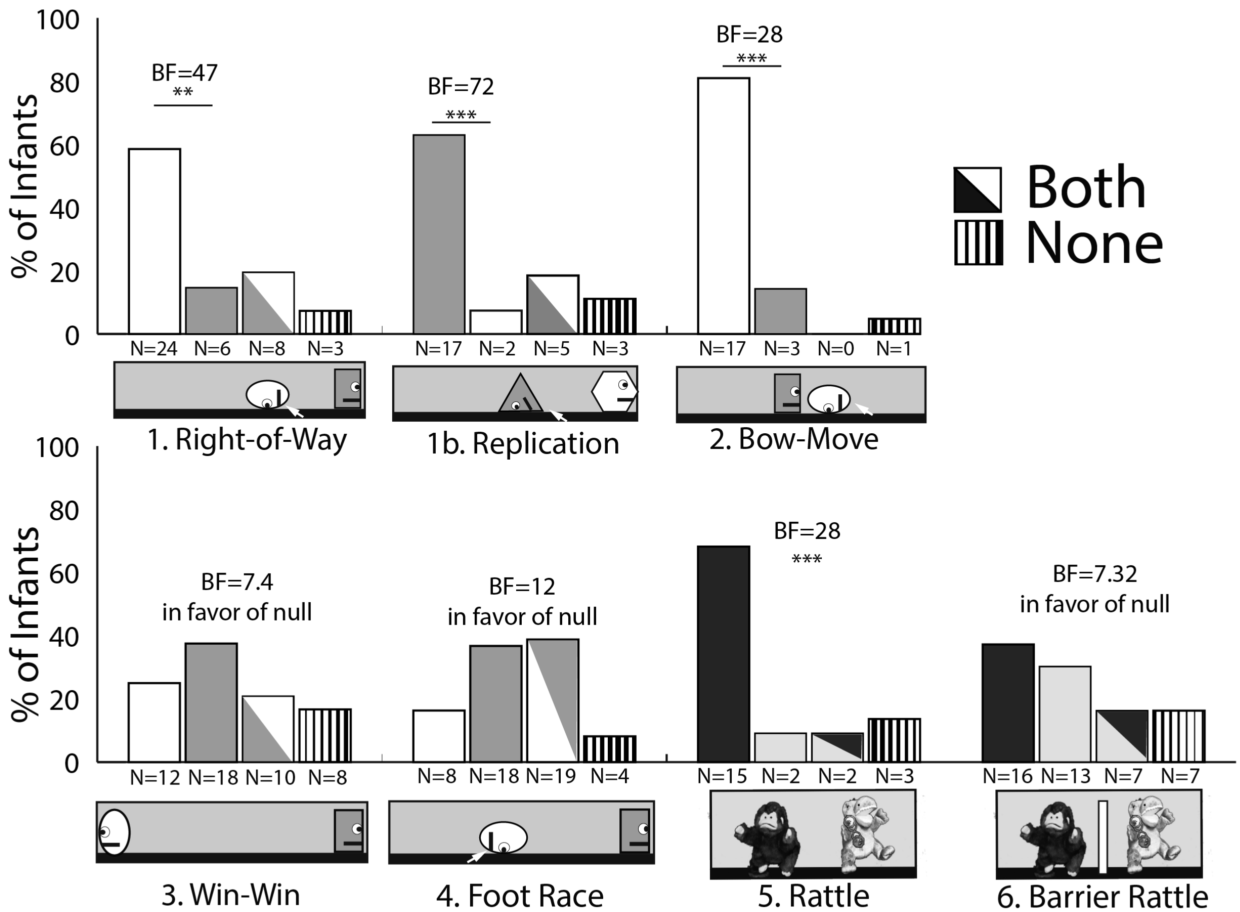

Figure 4. Proportion of infants choosing each puppet in Experiments 1-6. In Experiments 1 and 2, Bayes Factors were computed by comparing the likelihood of the data given the null hypothesis (that infants chose each puppet 50% of the time) against the alternative hypothesis (that children chose either puppet more than 50% of the time). In Experiments 3 and 4, Bayes Factors were computed in the same way, but the null hypothesis was that infants chose the bowing puppet less than 50% of the time. Two-sided binomial frequentist tests were also used to calculate p-values. ** indicates $p<.01$; *** indicates $p<.001$. The diagrams below each graph depict the last segment of the 'action phase' in each experiment. The colors of the winner and loser and the direction that they traveled were counterbalanced across participants. See Data S1.

