Supporting Online Material

Big and Mighty: Preverbal Infants Mentally Represent Social Dominance

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MATERIALS AND METHODS

Experiment 1: Conflicting Goals

Participants

Sixteen 11-16 month-old infants (mean age 14 months and 4 days, *SD*=63 days, 6 female) were recruited in the Boston Children's Museum exhibit and play areas to participate in the study conducted in the MIT PlayLab within the museum. The participants reflected the social class and ethnic make-up of visitors to the Children's Museum; largely middle-class and roughly 60% non-Hispanic white. An additional 21 infants were excluded from the sample because they did not watch the screen during both sequences when one of the agents bowed down (*n*=12), fussed out (*n*=4), or because of parent or sibling interference (*n*=5).

Procedures

A parent was present for all infants during the whole testing session, and infants received an MIT sticker and certificate upon completion of the study. The study had been approved for conducting research with infants by Harvard University's Committee for Use of Human Subjects as well as by the Boston Children's Museum.

The infants and parents were brought into the testing room where the experimenter explained the study in detail and the parent gave informed written proxy consent on behalf of the children. Parents were instructed not to speak or direct the attention of the infants. Parents of infants in the Conflicting Goals condition were instructed to close their eyes for the remainder of the study when they first saw two agents together on the stage and parents of infants in the Control Condition were instructed to close their eyes when one of the squares starting bumping back and forth.

Infants were seated at their parent's lap approximately 1.20 meters from a COBY 32 inch flat-screen monitor where they watched a series of animations, controlled from an adjacent room. After consent and calibration, where the experimenter used her keys to make the infant look at all four corners of the screen for subsequent recoding of the testing session, the experimenter left the room to start the first animation trial.

The unfamiliar agents in the trials were two blocks of different sizes, one green and one blue, each with an eye and a mouth. There were three types of trials (4 familiarization trials, 1 inter-trial, and 2 test trials). Each trial was terminated by the experimenter whenever the infant looked away for more than 2 seconds, and each trial was preceded by a 2 second attention getter of a laughing baby bouncing gently in the middle of the screen, developed by Raphael Castaneda (UCLA Infant Perception Lab).

Familiarization. During familiarization trials, which were identical across the two experiments, infants watched a single agent begin on one side of the platform (e.g., the large agent begins on the right side during one familiarization trial; the small agent begins on the left side during the other familiarization trial) and bounce gently to the other side. Each familiarization trial consisted of at most four repetitions of the same event, looped, or until the infant looked away. The familiarization trials established that each agent had the goal of moving to the opposite side of the platform from where it started.

Inter-trial. The inter-trial consisted of both agents simultaneously beginning from their respective beginning positions, moving toward each other as if to get to the other side. Each blocked the other's previously established path. They stopped before hitting each other, paused momentarily, and then moved on and bumped into each other, backed up, and approached again for a total of three times. The inter-trial served to highlight the conflict between the two agents' goals being simultaneously realized.

Test trials. Two test events followed, with order counterbalanced across participants. The test trials began the same as the inter-trial, with the agents approaching each other, stopping and backing up a bit. On one of the test trials, the small agent bowed forward, lying down, and scooting sideways out of the way, upon which the large agent continued on its path to the end of the stage. The other test trial was identical, except that the large agent prostrated itself and scooted sideways, and the small agent continued on its path to the end of the stage. After this sequence of 19.1 seconds, the animations froze for 60 seconds. Time was measured from the point at which the animation froze until the infant looked away from the display.

Materials

Counter-balancing. The color, presentation order, and side of entry of the agents during familiarization as well as the order of test events (big yields for small or small yields for big) were fully counter-balanced across participants, resulting in 16 different counter-balance conditions within each of the Conflicting Goals and Control conditions.

Recording of animations. All animations were recorded using Macromedia Flash 8 Professional. The stage on which the animations were built was 550 x 400 (width x height) pixels. The stage contained three objects: a small agent, a large agent, and a platform on which the agents interacted. The unfamiliar agents were two blocks of different sizes, one green and one blue, each with an eye and a mouth. The platform was recorded at a size of 540 x 111.5 pixels.

The left and right side of the platform extended inwards to a point at the horizon to create the perception of depth; the platform also contained five depth lines extending to the horizon. The size of the large agent was 72 x 108 pixels, and the small agent was 36 x 54 pixels. The large agent was thus exactly two times bigger than the small agent. One agent would always be Blue (Flash Color Code #0000CC; Alpha=100%), and the other agent Green (Flash Color Code #338D08; Alpha=100%). Both agents had one eye and a mouth; for the large agent the eye was 36 x 36 pixels and the mouth 31 x 7 pixels, for the small agent the eye was 26 x 25.5 pixels and the mouth 12.5 x 3.5 pixels. All animations were recorded at frame rate 12 fps. The familiarization clips comprised of 120 frames (9.9 s); followed by a frame-freeze of 20 frames (1.6 s), and a black screen covering the entire stage for 20 frames (1.6 s). The inter-trials comprised 140 frames (12.4 s); followed by a frame-freeze of 20 frames (1.6 s), and a black screen of 20 frames (1.6 s). The test trials (both the expected and the unexpected test trials) comprised of 230 frames (19.1 s); followed by frame-freeze of 630 frames (60 s), and a black screen of 20 frames (1.6 s).

Display. After being recorded in Flash, the clips were exported to QuickTime player (.MOV format) for display to 1375 x 1000 inch (width x height). They were presented on a COBY 32 Inch flat-screen monitor of size 32.01 x 9.68 x 24.38 inch (width x depth x height). The recording, exporting, and displaying of the clips in the *Control Condition* was identical to the *Conflicting Goal Condition*; except that in the *Control Condition* there was only one agent on the stage (either Small or Big), as the other agent had been removed.

Coding

The experimenter blind-coded all testing sessions online in the museum so as to move on to the next trial whenever the participating infant met the look-away criterion of 2 seconds. All testing sessions were recorded with EyeTV for subsequent re-coding in the Harvard Laboratory for Developmental Studies using the computer program xhab64 (*S1*). This re-coding was completed by two independent undergraduate research assistants who were blind to the animations displayed to the infants. These re-coded looking-times across all trials and participants equaled $r = .99$ and their average inter-coder agreement, measured at a rate of every tenth of second, equaled .92 across all trials and participants. On no occasion had the trial been terminated by the experimenter before the trial should have been terminated according to the subsequent coding by the undergraduate research assistants. Only the data from this subsequent coding by the most experienced of these undergraduate research assistants, who coded all test trials, was used in the results.

During the experimental session, looking-times to the test trials were coded from the point at which the agent bowed. Watching this sequence also served as the inclusion criterion for the sample. To meaningfully compare data across experiments with animations of slightly different lengths, for all analyses we computed looking-times to the animations once they had frozen to still pictures. Looking times in test trials where the infant had met the inclusion criterion of watching the bowing sequence, but had looked away before the animation froze were set to zero. This was the case for 4/32 looking times to test trials in Experiment 1 (1/16 unexpected trials and 3/16 expected trials).

Experiment 2: Developmental Onset of Conflicting Goals Effect

Participants

Participants were 64 infants from the greater Cambridge, Massachusetts area. The participants were contacted by letter using birth records from the towns immediately surrounding Cambridge, MA. The participants reflected the population of families who replied after having been so contacted. They were largely college-educated, over half with graduate degrees and approximately 80 % Non-hispanic Caucasian.

