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Supplementary Materials for

Observing the unexpected enhances infants' learning and exploration

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Supplementary Text

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Materials and Methods

Experiment 1

Solidity Condition

Participants. Twenty healthy full-term infants between 10.5 and 12 months old participated (range =10 months, 19 days to 11 months, 24 days; mean = 11 months, 7 days; 12 females). Two additional infants were excluded for fussiness (1) or parental interference (1).

Stimuli. Infants sat in a high chair in front of a stage; parents sat out of view. The stage (132 x 43 x 52.5 cm) had a concealed opening in its rear wall, a removable sloping ramp on its left side, and a track that ran across its width. A thin purple wall (1.5 x 28 x 27 cm) stood at the right-end of the track and a thicker purple wall (3 x 28 x 27 cm) could be placed across the track's path. A gray occluding screen (51 x 22 cm) was used to cover the right side of the stage during portions of the event; when the screen was in place, the purple wall(s) protruded 6 cm above it. A black curtain could be lowered to conceal the entire stage.

The stimulus objects were a green, yellow, and orange plastic car (approximately 17 x 13.5 cm) and a blue and red striped ball (7.5 cm diameter). For half of the infants the car was the target object and for the other half the ball was the target.

Procedure

Familiarization. Infants saw two identical familiarization trials. The curtain was raised to reveal the ramp at the left of the stage and the thin purple wall at the far right. The experimenter reached down and placed the gray screen onstage, covering the stage's right half. The top of the purple wall protruded above the screen. Next the experimenter reached in from above, holding the target object (e.g., car), and released it at the top of the ramp. The object rolled down the ramp, across the stage, and passed behind the occluding screen. Finally, the experimenter lifted the screen to reveal the object at the stage's far right, where it had been stopped by the thin purple wall. The object remained there for 5 s, after which the curtain was lowered to cover the stage.

Solidity Event. Next, infants saw a single solidity event. The curtain was raised to reveal the ramp on the left and the thin purple wall on the far right. The experimenter reached in from above and showed infants the thicker purple wall, twisting and knocking on it to show that it was solid before placing it across the center of the track. She then put the screen in place, covering the right half of the stage and hiding both walls except for their tops. The experimenter then said, "Look! Look at this! Watch this," as she reached in with the target object (e.g., the car) and released it at the top of the ramp. The object rolled down the ramp, across the stage, and disappeared behind the screen. The experimenter then lifted the screen to reveal either that the object appeared to have been stopped by the thick wall and come to rest near the center of the stage (Knowledge-Consistent solidity event, movie S1), or that the object appeared to have passed through the thick wall and come to rest at the far right side of the stage (Knowledge-Violation solidity event, movie S2). Infants were given 10 s to look at the event outcome.

Teaching Event. After 10 s the experimenter demonstrated the target object's hidden auditory property. She grasped the object from its outcome position and moved it up and down rhythmically for 12 s while a sound (e.g., squeaking) played from a hidden central location. Half the infants were taught that the target object made a squeaking sound, and half were taught that it made a ringing sound; this was fully crossed with the target object's identity (car versus ball). If infants looked away during these 12 s, the experimenter attracted infants' attention and only resumed when they re-attended. After 12 s of exposure to the auditory property, the curtain was lowered to cover the stage.

Test. Infants' learning was assessed in a single test trial. The curtain was raised to reveal an empty stage. The experimenter reached down and simultaneously placed two objects on the stage 70 cm apart: the target object from the preceding event (e.g., car) and a new distractor object (e.g., ball). These rested silently for 5 s (Baseline). Then the experimenter grasped both objects and moved them up and down rhythmically while the same sound that had played during the Teaching Event played for 10 s from a hidden central location (Mapping Test). Whether the target object was on the left or right side was counterbalanced across infants.

Infants' looking was coded offline, frame-by-frame, by a trained observer who was blind to experimental condition. A second observer recoded 20% of all testing sessions in Experiments 1-3; coder agreement averaged 0.98.

Spatiotemporal Continuity Condition

Participants. Twenty healthy full-term infants between 10.5 and 12 months old participated (range = 10 months, 15 days – 11 months, 26 days; mean = 10 months, 30 days; 13 females). Four additional infants were excluded for sibling interference (1), inattentiveness (1), or experimenter error (2).