DISCUSSION

To recap: In this series of experiments, 10- to 16-month-old infants chose (i.e., reached for) the puppet that yielded, rather than the puppet that prevailed, in two types of zero-sum conflict (Exp. 1 and replication, Exp.5). This was true even when neither puppet went on to reach its goal (Exp. 2). However, when one puppet yielded to the other, and then both puppets went on to achieve their goals (in other words, when the situation was a win/win rather than a zero-sum) infants showed no preference for either puppet (Exp. 3). Likewise, when there was no conflict between the puppets, infants no longer chose the bowing puppet or the puppet who ended without the rattle (Exp. 4 and Exp. 6). These results stand in contrast to recent reports that children just a few months older (ages 21-31 months) choose the other puppet (the winner) in the same right-of-way conflict used here [34]. This raises not only the question of why infants choose the loser (yielder) in these conflicts, but also why their choices appear to change between infancy and toddlerhood.

We considered the possibility that infants may prefer a puppet that yields because they see yielding as helping the other puppet reach its goal [26]. However, infants also chose the yielder in Experiment 2, where the other puppet did not reach its goal. Another form of the 'helper' explanation might be that infants prefer those who *intend* to help someone achieve a goal [47]. But the results of Experiment 3 did not support this version: When one puppet yielded the way (thus helping the other puppet reach its goal) and then went on to reach its *own* goal, infants no longer chose the helper. Moreover in Experiment 4, where the puppets were moving in the same direction and one puppet stopped and moved aside, effectively clearing a path for the other puppet, infants showed no preference for the puppet who cleared the path. In other words, we found no evidence that the results of Experiments 1 and 2 can be explained by an overall preference for helpers.

We also considered the possibility that infants may choose the yielder because they feel sympathy for a puppet that loses a conflict and/or fails to reach its goal. This explanation would be consistent with studies showing that when 10-month-olds see one shape squishing another one, they reach for the squished shape over a neutral shape. In other words, infants seem to prefer a victim over a neutral character [43]. However in the case of the present experiments, we are skeptical for two reasons. First, in our puppet shows, the aggression was mutual and symmetrical—the puppets bumped into one another. Second, the yielding puppet in our experiments appears to move out of the way voluntarily (i.e., its motion is self-generated), so it is not squished or pushed by the other puppet. Thus makes the puppet in our studies seem like less of a victim than those in the shape-squishing studies.

A variation of the ‘pity for the victim’ explanation is that infants might choose any puppet who failed to reach its goal. But if that were true, then they should not choose either puppet more than the other in Experiment 2 (where neither puppet reaches its goal), when in fact they chose the yielding puppet. Similarly, if infants prefer an individual that fails to reach its goal, then they should choose the puppet that stops halfway across the stage in Experiment 4. Again, that is not what we found: When there was no conflict between the puppets, infants showed no preference for the one that stopped and bowed.

In our view, the most plausible interpretation of the present results is that the infants saw these conflicts in terms of social status and avoided the higher-status puppet. This interpretation is consistent with previous research showing that infants recognize social-status cues in zero-sum conflicts like the ones used here [14–18]. It also makes sense given that how individuals behave in conflicts is a stable indicator of their social status [1,5,7–9,12]. Infants’ avoidance of high-status individuals echoes behavior seen in several non-human species where individuals avoid or withdraw from high-status others. This avoidance may be adaptive in situations where high-status individuals commit random acts of aggression [23] or infanticide [23,25,38].

The present results stand in contrast to those from recent studies that used the same experimental setup with toddlers 21-31 months old. In those studies toddlers chose the winner of the conflict, implying that there is a shift such that infants prefer low-status individuals and toddlers prefer high-status ones. These are the first studies to show such a shift, and we can only speculate about its nature. It seem to echo a pattern seen in the development of other social cognitive abilities, such as those measuring joint attention and over-imitation [48][49]. In these areas, among others, we see infant cognition showing similarities with non-human species, and uniquely human social behaviors emerging in toddlerhood.