Sixteen 8-month-olds (average age 8 months and 14 days; *SD*=7 days; 11 female) participated in the study, and an additional 3 infants we excluded from the sample due to parental interference (1) or because they did not watch the test events (1) or fussed out (1). Sixteen 9-month-olds (average age 9 months and 15 days, *SD*=9 days; 9 female) participated in the study, and an additional 4 infants were excluded from the sample due to parental interference (1) or because they did not watch the test events (1) or fussed out (2). Sixteen 10-month-olds (average age 10 months and 11 days; *SD*=6 days; 12 female) participated in the study, and an additional 5 10-month-olds were excluded from the sample because of general fussiness (2) or because they did not watch the screen during both test trials (3). Sixteen 12-13 month olds (average age 13 months, 6 days; *SD*=14 days; 9 female) participated in the study and an additional twenty 12-13 month old infants were excluded from the sample because of parental interference (5), general fussiness (9), or because they did not watch the screen during both test events (6).

Procedure and materials

Infants were tested at the Laboratory for Developmental Studies at Harvard University. Infants in the suitable age range were identified in the lab's database and recruited via telephone. A parent, who gave written informed consent, was present for all infants during the whole testing session. Families received a small toy and $5 travel compensation upon completion of the study.

The infants and parents were met in the parking lot at Harvard University and accompanied to the waiting area of the Laboratory for Developmental Studies. Here, the experimenter explained the study to the parent who gave informed proxy consent on behalf of the infants. Parents were instructed not to speak or direct the attention of the infants and to close their eyes for the remainder of the study when they first saw two agents together on the stage.

Next, infant and parent were accompanied to the testing room and the infant was seated on the parents lap in a chair approximately 1.20 meters from a 30-inch Apple HD Cinema Display monitor of size 27.2 x 8.46 x 21.3 inch (width x depth x height).

After calibration, where the experimenter used a colorful rattle to make the infants look at all corners of the screen, the experimenter hid behind a curtain to control the animations of the Conflicting Goals condition only. These animations were exported to a size of 1238 x 800 inch (width x height).

Again, each trial was terminated whenever the infant looked away for more than 2 seconds. Instead of a recorded attention getter, the experimenter lowered a curtain in front of the screen between trials and squeezed a squeaky toy once at the beginning of each trial. To maximize the likelihood that infants would watch the screen during the crucial bowing events, the experimenter (blind to the presentation order of test events at the first test trial) also squeezed the toy twice right before the bowing event in the test trials. All testing sessions were recorded and stored in iMovie.

Coding

All testing sessions were independently blind-coded live by two undergraduate research assistants, blind to the animations that were displayed, using the xhab64 coding program. Their coded looking-times were correlated $r = .98$ across all trials and participants and their average inter-coder agreement, sampled every tenth of a second, equaled .93 across all trials and participants. Only data from the most experienced coder, whose codes were used to pace the study, are reported in the results.

Again, during the experimental session, looking-times to the test trials were coded from the point at which the agent bowed. Watching this sequence also served as the inclusion criterion for the sample. To meaningfully compare data across experiments with animations of slightly different lengths, for all analyses we computed looking-times to the animations once they had frozen to still pictures. Looking times in test trials where the infant had met the inclusion criterion of watching the bowing sequence, but had looked away before the animation froze were set to zero. This was the case for 6/32 looking times for 8-month-olds (6/16 expected trials expected trials), 6/32 looking times among 9-month-olds (1/16 unexpected, and 5/16 expected trials) 1/32 looking-times (1/16 expected trial) among 10-month-olds and none among 12 & 12 month-olds.

Experiment 3: Isolated Motion

Participants

Sixteen 11-16 month-old infants (mean age = 14 months and 0 days, *SD*= 45 days, 4 female) were again recruited in the MIT Play Area of the Boston Children's Museum, using the same recruitment procedures as Experiment 1. An additional 19 infants were excluded from the sample because they did not watch the screen during the crucial test event (*n*=12) or fussed out (*n*=7)

Procedures

The general procedures were identical to those of Experiment 1, save that the following experimental stimuli was presented to the infants:

After the familiarization trials, which were identical to those of Experiment 1, two different inter-trials were presented. Each agent was shown separately, undergoing the motion it did in the inter-trial of the Conflicting Goal condition (i.e., approaching the other side, as usual, stopping in the middle, backing up, approaching the middle, backing up, for a total of 3 repetitions). The presentation order of the inter-trial was the same as that of the test events.

The test events were identical to those of the Conflicting Goal trials, except that only the agent that prostrated was present in the animation. Thus babies watching the *Isolated Motion* trials saw both the large agent or the small agent undergo the exact same bowing and scooting as did the babies watching the *Conflicting Goal* trials, but the behavior was not in the context of enabling another agent to attain its goal. Since the agent that was removed from the Isolated Motion Experiment was the agent who continued its path to the end of the stage after the other agent had scooted to lie still at the back of the stage in the Conflicting Goals Experiment, the duration of motion in the Isolated Motion Experiment was shorter. More precisely, the animations in the Isolated Motion Experiment froze to a still frame after 13.2 seconds.

As was the case in Experiment 1, an electronic beep was built into the animations right before the crucial test event, when bowing took place, at which point the coders started coding. Watching during the bowing sequence was also the criterion for including infants in the sample.

Materials

The counter-balancing, recording, and presentation of stimuli were identical to Experiment 1.

Coding

Coding procedures were identical to Experiment 1. The two undergraduate coders correlated at *r*=.99 and they agreed 91% of the time, sampled 10 times every second. Only data from the most experienced of these undergraduate coders who recoded the videos were used for the results. On no occasion had the experimenter terminated a trial before the subsequent coding indicated that the trial was over when recoding the video.

Again, during the experimental session, we coded looking times from the point at which the infant met the inclusion criterion of watching the focal agent bow. To meaningfully compare looking times across experiment, for all analyses we computed looking times once animations had frozen to stills. Since the agent that was removed from the Isolated Motion Experiment was the agent who continued its path to the end of the stage after the other agent had scooted to lie still in the back of the stage in the Conflicting Goals Experiment, there was motion in the Isolated Motion Experiment for a shorter period of time. More precisely, the animations in the Isolated Motion Experiment froze to a still frame after 13.2 seconds. Looking times in test trials where the infant had met the inclusion criterion of watching the bowing sequence, but had looked away before the animation froze were set to zero. This was the case for 7/32 looking times in the Isolated Motion Experiment (3/16 unexpected and 4/16 expected trials).

Experiment 4: Motion Behind

Participants

Sixteen 10-month-old infants (average age 10 months and 17 days; *SD*=6 days; 9 female) from the greater Cambridge, Massachusetts area participated in the study. They were recruited from the same population of families as participants in Experiment 2, using the same contact procedures. An additional 6 infants were excluded from the sample because they did not watch the screen during the crucial test event (*n*=4) or fussed out (*n*=2).

Procedures

The general procedures, lab setting, and display of stimuli were the same as in Experiment 2, save that the following experimental stimuli was presented to the infants:

Familiarization. Infants again watched each block in turn walking across the stage on its own as in the conflicting goals trials, but here the blocks each walked in the same direction (i.e. both walked left to right or they walked right to left). Again each trial, consisting of one block walking across the stage, was looped four times, and the sequence of the two different trials was repeated such that infants watched a total of four familiarization trials.

Inter-trials. Two inter-trials followed. In the first inter-trial one of the blocks (e.g. the large one) would again appear and walk across the stage (e.g. in a left to right direction) and come to halt on the right-most side, after which the other block (e.g. the small one) would appear to on the left-most side of the stage, such that it was standing at the opposite side of the stage, behind the back of the large block. The other inter-trial reversed these roles.

Test trials. The test trials again began by repeating the events taking place in the inter-trials. They were linked to the order of presentation of the inter-trials such that if the large agent walked across the stage and the small agent appeared behind its back in the first inter-trial, the first test trial began in the same way. In the *unexpected test trial,* the small agent appeared first and walked across the stage before coming to stop. Next, the large agent appeared at the beginning of the stage, walked across to the middle of it and then performed the exact same bowing and scooting away motion, at the exact same place as when it bowed and scooted away for the small agent in the conflicting goals test trials. The only difference was that in the present Motion Behind control, this motion was performed behind the back of the other, small agent, rather than in front of it, such that there was no social interaction and no conflicting goals, although both agents were present on stage, providing salient, simultaneous relative size information to the infants. The *expected test trial* reversed these roles such that the large agent first appeared and walked across the stage, after which the small agent appeared, walked to the middle of the stage behind its back, and bowed and scooted away.