Stimuli. Two identical black foam-core screens (27 x 29 cm) were used to hide the objects. Each had a concealed rear compartment that allowed the experimenter to surreptitiously add or remove objects from the stage.

The stimulus objects were a green and red spotted ball (7.5 cm diameter) and a blue block with a schematic face (6 x 10 x 6 cm). For half the infants the ball was the target object and for the other half the block was the target.

Procedure

Familiarization. Infants saw two identical familiarization trials. The experimenter placed a screen in the center of the empty stage. She waved the target object (e.g., ball), then held it directly above the screen. She said, "Watch this!" and placed the object behind the screen. She immediately lifted the screen to reveal the object resting on the stage. After 5 s the curtain was lowered to cover the stage.

Continuity Event. Next, infants saw a single continuity event. The curtain was raised to reveal an empty stage. The experimenter placed the two identical screens on stage 27 cm apart, wiggling them to show that they were unconnected. She waved the target object in front of the left screen, saying, "Look! Look at this! Watch this," then hid it behind the left screen. The experimenter then lifted both screens simultaneously to reveal either that the target object was still behind the left screen (Knowledge-Consistent

continuity event, movie S3), or that it was now behind the right screen (Knowledge-Violation continuity event, movie S4). Infants were given 10 s to look at the event outcome.

Teaching Event. The Teaching Event was nearly identical to that following the Solidity events: after 10 s the experimenter grasped the target object from its outcome position and moved it up and down while a sound played from a hidden central location. Half the infants were taught that the target object made a squeaking sound, and half were taught that it made a rattling sound—this was fully crossed with the target object's identity (ball versus block).

Test. Infants saw the curtain raised to reveal an empty stage. The experimenter reached down and simultaneously placed two objects on stage 70 cm apart: the target object (e.g., ball) and a new distractor object (e.g., block). These rested silently for 5 s (Baseline). Then the experimenter grasped both objects and moved them up and down rhythmically while the same sound that had played during the Teaching Event played for 10 s from a hidden central location (Mapping Test). Whether the target object was on the left or right side was counterbalanced across infants.

Experiment 2

Solidity Condition

Participants. Ten healthy full-term infants between 10.5 and 12 months old participated (range = 10 months, 26 days – 11 months, 24 days; mean = 11 months, 9 days; 6 females). Three additional infants were excluded for fussiness (2) or experimenter error (1).

Stimuli. The stimuli were identical to those in the Solidity condition of Experiment 1.

Procedure. The procedure was identical to that in the Knowledge-Violation solidity event of Experiment 1, with one exception. During the Mapping Test, infants heard a novel sound. Half the infants were taught that the object made a squeaking sound during the Teaching Event, but heard a ringing sound during the Mapping Test, and half experienced the reverse.

Spatiotemporal Continuity Condition

Participants. Ten healthy full-term infants between 10.5 and 12 months old participated (range = 10 months, 18 days – 11 months, 28 days; mean = 11 months, 6 days; 6 females). Three additional infants were excluded for inattentiveness (1) or experimenter error (2).

Stimuli. The stimuli were identical to those in the Continuity condition of Experiment 1.

Procedure. The procedure was identical to that in the Knowledge-Violation continuity event of Experiment 1, with one exception. During the Mapping Test, infants

heard a novel sound. Half the infants were taught that the object made a squeaking sound during the Teaching Event, but heard a rattling sound during the Mapping Test, and half experienced the reverse.

Experiment 3

Participants. Ten healthy full-term infants between 10.5 and 12 months old participated (range = range = 10 months, 28 days – 12 months, 0 days; mean = 11 months, 5 days; 5 females). Three additional infants were excluded for parental interference (1) or experimenter error (2).

Stimuli. The stimuli were the ball and block from the Experiment 1 Continuity event and the car from the Experiment 1 Solidity event.

Procedure. The procedure was identical to that in the Knowledge-Violation continuity event of Experiment 1, with two exceptions. After the Knowledge-Violation outcome was revealed (i.e., after the ball that had been hidden behind the left screen was revealed behind the right screen), the ball remained in place on the stage floor. After 10 s the experimenter reached in with a novel object (i.e., block) and moved it up and down rhythmically in the center of the stage for 12 s while either the squeaking or rattling sound played from a hidden central location (Teaching Event). During the Baseline, half the infants saw the block paired with the target object that had participated in the Continuity event (i.e., ball), and the other half saw the block paired with an entirely new distractor object (i.e., car)—these sat on stage silently for 5 s. After 5 s, the experimenter reached in and moved both objects up and down rhythmically while the sound that infants had heard during the Teaching Event (either squeaking or rattling) played from a hidden central location for 10 s (Mapping Test). Infants' learning scores did not differ depending on whether the block was paired with the ball or the car (P=0.69).