In the present case, infants' avoidance of high-status others echoes similar behaviors in many non-human species, where high-status individuals present a threat. Among humans however, high-status individuals are not necessarily aggressive or physically threatening. They are often responsible for protecting and guiding subordinates, and they typically control resources like information, wealth, and social connections. [2].Thus, in human societies, forming relationships with high-status people is often beneficial [29,50].

In sum, we think a possible explanation of our findings is that infants view high-status/dominant individuals with wariness or fear, consistent with the dynamics of dominance hierarchies in many non-human species. This speculation is supported by the previous research finding that when infants see interactions like the present ones, they recognize status differences among the characters[14,15]. In contrast to infants, toddlers appear to view high-status others the way older children and adults do: as potentially valuable allies. This interpretation of our data is consistent with other research showing that toddlers at 21 months distinguish between 'bullies' and 'leaders' [34,51] and that older children look to high-status individuals for information [52–54].

Further studies could test this account. For example, it would be useful to do a version of these experiments where infants decide between a puppet who was involved in the zero-sum conflict and a puppet who was not. This would show us whether infants actively prefer the low-status individual, or wish to avoid the high-status one. For now, we present evidence of a previously undiscovered developmental shift: Given a choice between the winner and yielder in a right-of-way conflict, toddlers choose those who win, and infants choose those who yield.

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Author Contributions

AJT and BWS designed the experiments and wrote the paper. AJT collected the data, oversaw research assistants, and analyzed the data.

Declaration of Interests. The authors declare no competing interests.

STAR Methods:

CONTACT FOR REAGENT AND RESOURCE SHARING

Besides sharing identifiable information about the participants, there are no restrictions about the materials disclosed. Further information and requests for resources should be directed to and will be fulfilled by the Lead Contact, Ashley J. Thomas (athomas@g.harvard.edu).

EXPERIMENTAL MODEL AND SUBJECT DETAILS

Participants were recruited from among the visitors to a children's museum during regular business hours. Experimenters approached parents on the museum floor and invited them to participate if their child was in the target age range (10 to 16 months). Informed consent was obtained from all subjects' parents or legal guardian. This work was approved by IRB protocol number #2013-9945

Experiment 1

We recruited 51 infants (20 boys, 31 girls), ages 10 to 16 months (*Range:* 316-516 days, *Mean*=437 days, *SD*= 61 days). Data from 21 of these infants were excluded from the analysis for the following reasons: 8 infants chose both puppets (reaching both hands forward toward both puppets at once); 5 infants became fussy, so the experiment was stopped before the choice procedure; 4 were excluded because of interference (the parent or sibling touched one of the puppets, or talked during the puppet show); 3 infants chose neither puppet; and 1 infant was excluded because of experimenter error (the eye fell off of one puppet during the puppet show). These exclusion criteria were decided before testing based on previous experiments with toddlers [34].

Some of the 15- and 16-month-olds who were included in the Experiment 1 data were tested in a different experiment using the identical procedure. The original purpose of that experiment was to investigate whether factors such as language or motor development might correlate with infants' choice of the winning or losing puppet. This experiment was started as a follow-up after the initial group of participants were tested in Experiment 1. There were 12 of these infants, (noted on the data sheet) and they are included in the analysis and summary of participants above. Note that we already had a strong enough Bayes Factor to stop testing *before* adding these data, but on the open-science principle that all relevant data should be made public, we include them here.

Experiment 1b: Replication of Experiment 1

We recruited 33 infants for Experiment 1b (15 boys; 18 girls), ages 10 to 16 months (Range: 306-432 days, Mean=407 days, SD= 54 days). Of these, 14 infants were excluded from the analysis for Experiment 1b for the following reasons: 5 infants chose both puppets; 3 chose neither puppet; 3 were excessively fussy and we stopped the experiment before the choice procedure; and 3 were excluded because of experimenter error (in one case the puppets were presented to the child upside-down, in another case the curtain went up before the puppets had been reset; in a third case one of the puppets was oriented incorrectly).