The experimenter (blind to presentation order on the first test trial) double-squeaked a squeaky toy right before the crucial test event, when the agent began to bow, at which point the coders started coding. Watching during the bowing sequence was also the criterion for including infants in the sample.

Materials

Counter-balancing. The color, presentation order, and side of entry of the agents during familiarization as well as the order of test events (Big bows behind the back of Small, or Small bows behind the back of Big) were fully counter-balanced across participants, resulting in 16 different counter-balance conditions.

Recording of animations. All animations were recorded using Macromedia Flash 8 Professional. The stage on which the animations were built was 550 x 400 (width x height) pixels. The stage contained three objects: a small agent, a large agent, and a platform on which the agents interacted. The agents were two blocks of different sizes, one green and one blue. The platform was recorded at size 540 x 111.5 pixels. The left and right side of the platform extended inwards to a point at the horizon to create the perception of depth; the platform also contained 5 depth lines extending to the horizon. The large agent was recorded at size 72 x 108 pixels, and the small agent at size 36 x 54 pixels. The large agent was thus exactly two times bigger than the small agent. One agent would always be Blue (Flash Color Code #0000CC; Alpha=100%), and the other agent Green (Flash Color Code #338D08; Alpha=100%). All animations were recorded at frame rate 12 fps.

In the first two familiarization trials, when the agents walked across to the end of the stage, the clips comprised of 125 frames (10.4 s), followed by a frame-freeze of 20 frames (1.6 s), and a black screen covering the entire stage for 20 frames (1.6 s). In the 3rd and 4th familiarization trials, when the agents walked to the middle of the stage, the clips comprised of 58 frames (4.8 s): followed by a frame-freeze of 87 frames (7.2 s), and a black screen covering the entire stage for 20 frames (1.6 s). Thus, in both familiarization conditions the agents were visible to the infants for an equal amount of time (12.0 s). The inter-trials comprised of 188 frames (15.6 s) followed by a frame-freeze of 17 frames (1.4 s), and a black screen of 20 frames (1.6 s). The test trials (both big bows behind small and small bows behind big) comprised 247 frames (20.5 s): followed by frame-freeze of 719 frames (59.9 s), and a black screen of 20 frames (1.6 s).

Coding

We set the inclusion criterion so that infants must watch the animation at the point at which the focal agent began to bow, and again during the experimental session we coded looking-times from this point. In order to meaningfully compare looking-times across experiments with animations of slightly different lengths, we computed looking times for all analyses from the point at which the animations had frozen to stills. Looking times in test trials where the infant had met the inclusion criterion of watching the bowing sequence, but had looked away before the test trial animations froze were set to zero. This was the case for 2/32 looking times (1/16 unexpected and 1/16 expected test trial)

Experiment 5: Occlusion

Participants

Participants were 32 10-13 month-old infants from the greater Cambridge, Massachusetts area. They were recruited from the same population of families as participants in Experiment 2, using the same contact procedures

Sixteen 10-month-olds (average age 10 months and 10 days, *SD*=13 days, 9 female) participated in the study. An additional 3 infants were excluded from the sample because they did not watch the screen during the crucial test events (*n*=2) or fussed out (*n*=1). Sixteen 12 & 13-month-olds (average age 12 months and 20 days, *SD*=15 days, 10 female) participated in the study. An additional 7 infants were excluded from the sample because they did not watch the screen during the crucial test events (*n*=5) or fussed out (*n*=2).

Procedures

The general procedures were the same as in Experiment 2, save that the following experimental stimuli was presented to the infants:

Familiarization. In familiarization trials 1 and 2, infants watched a large and small block, with *no* eyes or mouth, glide across the stage on their own, in turn and in opposite directions. We eliminated the bouncing movement from the conflicting goals trials to further minimize agency cues, but the blocks followed the same path with the same speed as in the conflicting goals trials. In the third and fourth familiarization trials, infants instead watched the blocks lying down in the back of the stage where they again glided across the stage and came to stop half-way across it, at the exact place where the yielding block comes to a stop in the conflicting goals scenarios. The size of the blocks gliding in the back track in the 3rd and 4th familiarization trials also exactly matched the size of the yielding block in the conflicting goals test trials, once it has withdrawn to the back of the stage.

Inter-trials. The inter-trials consisted of two still pictures, setting the scene for the full versus partial occlusion to take place in test. One inter-trial showed the large block lying down half-way across the stage in the back track, and the small block standing up to the side of the stage in front track, ready to glide across it. The other inter-trial reversed these roles.

Test trials. Two test trials followed, designed to mimic the partial versus full occlusion confounded with Big versus Small agent yielding in the conflicting goals trials. The *unexpected test trial* mimicked the partial occlusion inherent in the unexpected conflicting goals test trial when the big block bows down and scoots away to the back of stage, before it is passed by the small block continuing its path to the end of the stage. In the present test trial, the big block (with no eyes nor mouth) was instead already lying down half-way across the stage in the back and the small block glided across the stage in the front track, with the same speed as in the conflicting goals scenario, exactly mimicking the partial occlusion. The *expected test trial* instead reversed the roles such that the small block was lying down half way across the stage in the back track and the large block glided across the stage in the front track, exactly mimicking the full occlusion inherent in the expected conflicting goals test trials.

The experimenter (blind to presentation order at the first test trial) double-squeaked a squeaky toy right before the crucial test event, when occlusion took place, at which point the coders started coding. Watching during the occlusion phase was also the criterion for including infants in the sample.

Materials

In the first familiarization trial, one block glided smoothly across the stage from one end to the other and this sequence was again looped four times, separated by a black screen of 20 frames. In the second familiarization trial, again looped four times, the other block glided across the stage in the opposite direction. In both trials the blocks moved the same distance across the stage, where they would lay in view for 20 frames. These clips comprised 120 frames (9.9 s): followed by a frame-freeze of 20 frames (1.6 s), and a black screen covering the entire stage for 20 frames (1.6 s).

In the third and fourth familiarization trials, the blocks were lying down in the background of the stage and glided, lying down, across the stage to the exact place where they would come to a halt when scooting away in the Conflicting Goals scenarios. Here, the large block was recorded at size 48 x 72 pixels and the small block was recorded at size 24 x 36 pixels, exactly matching the size of the blocks after they have scooting away and come to a halt in the Conflicting Goals trials. In both trials the blocks moved the same distance to the middle of the stage, where they would lay in view for 20 frames. The animation clips for the third and fourth familiarization trials, that were again looped four times, comprised of 45 frames (3.7 s), followed by a frame-freeze of 20 frames (1.6 s), and a black screen covering the entire stage for 20 frames (1.6 s).

The inter-trials comprised of 170 frames (14.1 s) followed by a black screen of 20 frames (1.6 s). The test trials (both big occludes small and small occludes big) comprised 120 frames (9.9 s): followed by frame-freeze of 693 frames (57.8 s), and a black screen of 20 frames (1.6 s).

The clips were exported from Flash to QuickTime and stimuli were presented to infants in an identical manner to Experiment 2.

Coding

Again, we measured looking times from the point at which the inclusion criterion took place, which was from the beginning of the occlusion sequence. To meaningfully compare looking-times across experiments with animations of slightly different lengths, we also computed looking-times once the animations had frozen to stills. Looking times in test trials where the infant had met the inclusion criterion of watching the bowing sequence, but had looked away before the test trial animations froze were set to zero. This was the case for 13/32 looking times for 10-month-olds (5/16 unexpected test trials and 8/16 expected test trials) and 11/32 trials among12 & 13- month-olds (6/16 unexpected trials and 5/16 expected trials).