Experiment 4

Solidity Condition

Participants. Twenty healthy full-term infants between 10.5 and 12 months old participated (range = 10 months, 15 days – 11 months, 28 days; mean = 11 months, 4 days; 8 females). Nine additional infants were excluded for fussiness (2), parental interference (4), experimenter error (1), equipment failure (1), or refusal to engage with the objects (1).

Stimuli. The stimuli were identical to those in the Solidity event of Experiment 1. For half the infants the car was the target object, and for the other half the ball was the target.

Procedure. The Familiarization and Solidity event were identical to those in Experiment 1. Half the infants saw the Knowledge-Consistent solidity event and half saw the Knowledge-Violation solidity event. Following the event, the target object remained visible in its revealed position for 10 s before the curtain was lowered over the stage. Infants were not taught any properties of the object.

Exploration Period. After the curtain was lowered, the experimenter emerged from behind the stage and placed two objects on either side of the infant's high chair tray: the car and the ball. Whether the target object was on the left or right side was counterbalanced across infants. The experimenter did not look at or engage infants while placing the objects. She then stepped out of view and gave infants 60 s to freely explore the objects. If either object went out of infants' reach (e.g., by falling on the floor), the experimenter immediately retrieved it and placed back it on the tray. No objects made any sound.

Support Condition

Participants. Twenty healthy full-term infants between 10.5 and 12 months old participated (range = 10 months, 17 days – 12 months, 4 days; mean = 11 months, 7 days; 7 females). Two additional infants were excluded for sleepiness (1) or parental interference (1).

Stimuli. A white and gray horizontally striped box (33 x 20.5 x 10 cm) rested on the left side of the stage. The stimulus objects were the car and ball from the Solidity condition; which of these served as the target object was counterbalanced across infants.

Procedure.

Familiarization. Infants saw two identical familiarization trials. The curtain was raised to reveal the target object (e.g., car) resting on top of the striped box. The experimenter reached in and used her index finger to slowly push the object 8 cm to the center of the box, then removed her hand from the stage while leaving the object in place. After 5 s, the curtain was lowered over the stage.

Support Event. Next, infants saw a single support event. The curtain was raised to reveal the target object resting on the box. For infants who saw the Knowledge-Consistent event (movie S5), the experimenter said, "Look! Look at this! Watch this," and then slowly pushed the object from the left side of the box 16 cm to the box's edge, so that it remained completely supported throughout. For infants who saw the Knowledge-Violation event (movie S6), the target object started in the center of the box, and the experimenter slowly pushed it 16 cm, over the box's edge so that it no longer had any contact with the box and appeared to float in mid-air. Infants had 10 s to look at the event outcome.

Exploration Period. The Exploration Period was exactly as in the Solidity condition.

Coding

Exploration. We coded infants' looking and touching behaviors. Looking was coded as either directed at the target object, the distractor object, or neither. Touching was coded as either directed at the target object, the distractor object, both, or neither. Infants were only coded as touching an object if contact with the object appeared to be intentional (e.g., an elbow grazing an object did not count). All exploratory behaviors were coded offline, frame-by-frame, by a trained observer who did not know whether infants had seen a Knowledge-Consistent or Knowledge-Violation event, and who was

unaware which object was the target. A second observer recoded all sessions and coder agreement averaged 0.97.

Banging and Dropping Behavior. An action was coded as banging if infants intentionally brought an object into abrupt contact with any other surface (the tray, themselves, or the other object), or if they brought their hand into abrupt contact with the object. An action was coded as dropping if infants intentionally released an unsupported object onto the floor or onto the high chair tray, or if they intentionally pushed the object off the tray surface. An object accidentally falling off the tray (e.g., by rolling during play) did not qualify. An observer who did not know whether infants had seen a Knowledge-Consistent or Knowledge-Violation event, and who was unaware which object was the target, coded all behaviors. A second observer recoded all sessions and coder agreement averaged 0.98 for banging and 0.98 for dropping.