Experiment 2

We recruited 26 infants (16 boys, 10 girls), ages 10 to 16 months (*Range:* 312-512 days, *Mean*=391 days, *SD*= 64 days). Of these, 6 infants were excluded from the analysis for Experiment 3 for the following reasons: 4 for excessive fussiness; 1 because the child grabbed both puppets; and 1 because of interference from a sibling.

Experiment 3

We recruited 55 infants (21 boys, 35 girls), ages 10 to 16 months (*Range:* 304-505 days, *Mean*=387 days, *SD*= 50 days). Of these, 25 infants were excluded from the analysis for Experiment 3 for the following reasons: 10 infants chose both puppets; 8 chose neither puppet; 5 were excluded because of experimenter error (there was black tape stuck to one puppet's face during the puppet show; the experimenter forgot to tell the parent to close their eyes during the choice procedure; the faces on the choice puppets did not match the puppets used in the puppet show; the stage fell off the table during the puppet show; the puppeteer was looking at the wrong child when habituating the infant); 1 for excessive fussiness; 1 for sibling or parental interference (a sibling pointed to a puppet before the infant did). The analysis was based on data from the remaining 30 infants.

Experiment 4

We recruited 52 infants (25 boys, 27 girls), ages 10 to 16 months (*Range:* 315-500 days, *Mean*=414 days, *SD*= 54.29 days). Of these, 26 infants were excluded from the analysis for the following reasons: 19 infants chose both puppets; 4 infants did not choose either puppet; 3 experiments were stopped before the choice procedure because the infant became overly fussy.

Experiment 5

The same infants who participated in Experiment 5 also participated in Experiment 2. Of the 26 infants we tested, 9 infants were excluded from Experiment 5. Of these, 3 were excluded because of experimenter error (in one case, the puppeteer mistakenly made the winning puppet return the rattle to the center of the stage at the end of one of the action sequences; in another case the action phase did not show either of the puppets winning the rattle; in the third case two different puppets won in two repetitions within the same action phase). Another 3 infants were excluded from the statistical analysis because they did not choose either puppet; 2 were excluded because they chose both puppets; and 1 was excluded because the infant became overly fussy and the experiment was stopped early.

Experiment 6

The participants in Experiment 6 were the same infants as in Experiment 4. Of the 52 infants tested, 23 were excluded from the Experiment 6 statistical analysis for the following reasons: 8 infants chose both puppets; 7 infants failed to choose either puppet, 5 infants were too fussy to complete the procedure; 1 infant was excluded because the experimenter knocked over the barrier during the action phase, 1 was excluded due to interference from a sibling, and 1 was excluded because the infant did not watch the puppet show.

METHOD DETAILS

General Methods

Testing took place in a museum, in a quiet room separate from the main museum floor. Parents filled out a consent form while the experimenter interacted with the infant before leading both parent and infant into the testing room. Before entering the testing room, parents were briefed about the procedure. They were asked to remain quiet during the puppet show and to close their eyes during the choice procedure. The participating infant sat on their parent’s lap. One experimenter, sitting behind the stage and occluded from the infant’s view, acted as the puppeteer. A second experimenter, who could not see what the puppets were doing onstage, stood to the side and opened and closed the curtain between segments, saying "Down goes the curtain!" and "Up goes the curtain!"

The puppet show consisted of a familiarization phase and an action phase. The purpose of the familiarization phase was to show infants that each puppet had the goal of crossing the stage. In Experiments 1-3, in the familiarization phase infants first saw one puppet cross the stage alone. Then they saw the other puppet cross the stage in the opposite direction, also alone. In Experiment 4, the familiarization phase was the same (each puppet crossed the stage alone) except that the puppets both crossed in the same direction. Each infant was shown the first puppet’s familiarization sequence (i.e., crossing the stage alone, over and over again) until they looked away for at least half of the sequence, as judged by the puppeteer who could see the infant’s gaze through the curtain. Then, the infant was shown the other puppet’s familiarization sequence the same number of times as the first. Next, the infant was shown the action phase until they looked away for more than half of the sequence. That is, the entire action phase was repeated (with the curtains going up and down in between segments) until the puppeteer, who could see the infant's gaze through the curtain, judged that the infant was looking away for more than half the sequence. If the puppeteer was unsure, during any sequence, whether the infant looked away for more than half of the sequence, they repeated the sequence one more time.