SUPPORTING TEXT (SUPPLEMENTARY RESULTS)

Experiment 1 (Conflicting Goals)

Infants' looking times decreased across the four familiarization trials, indicating that they were encoding the events ($M_{\text{familiarization 1}}$ = 40.2 seconds, $M_{\text{familiarization 2}}$ = 28.6, $M_{\text{familiarization 3}}$ = 24.2, $M_{\text{familiarization 4}}$ = 22.1; linear contrast $F_{(1,14)} = 18.23$, $p = .001$, partial $\eta^2 = .57$). Unfortunately, video was not recorded during all familiarization trials for one infant who was excluded from these analyses.

A repeated-measures ANOVA with test trials (Unexpected:Big Yields, Expected:Small Yields) varied within subjects and order of presentation (Unexpected presented first, Expected presented first) varied between subjects showed no main or interactive effects of presentation order on looking times to the test trials.

Experiment 2 (Developmental Onset of Conflicting Goals Effect)

Infant looking-times decreased across the familiarization trials ($M_{\text{familiarization 1}}$ = 26.5 seconds, $M_{\text{familiarization 2}}$ = 21.2, $M_{\text{familiarization 3}}$ = 15.1, $M_{\text{familiarization 4}}$ = 16.3, linear contrast $F_{(1,60)} = 27.31$, $p < .0005$, $\eta^2 = .31$), indicating that infants were encoding the information in the familiarization trials. Degree of decrease was unrelated to infant age and to presentation order of the subsequent test trials, indicating that all groups of infants encoded the familiarization stimuli. Indeed, planned follow-up linear contrasts confirmed that looking-times significantly decreased within 8-month-olds ($F_{(1,13)} = 9.28$, p=.009; $\eta^2 = .42$), 9-month-olds ($F_{(1,14)} = 6.43$, p=.024; $\eta^2 = .32$), 10-month-olds ($F_{(1,14)} = 9.47$, p=.008; $\eta^2 = .40$), and 12&13-month-olds ($F_{(1,13)} = 6.62$, p=.023; $\eta^2 = .34$). Unfortunately, the video signal was not recorded for the full duration of the first familiarization trial for one 8-month-old and one 13-month-old infant who were excluded from these analyses.

There was a main effect of age, such that the general looking times to both test events increased with age ($M_{\text{8-month-olds}}$=7.1, $M_{\text{9-month-olds}}$=9.3, $M_{\text{10-month-olds}}$=18.1, $M_{\text{12\&13-month-olds}}$=23.5; $F_{(3,56)}$=10.19, p<.0005, η^2=.35).

Experiment 3 (Isolated Motion)

Infants' looking times decreased across the four familiarization trials, indicating that they were encoding the events ($M_{\text{familiarization 1}}$ = 29.79 seconds, $M_{\text{familiarization 2}}$ = 25.19, $M_{\text{familiarization 3}}$ = 21.99, $M_{\text{familiarization 4}}$ = 19.75; linear contrast $F_{(1,12)} = 5.35$ $p = .001$, partial $\eta^2 = .31$). Unfortunately, video was not recorded during all familiarization trials for three infants who were excluded from these analyses.

Pooling the data, across the Experiments 1 and 3, looking times to each of the identical familiarization trials (i.e., trial 1, trial 2, trial 3, and trial 4) did not differ across the two experiments (Conflicting Goals, Isolated Motion), ruling out any pre-existing group differences in general length of looking. Degree of *decrease* in looking during familiarization was also unrelated to experiment or presentation order of the subsequent test trials, ruling out differences between studies in whether infants encoded the identical familiarization stimuli.

A repeated-measures ANOVA that varied test trials (Big Yields, Small Yields) within subjects and presentation order between subjects found main effects of Experiment ($M_{\text{Conflicting Goals}}$=16.47; $M_{\text{Isolated Motion}}$ =7.20; $F_{(1,28)}$=5.81, p=.023, partial η^2=.17) and Test Event ($M_{\text{Big bows}}$=13.85; $M_{\text{Small bows}}$=9.82; $F_{(1,28)}$=6.34, p=.018, partial η^2=.19) on looking times to the animations once they had frozen to stills. As reported in the main paper, these factors interacted (Test X Experiment: $F_{(1,28)}$=4.44, p=.044, partial η^2=.14). There were no effects involving presentation order of the two test trials on looking time to the test events.

An analysis that instead used looking times measured from when the inclusion criterion (of watching when the agents bowed) was met, disregarding the longer period of motion in the Conflicting Goals trials, revealed similar results with main effects of test event ($M_{big\ bows}$ = 19.42, $M_{small\ bows}$ = 15.09, $F_{(1.28)}$ = 6.54, p = .016) and experiment ($M_{Conflicting\ Goals}$ = 24.90, $M_{Isolated\ Motion}$ = 9.61, $F_{(1,\ 28)}$ = 14.39, p = .001). Again, these main effects interacted ($F_{(1,\ 28)}$ = 4.75, p =.038).

Experiment 4 (Motion Behind)

Infant looking-times decreased across the four familiarization trials ($M_{\text{familiarization1}}$ = 22.93 seconds, $M_{\text{familiarization 2}}$=16.59, $M_{\text{familiarization 3}}$= 17.50, $M_{\text{familiarization 4}}$=10.99; linear contrast $F(_{1,15})$ = 8.22 p = .012, partial η^2 = .35) indicating that they encoded the information presented in familiarization. In addition to the null effect of unexpected versus expected test outcomes on looking-times reported in the main paper, the repeated-measures ANOVA with expected and unexpected test trials presented within subjects and order of presentation (Unexpected test trial presented first, Expected test trial presented first) found no effects of presentation order on differentiation of unexpected and expected test trials.

Pooling the data from Experiment 4 with the age-appropriate 10-month-old comparison sample from Experiment 2, the decrease in looking-times across all four familiarization trials did not vary between experiments.

Using computed looking-times to the test trials once they had frozen to stills, a repeated-measures ANOVA with the different test trials (unexpected, expected) presented within subject and Experiment (conflicting goals, motion behind) and Presentation Order (unexpected trial presented first, expected trial presented first) varied between subjects, we found a main effect of experiment ($M_{\text{Motion\_behind}}$=5.54 seconds, $M_{\text{Conflicting Goals}}$=18.07 seconds, $F_{(1.28)}$=16.91, p<.0005, η^2 = .38), but no main effect of the test trial factor. There were no other interactions save the Experiment X Test interaction reported in the main paper that confirmed infants looked longer when a large agent bowed in the presence of a smaller one *only* when this happened in context of dominance conflict.

An analysis that instead measured looking-times as soon as the inclusion criterion was met in both experiments by watching the agent bowing yielded identical results with a significant Test X Experiment interaction ($F_{(1,28)}$=4.40, p=.045, partial η^2=.14). Again, there were no other main or interactive effects.

Experiment 5 (Occlusion)

Infant looking-times decreased across the four familiarization trials $M_{\text{familiarization 1}}$= 16.66 seconds, $M_{\text{familiarization 2}}$=13.62, $M_{\text{familiarization 3}}$= 11.39, $M_{\text{familiarization 4}}$=11.07; linear contrast $F_{(1,31)}$ = 8.00, p = .008, partial η^2 = .21, indicating that they encoded the information presented in familiarization.

A repeated-measures ANOVA with the test factor (Unexpected test trial: Big bows, Expected test trial: Small bows) presented within subjects and presentation order (Unexpected trial presented first, expected trial presented first) varied between subjects found no effect of expected versus unexpected test trials, as reported in the main paper, and also no effects of presentation order.