Supplementary Text (Supporting Results)

Experiment 1

We first analyzed infants' looking to the outcomes of the Solidity and Continuity events, prior to the Teaching Event. Infants in the Solidity condition looked for an average of 6.33 s at the Knowledge-Consistent event outcome (SD=2.33 s) and 5.29 s at the Knowledge-Violation event outcome (SD=2.05 s). Infants in the Spatiotemporal Continuity condition looked for an average of 3.19 s at the Knowledge-Consistent event outcome (SD = 1.80 s) and 4.29 s at the Knowledge-Violation event outcome (SD=1.99 s) (table S1). A univariate ANOVA with outcome looking time as the dependent variable and event type (Solidity or Continuity) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors revealed no main effect of outcome type, $F(1,36)=0.002$, $P=0.96$; this was as predicted since we limited the time infants had to view these outcomes. However, there was a main effect of event type, $F(1,36)=10.159$, $P=0.003$, partial $\eta^2=0.22$, with infants looking longer at outcomes of Solidity events (M=5.81 s, SD=2.20 s) than Continuity events (M=3.74 s, SD=1.93 s).

We then examined infants' learning scores, calculated by subtracting the proportion of infants' looking at the target object (relative to the new distractor object) during Baseline from the proportion of looking at the target object during the Mapping Test (table S1). A univariate ANOVA with learning score as the dependent variable and event type (Solidity or Continuity) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors yielded only a significant main effect of outcome type: infants' learning scores were significantly greater following Knowledge-Violation than Knowledge-Consistent events, $F(1,36)=10.691$, $P=0.002$, partial $\eta^2=0.229$. When we compared infants' learning scores to chance (zero), we found that these were no different from chance following events that accorded with object Solidity (M=-0.10, SD=0.29), $t(9)=-1.088$, $P=0.31$, or Continuity (M=0.06, SD=0.12), $t(9)=1.62$, $P=0.14$. However, learning scores were significantly greater than chance following violations to both object Solidity (M=0.17, SD=0.18), $t(9)=3.092$, $P=0.01$, and Continuity (M=0.20, SD=0.17), $t(9)=3.715$, $P=0.005$ (table S1).

Experiment 2

In Experiment 2 we asked whether infants increased their looking to the target object when a novel sound played during the Mapping Test. A univariate ANOVA with learning score as the dependent variable and event type (Solidity or Continuity) and sound type (taught sound from the Knowledge-Violation conditions of Experiment 1 or novel sound from Experiment 2) as fixed factors yielded only a significant main effect of sound type. Infants' learning scores were significantly greater when the taught sound played in the Mapping Test (Experiment 1) than when the novel sound played, $F(1,36)=5.349$, $P=0.03$, partial $\eta^2=0.129$. When a novel sound was played during the Mapping Test, infants' learning scores were not significantly above chance following violations to object Solidity (M=0.07; SD=0.15), $t(9)=1.453$, $P=0.18$, or Continuity (M=0.003, SD=0.29), $t(9)=0.036$, $P=0.97$ (table S1).

Infants' greater learning scores in the Knowledge-Violation conditions of Experiment 1 cannot be attributed to those infants having had more perceptual exposure to the target object (as compared to infants in Experiment 2). A univariate ANOVA with looking time to the event outcome as the dependent variable and event type (Solidity or Continuity) and sound type (taught sound from Experiment 1 or novel sound from Experiment 2) yielded a main effect of sound type, $F(1,36)=4.452$, $P=0.042$, $\eta^2=0.11$. Infants in Experiment 2 (who heard the novel sound at test) looked longer following violations to object Solidity (M=6.79, SD=1.93) and Continuity (M=5.81, SD=2.93) than did infants in Experiment 1 (who heard the taught sound at test) (table S1).

Experiment 3

In Experiment 3 we asked whether infants experienced enhanced learning for anything that followed an event that violated expectations, or only for objects involved in the event. When infants were taught about a novel, unrelated object following a Knowledge-Violation continuity event, their learning scores did not differ from chance (M=0.005, SD=0.23), $t(9)=0.074$, $P=0.94$ (table S1). Infants' learning scores were significantly greater when they had been taught about the object that had violated their expectations (Experiment 1) than when taught about an unrelated novel object (Experiment 3), $t(18)=2.126$, $P=0.048$.