In all experiments, one puppet at a time was visible during the familiarization phase and both puppets were visible during the entire action phase. The directions traveled by the puppets across the stage, the order in which the puppets crossed the stage, and the specific puppet assigned to play each role were counterbalanced. After the puppet show came the choice procedure. First, an experimenter who was blind to the condition (i.e., had not seen the puppet show and did not know which puppet had 'won') asked the parent to close his or her eyes. The experimenter then held one puppet in each hand, approximately 12 inches apart. (The puppets' positions were counterbalanced so that the 'winner' was on the infant's right for half of the participants). The experimenter made sure to hold the puppets so that each was equally close to the infant, and the infant could reach either one easily. Then the experimenter looked at the child and said, "Hi! Look!" and looked down, fixing her gaze directly in the center of two puppets. Then the experimenter said, "Which one do you like?" and moved the puppets toward the infant so that the infant could reach them (See Figures S1 and S2). If the infant reached simultaneously for both puppets (one with each hand), the trial was coded 'both.' If the infant chose neither puppet, the procedure was repeated. If after three times the infant had made no choice, the trial was coded 'no response.' These exclusion criteria, along with others described below, were decided after pilot testing and before we started data collection for Experiment 1.

The choices of the infants were recorded on a written data sheet, at the time of the experiment. Later, a research assistant who was blind to which role each puppet had played coded the child's choice again (as, e.g., 'both,' 'neither,' 'yellow puppet,' or 'red puppet') by watching the video of the choice procedure. In cases where these two pieces of information disagreed (i.e. the written answer said, 'red' and 'chose winner'), the video coder would re-watch the entirety of the video to check the other aspects of the puppet show, and a third research assistant who was blind to the condition coded the choice. Some parents did not wish for their children to be video recorded. In these cases we relied on the written notes taken by the experimenter at the time of testing.

Data for Experiment 2 was collected in the same session as data for Experiment 5 and Data for Experiment 4 was collected in the same session as data for Experiment 6 . In each two-experiment session, the infant first watched one puppet show and chose a puppet during the choice procedure. Then, after a short break, infants watched the second puppet show and chose between the new pair of puppets. *(The second experiment always featured different puppets and a different puppet show than the first one.)* The order of experiments was counterbalanced across infants, and the order did not affect infants' choice of one puppet or the other. (Experiment 2: Bayes Factor of 8.70 in favor of the null hypothesis that the distributions of choices were the same for both orders; Experiment 4: Bayes Factor of 3.68 in favor of the null hypothesis). All data can be found in Data S1, this data and videos of all experiments can be found here: https://osf.io/nyefd/ as well as in the supplementary information .

Sampling Strategy

We used a flexible stopping rule where we checked the Bayes Factor after each testing session. (Sessions included anywhere from 1 to 12 infants; the average was around 3.) We stopped testing when we had a Bayes Factor of 7 or greater in either direction (i.e., either for or against our original hypothesis). Note that although frequentist statistical analyses do not allow for preferential stopping, Bayesian analyses do (Csibra, Hernik, Mascaro, Tatone, & Lengyel, 2016; Schönbrodt & Wagenmakers, 2017). We also included frequentist analyses for those readers unfamiliar with Bayesian methods. We chose to collect a sample of at least 20 children per experiment even when a Bayes Factor of 7 or higher was reached before that. This was decided after we ran the first experiment and before we ran the replication or the subsequent experiments. We reasoned that sample sizes of at least 20 would be reassuring to readers unfamiliar with Bayesian methods.

Exclusion Criteria

An infant's data were excluded for the following reasons: if they chose both puppets or chose neither puppet; if there were experimenter errors (e.g. orienting a puppet incorrectly during the puppet show, or forgetting to remind the parents to close their eyes); if there was interference by a sibling or parent;or for disturbances in the testing environment (e.g., if a museum maintenance person entered the testing room during the session). These exclusion criteria were the same as those used in our earlier study with toddlers [34] and decided before the data collection began.