Next, we pooled the occlusion data with a comparison sample of 10 and 12-13 month-old infants from Experiment 2. The degree of decrease across familiarization trials did not vary between the experiments for the first two, comparable familiarization trials (in the Conflicting Goals familiarization, two agents with eyes and mouth bounced across the stage in turn and in opposite directions, in the first two Occlusion familiarization trials, two blocks of the same size but with no eyes or mouth glided across the same path with the same speed).

In contrast, a repeated-measures ANOVA with the test factor (Unexpected: Big yields and/or is partially occluded by the passing small block; Expected: Small yields and/or is fully occluded by the passing big block) presented within subjects and Experiment (Conflicting Goals, Occlusion) and Presentation order (unexpected presented first, expected presented first) varied between subjects found main effects of expected versus unexpected trials ($M_{\text{unexpected}}$=14.04, M_{expected}=9.26, $F_{(1,60)}$ = 14.09, p<0005, partial η^2 = .19) and Experiment ($M_{\text{Conflicting Goals}}$=22.77, $M_{\text{Occlusion}}$=2.53, $F_{(1,60)}$ = 71.65, p<.0005, partial η^2=.54) on looking-times once the animations had frozen to still pictures, as well as the predicted interaction of the two ($F_{(1,60)}$ = 12.09, p =001, partial η^2 = .17), confirming that infants' differentiations of unexpected and expected test trials differed significantly across the two experiments.

In addition, we found an interaction of the test factor X presentation order ($F_{(1,60)}$ = 5.79, p = .019, partial η^2 = .09) that was further qualified by a three-way interaction (Test X Experiment X Presentation Order: ($F_{(1,60)}$ = 5.52, p = .022, partial η^2 = .08): In the Conflicting Goals experiment *only*, infants more strongly differentiated the test trials when the unexpected test trial was presented first ($M_{\text{unexpected}}$=28.33, M_{expected}=13.08) rather than last ($M_{\text{unexpected}}$=22.41, M_{expected}=19.26), although infants looked the longest to the unexpected test trial under both presentation orders. In contrast, in the occlusion experiment infants looked approximately 2 seconds to all test animations once they had frozed to stills under both presentation orders (Unexpected trial presented first: $M_{\text{unexpected}}$=2.96, M_{expected}=2.54, Expected trial presented first: ($M_{\text{unexpected}}$=2.44, M_{expected}=2.16).

Adding infant age (10-month-old versus 12&13-month-old) to this analysis as a between-subjects factor, there were no main or interactive effects of age on looking-times, and we retained the original analysis without it.

An analysis that used the unadjusted looking times measured from when infants met the inclusion criteria, instead of from the point at which the animations froze to stills, found an identical pattern of results with main effects of expected versus unexpected trials ($F_{(1,60)}$ = 13.60, p<.0005, partial η^2 = .19) and Experiment ($F_{(1,60)}$ = 74.02, p<.0005, partial η^2=.55) on looking-times, as well as the predicted interaction of the two ($F_{(1,60)}$ = 0.73, p =.002, partial η^2 = .15), and an interaction of the test factor X presentation order ($F_{(1,60)}$ = 6.24, p = .015, partial η^2 = .094) that was further qualified by a three-way interaction (Test X Experiment X Presentation Order: ($F_{(1,60)}$ = 5.09, p = .028, partial η^2 = .078).

Main Effects of Conflicting Goals versus Control Experiments on Looking-times to Test Trials

As reported as part of the analyses for each control experiment above, infants looked longer to the test trials that invoked conflicting goals than they did to any of the control experiments. This was the case when comparing Experiment 1 (Conflicting Goals) and Experiment 3 (Isolated Motion): $M_{\text{Conflicting Goals}}$=16.47; $M_{\text{Isolated Motion}}$ =7.20; $F_{(1,28)}$=5.81, p=.023, partial η^2=.17; when comparing Experiment 4 (Motion Behind) with 10-month-olds from Experiment 2 (Conflicting Goals): $M_{\text{Conflicting Goals}}$=18.07 seconds, $M_{\text{Motion\_behind}}$=5.54 seconds, $F_{(1.28)}$=16.91, p<.0005, η^2 = .38; and when comparing 10 and 12-13 month-olds in Experiment 5 (Occlusion) and Experiment 2 (Conflicting Goals): $M_{\text{Conflicting Goals}}$=22.77, $M_{\text{Occlusion}}$=2.53, $F_{(1,60)}$ = 71.65, p<.0005, partial η^2=.54).

What the three qualitatively different control experiments have in one common is the fact that they do not invoke conflicting goals. Hence, these results provide further support that infants do indeed pick up on and attend to the conflicting goals in Experiments 1 and 2. Note that all looking times reported here only refer to how long infants looked to the display screen once the test animations had frozen to stills. The length of the animations were 19.1 seconds for the Conflicting Goals experiments, 13.2 seconds for the Isolated Motion Control experiment, 20.5 seconds for the Motion Behind Control experiment, and 9.9 seconds for the Occlusion Control experiment such that the shortest actual mean looking times (to the Occlusion Control) was around 12 seconds and the longest actual mean looking times (to the Conflicting Goals) around 37 seconds.

SUPPORTING FIGURES

Figure legends

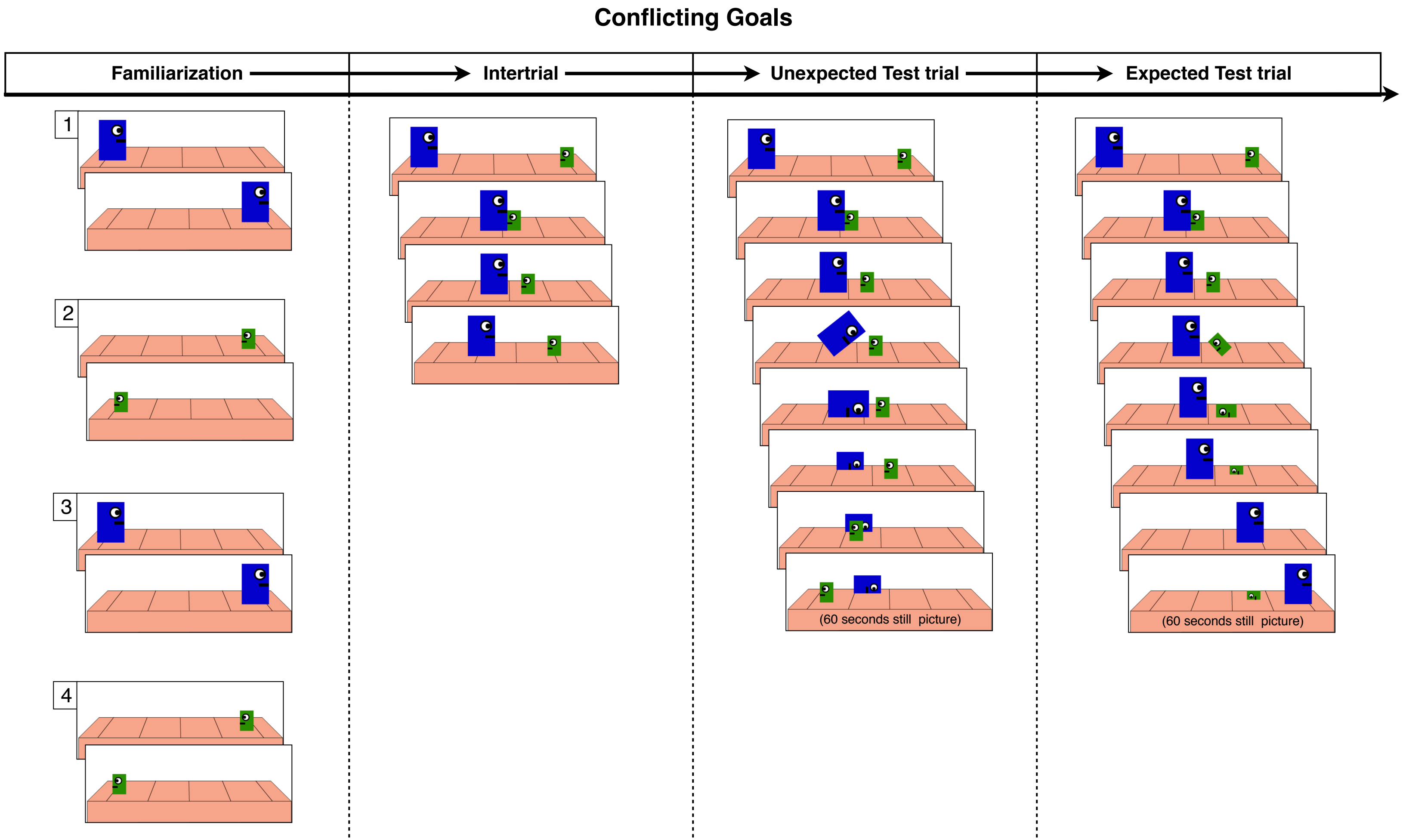
Figure S1. Schematic of Experimental Stimuli for Experiments 1 and 2 (Conflicting Goals)