Infants' greater learning scores in the Knowledge-Violation conditions of Experiment 1 cannot be attributed to those infants having had more perceptual exposure to the target object (as compared to infants in Experiment 3). An independent samples t-test found that infants' looking to the Knowledge-Violation Continuity event outcome in Experiment 3 (M=3.45, SD=1.76) did not differ from that of Experiment 1, $t(18)=1.0$, $P=0.33$ (table S1).

Experiment 4

In Experiment 4 we asked whether infants preferred to explore objects that violated expectations over objects that did not. Before examining exploratory behavior, we analyzed infants' looking times to the Solidity and Support event outcomes, prior to the Exploration Period. For the solidity events, infants looked for 4.37 s at the Knowledge-Consistent event outcome (SD=2.12 s) and 4.41 s at the Knowledge-Violation event outcome (SD=1.73 s). For the support events, infants looked 4.49 s at the Knowledge-Consistent event outcome (SD = 2.01 s) and 5.59 s at the Knowledge-

Violation event outcome (SD=2.20 s) (table S2). A univariate ANOVA with looking time as the dependent variable and event type (Solidity or Support) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors showed no main effect of outcome type, $F(1,36)=0.794$, $P=0.379$, and no interactions.

Next we analyzed how long infants spent exploring (looking at and/or touching) the target object versus the new distractor object during the Exploration Period (table S2). We calculated infants' preference to explore the target object versus the new distractor object by subtracting the amount of time infants explored the distractor object from the amount of time they explored the target object. A univariate ANOVA with infants' exploration preference score as the dependent variable and event type (Solidity or Support) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors yielded a significant main effect of outcome type, $F(1,36)=5.933$, $P=0.02$, partial $\eta^2=0.14$; infants who had seen a Knowledge-Violation event showed a greater preference to explore the target object than infants who had seen the Knowledge-Consistent event. We next compared infants' preference scores to chance (i.e., no difference). Across Knowledge-Consistent solidity (M=-18.87, SD=32.20) and support (M=2.80; SD=29.08) events, infants' exploration preference scores did not differ from chance, indicating that they explored the objects equally, $t(19)=-1.128$, $P=0.27$. In contrast, across Knowledge-Violation solidity (M=16.98, SD=27.96) and support (M=11.85, SD=27.09) events, infants' exploration scores were significantly above chance; they spent significantly longer exploring the target object than the distractor object, $t(19)=2.395$, $P=0.027$ (table S2).

Next we examined the types of exploratory behaviors infants produced. First we measured the frequency of infants' banging and dropping of the target object. Because more instances of object banging can occur within a given time period than can instances of object dropping, we converted the frequencies of these behaviors into z-scores to empower their direct comparison (table S2). We calculated z-scores for each behavior separately, using the averages and standard deviations of banging (M=1.73, SD=2.61) and dropping (M=0.58, SD=1.26) performed on the target object by all infants. We then calculated an action tendency score by subtracting the z-scored frequency of infants' object dropping from the z-scored frequency of their object banging. A univariate ANOVA with action tendency score as the dependent variable and event type (Solidity or Support) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors yielded a significant interaction between event type and outcome type, $F(1,36)=9.43$, $P=0.004$, partial $\eta^2=0.208$. Infants who had seen a Knowledge-Violation outcome of a solidity event showed a greater tendency to bang the target (rather than drop it) (M=0.97, SD=1.57), relative to infants who had seen a Knowledge-Consistent outcome of a solidity event (M=-0.29, SD=0.60), $t(18)=2.378$, $P=0.029$. In contrast, infants who had seen a Knowledge-Violation outcome of a support event showed a greater tendency to drop the target object (rather than bang it) (M=-1.05, SD=1.96), relative to infants who had seen a Knowledge-Consistent outcome of a support event (M=0.37, SD=0.96), $t(18)=-2.045$, $P=0.056$ (table S2).