Materials

The puppet stage used in all experiments was 75 cm tall, 32.5 cm deep, and 95 cm long. It sat on a folding table covered with black fabric. There were black curtains hanging at the left and right sides of the stage, and a black curtain was used to cover the stage between scenes. Another black curtain behind the stage hid the experimenter who was manipulating the puppets. This curtain had two layers, which the puppeteer sat between. Another piece of black cloth hung behind the puppet stage. This allowed the puppeteer to see the infant while remaining hidden from view. The puppeteer wore black clothing, with long sleeves pulled down to hide her hands.

The puppets used in all experiments were 12.5 cm tall and made of polymer clay. Each had one plastic craft eye with a fixed pupil (so that the puppet always seemed to be looking straight ahead) and a rectangular piece of black electrical tape forming a mouth (See Figure S1

). In all experiments except 1b, one puppet was a yellow oval and the other was a red square. In Experiment 1b, one puppet was an orange triangle and the other was a green hexagon. A black wooden dowel was attached to the back of each puppet and used to move it across the stage. An identical pair of puppets were used for the choice procedure and were hidden from view until the choice procedure, which came after the puppet show.

Procedure

Experiment 1

The puppet show began with a familiarization phase, during which each puppet appeared alone at one end of the stage and crossed to the other side. After the first puppet crossed twice, the second puppet appeared at the other end of the stage and crossed twice in the other direction. The purpose of this was to show children that each puppet's goal was to cross the stage in a particular direction. This whole sequence of 4 crossings (2 in one direction, 2 in the other) was repeated until the infants looked away for at least half of the sequence (as judged by the puppeteer who could see the gaze of the infant from behind the curtain) or a maximum of ten times. If the puppeteer was unsure whether the infant looked away for more than half the time (e.g. if the infant looked away at the beginning and end of the sequence but watched the middle part), she repeated the sequence. Videos of the puppet shows for all experiments can be found at https://osf.io/nyefd/ .

Next came the action phase of the puppet show, when the two puppets appeared on opposite ends of the stage and tried to cross at the same time. The puppets met in the middle and bumped into each other. Then both puppets backed up and tried to cross the stage again, bumping again in the middle. This bumping-and-backing-up sequence was repeated five times. On the sixth approach, the puppets stopped short of meeting in the middle and one puppet yielded the way to the other: The yielding puppet made a 'bowing' motion by rotating 90 degrees (so that its eye faced downward) and then moved upstage, clearing the way for the other puppet. The other puppet then passed in front of the yielding puppet and continued across the stage (see Figure 1). This action phase was repeated until the infant looked away for more than half of the sequence, and at least 3 times and no more than 10 times. Again this was judged by the puppeteer who could see the infant's gaze.

After the puppet show ended, we asked infants which puppet they liked. To do this, an experimenter who had not seen the puppet show held out both puppets toward the infant and said, 'Hi, look, which one do you like?' The dependent measure was which puppet the infant reached for. This was the same choice procedure used in previous experiments [41,42] (See Figure S1).

Experiment 1b: Replication of Experiment 1

Experiments 1b and another experiment with different puppets were conducted in the same session, in counterbalanced order. There was no effect of experiment order. In Experiment 1b the puppets were an orange triangle and a green hexagon. The Experiment 1b puppet show was the same as the puppet show in Experiment 1 except that it used different puppets.

Experiment 2

This experiment was the same as Experiments 1 and 1b, except that the puppet show was stopped as soon as one puppet yielded the way. The curtains closed with the other puppet still standing at center stage. Experiment 2 was conducted in the same session as another experiment (not reported here) that used different puppets (plush toys) (See Figure S2). Experiment 2 used the same puppets as Experiment 1. During one session, the experimenter mistakenly used the orange triangle and green hexagon from Experiment 1b instead of the yellow oval and red rectangle from Experiment 1; we included these data and made a note on the data sheet.

Experiment 3

This puppet show began the same way as in Experiments 1,1b and 2, with a familiarization phase where each puppet crossed the stage, followed by an action phase where two puppets attempted to cross in opposite directions at the same time, and wound up blocking each other's path. In this experiment, one puppet bowed and moved aside, the other puppet crossed in front of it and continued to the other side of the stage, and then (unique to this experiment) the bowing puppet 'stood up' (i.e., rotated back up until it was facing forward again) and continued across the stage. Thus, one puppet still yielded to the other, but both eventually reached their goals.