Figure S2. Schematic of Experimental Stimuli for Experiment 3 (Isolated Motion)

Figure S3. Schematic of Experimental Stimuli for Experiment 4 (Motion Behind)

Figure S4. Schematic of Experimental Stimuli for Experiment 5 (Occlusion)

Figure S1



(presentation order of events, color, side and order of entry of the agents were fully counter-balanced across subjects)

Figure S2

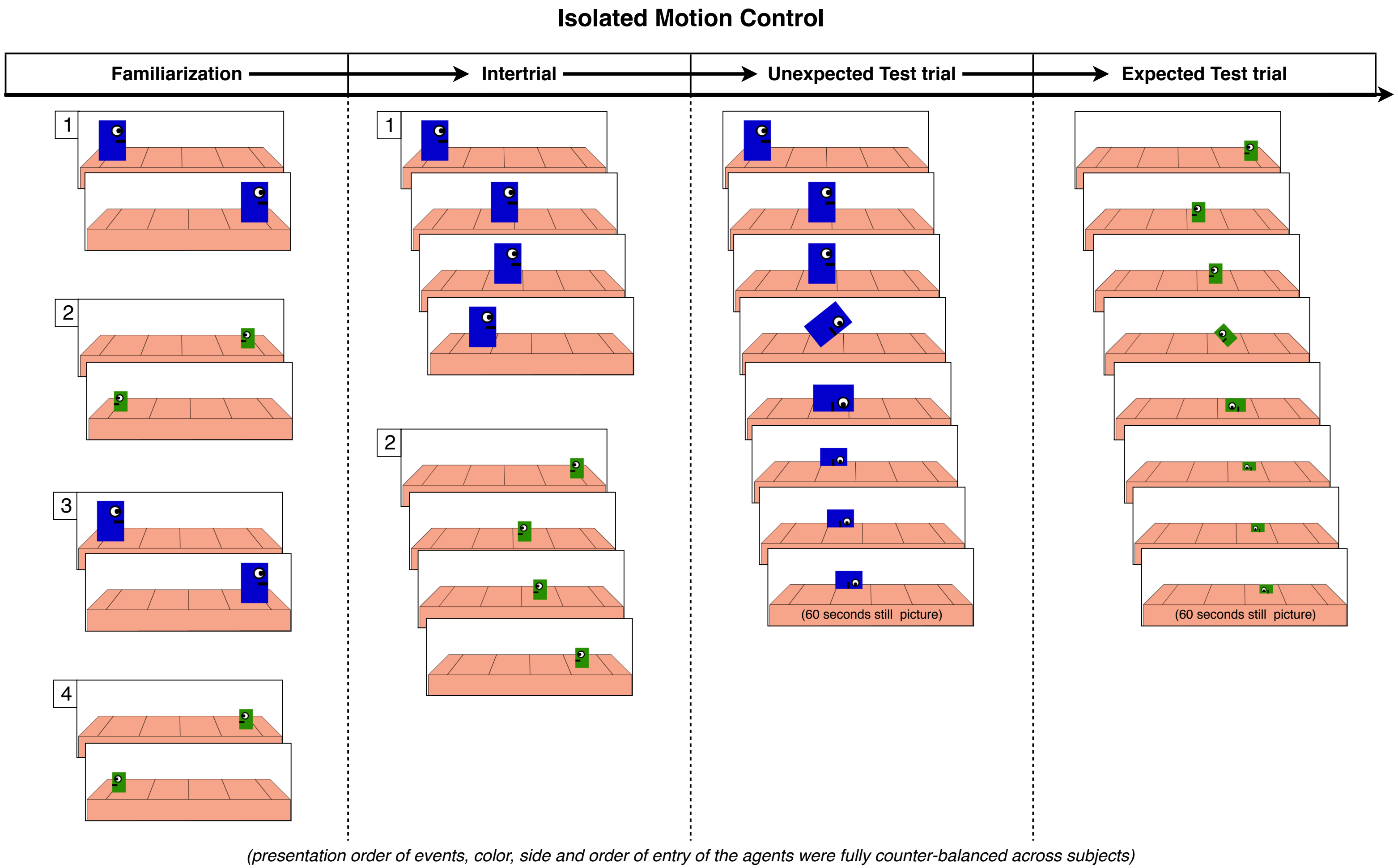
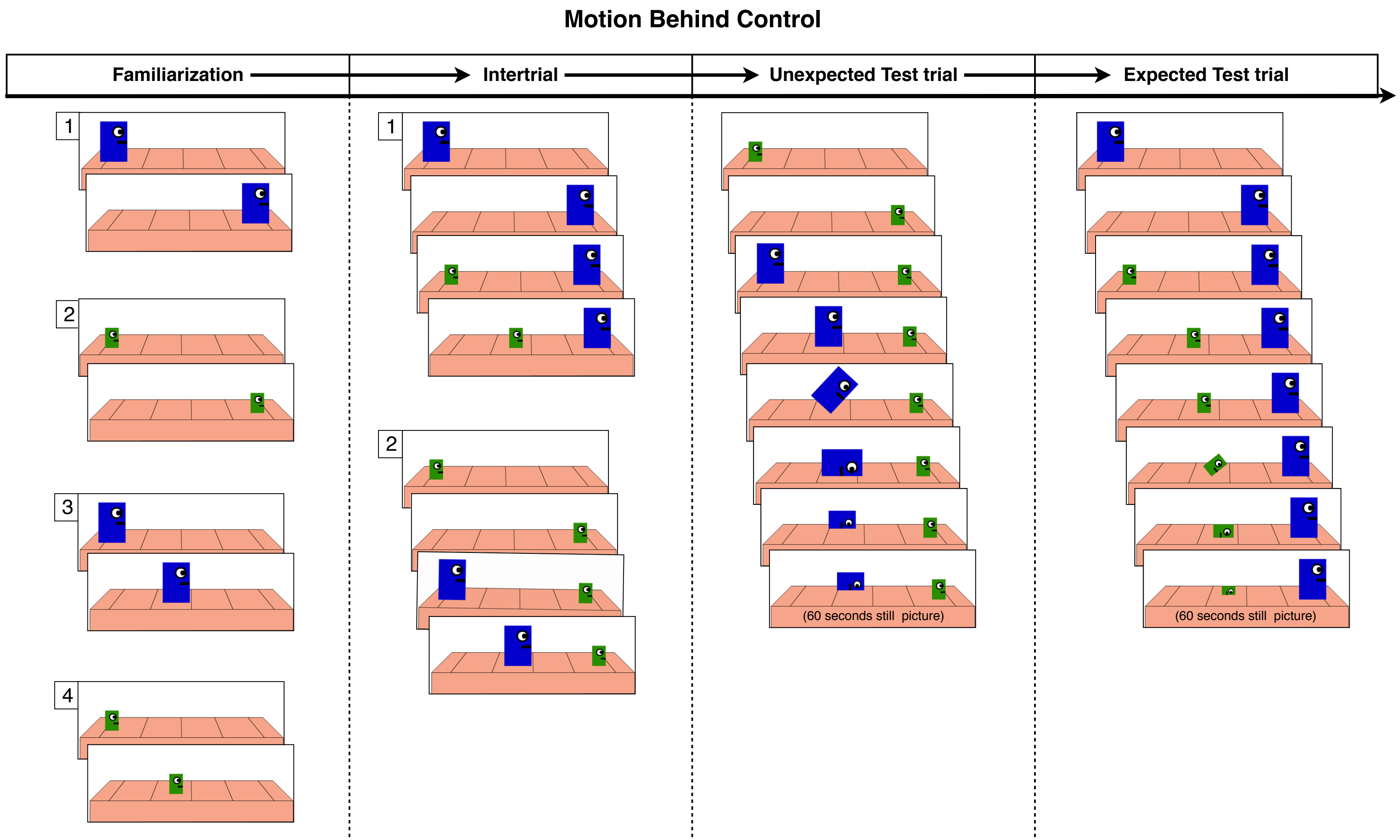
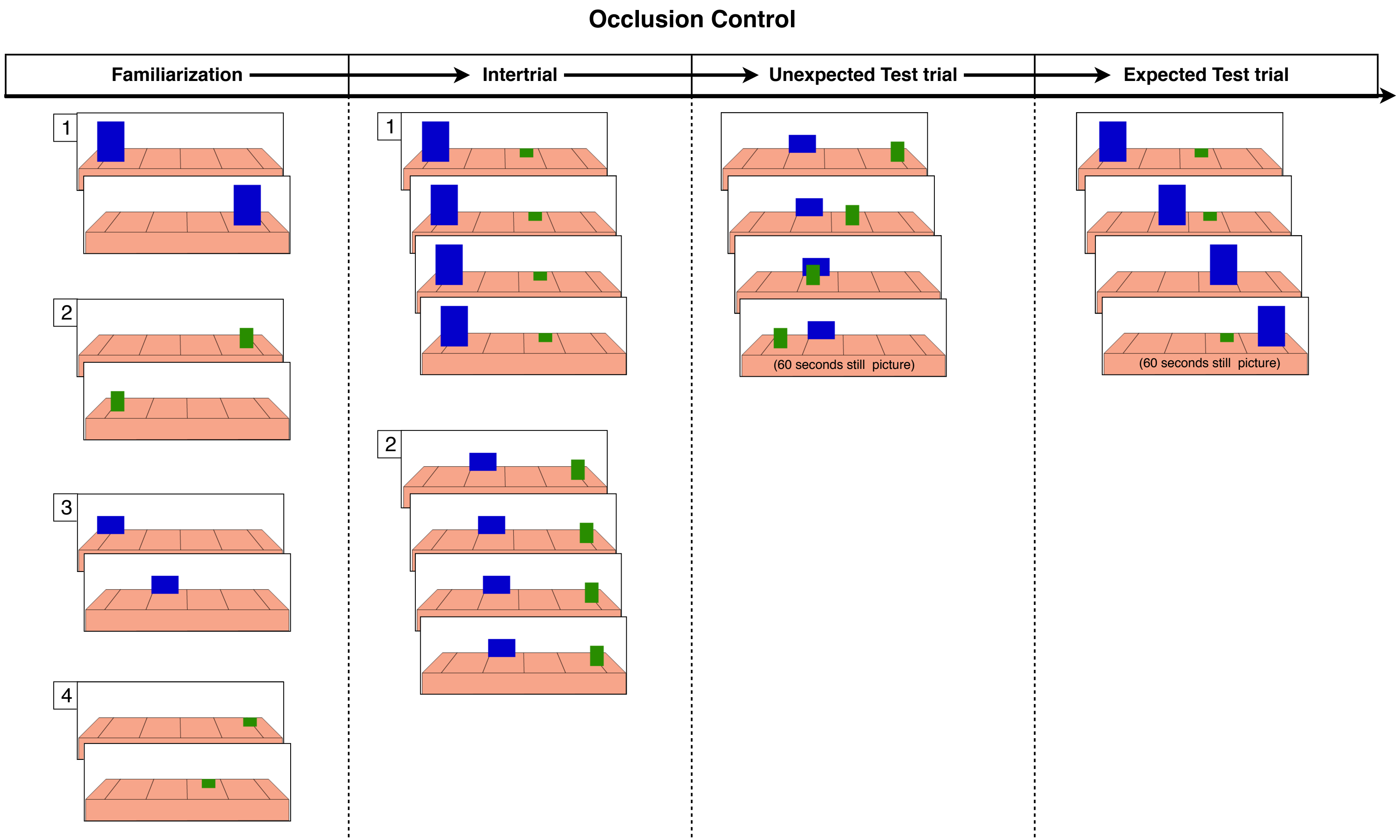