Experiment 4

In Experiment 4, we used the same clay block puppets (a red rectangle and a yellow oval) as in Experiments 1, 2 and 3. However, for three of the participants the experimenter accidentally used the orange triangle and the green hexagon used in Experiment 2 (the data were included; this is noted on the data sheet). Experiment 4 was conducted in the same session as another experiment that involved plush puppets. The experiments were presented in counterbalanced order; there was no effect of experiment order on children's responses The Experiment 4 familiarization phase was the same as those in Experiments 1, 1b, 2, and 3, except that both puppets crossed the stage in the same direction. During the action phase of the show, the puppets both appeared, at the same time, at one side of the stage. Then, one of the puppets moved forward, stopped at center stage, and made the yielding motion from Experiments 1-3 by bowing down and moving aside. Then the other puppet came from behind the first one, crossed in front of it and continued across the stage. This scene replicated the movements from Experiment 1 in many ways (detailed in the main text) but lacked any overt conflict between the puppets.

Experiment 5

Experiment 5 was conducted in the same session as Experiment 2, in counterbalanced order. The materials were the same as in Experiments 1-4, but instead of the clay puppets used previously, we used two plush puppets: A monkey (https://www.amazon.com/Folkmanis-2123-Monkey-Hand-Puppet/dp/B00000K1Y9) and a dinosaur (the dinosaur puppet was used in previous experiments in the lab and purchased around 10 years ago. Similar ones can be purchased on ebay by searching 'animal alley' dinosaur') (See Figure S2). We also used a rattle that was approximately 4" wide and made a jingling noise when shaken.

The puppet show started with a familiarization phase: One puppet appeared alone at one side of the stage. It moved to center stage, picked up a rattle that lay in the middle, took the rattle back to its side of the stage and shook it to make a noise. Then the puppet returned the rattle to center stage, then the curtain went up. Then a second puppet appeared at the other side of the stage and repeated the same actions. Next came the action phase. Both puppets appeared simultaneously on opposite sides of the stage. They both approached the rattle, picked it up together, and pulled it back and forth as if struggling over it. Then the puppets both put down the rattle together, and each moved back toward its own side of the stage, where they jumped up and down several times as if in frustration. This 'struggle' sequence was repeated three times. On the fourth time, both puppets approached the rattle again, but one puppet appeared to 'yield' by backing away and bowing its head. The other puppet picked up the rattle, went back to its side of the stage, and shook the rattle before the curtain closed on the scene.

Experiment 6

Experiment 6 used the same plush hand puppets as in Experiment 5 (See Figure S2). The materials were the same as those used in Experiment 6, except that the action phase included a barrier (a magazine holder, approximately 24x8x32 cm, covered with white paper).

The familiarization phase and the first part of the action phase (where the puppets took turns picking up the rattle) were the same as in Experiment 5. But then, unlike in Experiment 5, a barrier appeared at center stage, blocking one puppet's access to the rattle. The puppets carried out the final sequence of the action phase with one puppet—the one who could reach the rattle—picking it up and shaking it, and the other puppet (who could not reach the rattle because of the barrier) making the same 'yielding' motions as in Experiment 5.

QUANTIFICATION AND STATISTICAL ANALYSIS

Software

To calculate Bayes Factors we used the proportionBF function in the BayesFactor package in R https://richarddmorey.github.io/BayesFactor/ [55] with a null value of p=.5. We decided to use this package and its default priors before data collection began. To calculate the one-sided Bayes Factors, we used the Bayesian Binomial Test in JASP https://jasp-stats.org/ [56], again with default priors and with the null hypothesis being '< Test value' and the test value was .5. To calculate p-values, we used the binom.test function in R . Data for all experiments can be found here: https://osf.io/nyefd/ and Data S1. To calculate Bayes Factors we used we used the proportionBF function in the BayesFactor package in R https://richarddmorey.github.io/BayesFactor/ [55]. To calculate the one-sided Bayes Factors, we used the Bayesian Binomial Test in JASP https://jasp-stats.org/ [56].

DATA AND SOFTWARE AVAILABILITY

Data for all experiments can be found here: https://osf.io/nyefd/ and Data S1.

Data S1. Data from all experiments. Related to Figure 4.

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