Isolated Motion Control
Familiarization
Intertrial
Unexpected Test trial
Expected Test trial
1
2
3
4
1
2
(60 seconds still picture)
(60 seconds still picture)
(presentation order of events, color, side and order of entry of the agents were fully counter-balanced across subjects)

Figure S3



(presentation order of events, color, side and order of entry of the agents were fully counter-balanced across subjects)

Figure S4



(presentation order of events, color, side and order of entry of the agents were fully counter-balanced across subjects)

SUPPORTING TABLES

Table legends

Table S1. Looking-times in seconds to still pictures following test events across all experiments and samples

Table S1

	Mean looking-time in seconds		Standard Deviation	
	Unexpected Test event	**Expected Test event**	**Unexpected Test event**	**Expected Test event**
Experiment 1: Conflicting Goals				
11-16 month-olds	20.0	12.0	17.0	12.7
Experiment 2: Conflicting Goals				
8-month-olds	6.0	8.2	3.9	9.8
9-month-olds	11.9	6.7	12.0	7.5
10-month-olds	21.7	14.4	16.3	10.3
12-13 month-olds	29.0	18.0	15.5	11.4
Experiment 3: Isolated Motion				
11-16 month-olds	6.9	6.3	8.6	8.9
Experiment 4: Motion Behind				
10-month-olds	4.5	6.5	4.2	7.0
Experiment 5: Occlusion				
10-month-olds	2.8	1.5	3.7	2.8
12- to 13-month-olds	2.6	3.2	3.0	5.5

SUPPORTING REFERENCES AND NOTES

S1. Pinto, J. (1995). Xhab64 [Computer software]. Stanford University, Palo Alto, CA: Author.

1199198s1.mov

Movie S1: Conflicting Goals Familiarization trial 1.

This QuickTime file contains Supporting Video 1. This movie shows the Conflicting Goals familiarization event in Experiments 1, 2, and 3, in which the Large Agent bounces gently from one side of the stage to the other side (in this case, the Large Agent is blue).

1199198s2.mov

Movie S2: Conflicting Goals Familiarization trial 2.

This QuickTime file contains Supporting Video 2. This movie shows the Conflicting Goals familiarization event in Experiments 1, 2, and 3, in which the Small Agent bounces gently from one side of the stage to the other side (in this case, the Small Agent is green).

1199198s3.mov

Movie S3: Conflicting Goals Intertrial.

This QuickTime file contains Supporting Video 3. This movie shows the Conflicting Goals inter-trial event in Experiments 1 and 2, in which the Large Agent and the Small Agent obstruct each other's goal in the center of the stage (in this case, the Large Agent is blue and the Small Agent is green).

1199198s4.mov

Movie S4: Conflicting Goals Expected Test trial.

This QuickTime file contains Supporting Video 4. This movie shows the expected Conflicting Goals test event in Experiments 1 and 2, in which the Large and Small Agent obstruct each other's goal in the center of the stage, and the Large Agent wins (in this case, the Large Agent is blue and the Small Agent is green).

1199198s5.mov

Movie S5: Conflicting Goals Unexpected Test trial.

This QuickTime file contains Supporting Video 5. This movie shows the unexpected Conflicting Goals test event in Experiments 1 and 2, in which the Large and Small Agent obstruct each other's goal in the center of the stage, and the Small Agent wins (in this case, the Large Agent is blue and the Small Agent is green).

1199198s6.mov

Movie S6:Isolated Motion Control Intertrial 1.

This QuickTime file contains Supporting Video 6. This movie shows the Isolated Motion Control inter-trial event in Experiment 3, in which the Large Agent bounces gently to the center of the stage and moves in an identical fashion to the inter-trial event in Experiments 1 and 2 (in this case, the Large Agent is blue).

1199198s7.mov

Movie S7: Isolated Motion Control Intertrial 2.

This QuickTime file contains Supporting Video 7. This movie shows the Isolated Motion Control inter-trial event in Experiment 3, in which the Small Agent bounces gently to the center of the stage and moves in an identical fashion to the inter-trial event in Experiments 1 and 2 (in this case, the Small Agent is green).

1199198s8.mov

Movie S8: Isolated Motion Control Expected Test trial.

This QuickTime file contains Supporting Video 8. This movie shows the expected Isolated Motion Control test event in Experiment 3, in which the Small Agent bounces gently to the center of the stage before bowing and scooting away in an identical fashion to the test event in which it defers to the Large Agent in Experiments 1 and 2 (in this case, the Small Agent is green).

1199198s9.mov

Movie S9: Isolated Motion Control Unexpected Test trial.

This QuickTime file contains Supporting Video 9. This movie shows the unexpected Isolated Motion Control test event in Experiment 3, in which the Large Agent bounces gently to the center of the stage before bowing and scooting away an identical fashion to the test event in which it defers to the Small Agent in Experiments 1 and 2 (in this case, the Large Agent is blue).

1199198s10.mov

Movie S10: Motion Behind Control Familiarization trial 1.

This QuickTime file contains Supporting Video 10. This movie shows the first Motion Behind Control familiarization event in Experiment 4, in which the Large Agent pops into existence and bounces gently from one side of the stage to the other side (in this case, the Large Agent is blue).

1199198s11.mov

Movie S11: Motion Behind Control Familiarization trial 2.

This QuickTime file contains Supporting Video 11. This movie shows the second Motion Behind Control familiarization event in Experiment 4, in which the Small Agent pops into existence and bounces gently from one side of the stage to the other side (in this case, the Small Agent is green).

1199198s12.mov

Movie S12: Motion Behind Control Familiarization trial 3.

This QuickTime file contains Supporting Video 12. This movie shows the third Motion Behind Control familiarization event in Experiment 4, in which the Large Agent pops into existence and bounces gently to the center of the stage (in this case, the Large Agent is blue).

1199198s13.mov

Movie S13: Motion Behind Control Familiarization trial 4.

This QuickTime file contains Supporting Video 13. This movie shows the second Motion Behind Control familiarization event in Experiment 4, in which the Small Agent pops into existence and bounces gently to the center of the stage (in this case, the Small Agent is green).

1199198s14.mov

Movie S14: Motion Behind Control Intertrial 1.

This QuickTime file contains Supporting Video 14. This movie shows the Motion Behind Control inter-trial event in Experiment 4, in which the Large Agent pops into existence and bounces gently from one side of the stage to the other side. Next, the Small Agent pops into existence and bounces gently to the center of the stage (in this case, the Large Agent is blue and the Small Agent is green).

1199198s15.mov

Movie S15: Motion Behind Control Intertrial 2.

This QuickTime file contains Supporting Video 15. This movie shows the Motion Behind Control inter-trial event in Experiment 4, in which the Small Agent pops into existence and bounces gently from one side of the stage to the other side. Next, the Large Agent pops into existence and bounces gently to the center of the stage (in this case, the Large Agent is blue and the Small Agent is green).

1199198s16.mov

Movie S16: Motion Behind Control Expected Test trial.

This QuickTime file contains Supporting Video 16. This movie shows the expected Motion Behind Control test event in Experiment 4, in which the Large Agent pops into existence and bounces gently from one side of the stage to the other side. Next, the Small Agent pops into existence, bounces gently to the center of the stage, and lies down and scoots away (in this case, the Large Agent is blue and the Small Agent is green).

1199198s17.mov

Movie S17: Motion Behind Control Unexpected Test trial.

This QuickTime file contains Supplementary Video 17. This movie shows the unexpected Motion Behind Control test event in Experiment 4, in which the Small Agent pops into existence and bounces gently from one side of the stage to the other side. Next, the Large Agent pops into existence, bounces gently to the center of the stage, and lies down and scoots away (in this case, the Large Agent is blue and the Small Agent is green).

1199198s18.mov

Movie S18: Occlusion Control Familiarization trial 1.

This QuickTime file contains Supporting Video 18. This movie shows the first Occlusion Control familiarization event in Experiment 5, in which the Large Inanimate Block vertically slides from one side of the stage to the other side (in this case, the Large Inanimate Block is blue).

1199198s19.mov

Movie S19: Occlusion Control Familiarization trial 2.

This QuickTime file contains Supporting Video 19. This movie shows the second Occlusion Control familiarization event in Experiment 5, in which the Small Inanimate Block vertically slides from one side of the stage to the other side (in this case, the Small Inanimate Block is green).

1199198s20.mov

Movie S20: Occlusion Control Familiarization trial 3.

This QuickTime file contains Supporting Video 20. This movie shows the third Occlusion Control familiarization event in Experiment 5, in which the Large Inanimate Block horizontally slides to the center of the stage (in this case, the Large Inanimate Block is blue).

1199198s21.mov

Movie S21: Occlusion Control Familiarization trial 4.

This QuickTime file contains Supporting Video 21. This movie shows the fourth Occlusion Control familiarization event in Experiment 5, in which the Small Inanimate Block horizontally slides to the center of the stage (in this case, the Small Inanimate Block is green).

1199198s22.mov

Movie S22: Occlusion Control Intertrial 1.

This QuickTime file contains Supporting Video 22. This movie shows the first Occlusion Control inter-trial event in Experiment 5, in which the Large Inanimate Block is standing vertically and motionless on one side of the stage, while the Small

Inanimate Block is lying down horizontally and also motionless in the center of the stage (in this case, the Large Inanimate Block is blue and the Small Inanimate Block is green).

1199198s23.mov

Movie S23: Occlusion Control Intertrial 2.

This QuickTime file contains Supporting Video 23. This movie shows the Occlusion Control inter-trial event in Experiment 5, in which the Small Inanimate Block is standing vertically and motionless on one side of the stage, while the Large Inanimate Block is lying down horizontally and also motionless in the center of the stage (in this case, the Large Inanimate Block is blue and the Small Inanimate Block is green).

1199198s24.mov

Movie S24: Occlusion Control Unexpected Test trial.

This QuickTime file contains Supporting Video 24. This movie shows the unexpected Occlusion Control test event in Experiment 5, in which the Large Inanimate Block is lying down horizontally and motionless in the center of the stage, while the Small Inanimate Block slides vertically from one side of the stage to the other side (in this case, the Large Inanimate Block is blue and the Small Inanimate Block is green).

1199198s25.mov

Movie S25: Occlusion Control Expected Test trial.

This QuickTime file contains Supporting Video 25. This movie shows the Occlusion Control test event in Experiment 5, in which the Small Inanimate Block is lying down horizontally and motionless in the center of the stage, while the Large Inanimate Block slides vertically from one side of the stage to the other side (in this case, the Large Inanimate Block is blue and the Small Inanimate Block is green).