Finally, we examined infants' banging and dropping of the new distractor object that had not participated in the solidity or support event. We calculated z-scores for each behavior separately, using the averages and standard deviations of banging (M=1.85, SD=4.63) and dropping (M=0.90, SD=1.96) on the distractor object for all infants. The z-

scored banging behaviors of infants who had seen the Knowledge-Consistent outcome of a solidity event averaged 0.29 (SD=1.44); their z-scored dropping behaviors averaged -0.10 (SD=0.64). The z-scored banging behaviors of infants who had seen the Knowledge-Violation outcome of a solidity event averaged 0.29 (SD=1.35); their z-scored dropping behaviors averaged -0.31 (SD=0.48). The z-scored banging behaviors of infants who had seen the Knowledge-Consistent outcome of a support event averaged -0.23 (SD=0.22); their z-scored dropping behaviors averaged 0.26 (SD=1.51). The z-scored banging behaviors of infants who had seen the Knowledge-Violation outcome of a support event averaged -0.36 (SD=0.09); their z-scored dropping behaviors averaged 0.15 (SD=1.10).

As before, we calculated action tendency scores by subtracting the z-scored frequency of infants' object dropping from the z-scored frequency of their object banging, this time on the distractor object. A univariate ANOVA with action tendency score on the distractor object as the dependent variable and event type (Solidity or Support) and outcome type (Knowledge-Consistent or Knowledge-Violation) as fixed factors yielded a main effect of event type, $F(1,36)=4.574$, $P=0.04$, partial $\eta^2=0.11$. Critically, there was no significant interaction between event type and outcome type, $F(1,36)=0.062$, $P=0.80$. Infants did not act differentially on an object that had not participated in the preceding event, regardless of whether that event involved a Knowledge-Consistent outcome of a solidity event (M=0.39, SD=1.60), a Knowledge-Consistent outcome of a support event (M=-0.48, SD=1.57), a Knowledge-Violation outcome of a solidity event (M=0.60, SD=1.52), or a Knowledge-Violation outcome of a support event (M=-0.51, SD=1.13). A repeated measures ANOVA with action tendency score as the dependent variable, object type (target or distractor) as the within-subjects factor, and event type (Solidity or Support) and outcome type (Knowledge-Consistent or Knowledge-Violation) as between-subjects factors yielded a significant main effect of event type, $F(1,36)=5.502$, $P=0.03$, $\eta^2=0.133$ – overall, infants who saw a solidity event banged more, whereas infants who saw a support event dropped more. The analysis also yielded a significant interaction between event type and outcome type, $F(1,36)=4.172$, $P=0.048$, $\eta^2=0.104$. Infants who saw the Knowledge-Consistent events did not differentially engage with the objects. Infants who saw a solidity event end in a Knowledge-Violation outcome banged the objects more than they dropped them, whereas infants who saw a support event end in a Knowledge-Violation outcome dropped the objects more than they banged them. However, this interaction must be interpreted in light of the predicted significant interaction between object type, event type, and outcome type, $F(1,36)=4.95$, $P=0.032$, partial $\eta^2=0.12$. The kinds of exploratory actions infants produced depended on whether they had seen a solidity or support event, whether they had seen a Knowledge-Consistent or a Knowledge-Violation outcome, and whether they were engaging with the target object or the new distractor object.

	Event Outcome Looking (sec)	**Baseline** Target Looking (sec)	New Distractor Looking (sec)	Avg. Target Proportion	**Mapping Test** Target Looking (sec)	New Distractor Looking (sec)	Avg. Target Proportion	**Learning Score**
Experiment 1								
Knowledge-Consistent *Solidity*	6.33	1.91	2.34	0.46	2.72	4.98	0.36	**-0.10**
Knowledge-Violation *Solidity*	5.29	0.78	2.47	0.23	3.03	4.64	0.40	**0.17**
Knowledge-Consistent *Continuity*	3.19	1.27	2.62	0.32	2.96	4.68	0.38	**0.06**
Knowledge-Violation *Continuity*	4.29	1.05	2.38	0.29	3.33	3.77	0.49	**0.20**
Experiment 2								
Knowledge-Violation *Solidity*	6.79	1.58	2.41	0.40	3.38	3.94	0.47	**0.07**
Knowledge-Violation *Continuity*	5.81	1.51	2.12	0.433	3.34	4.3	0.436	**0.003**
Experiment 3								
Knowledge-Violation *Continuity*	3.45	2.05	1.56	0.539	4.07	3.39	0.544	**0.005**

Table S1. Infants' performance in Experiments 1-3.

	Event Outcome Looking (sec)	**Exploration** Target (sec)	New Distractor (sec)	**Exploration Score**	**Actions Performed on Target Object** Banging Frequency	Dropping Frequency	Z-scored Banging	Z-scored Dropping	**Action Tendency Score**
Experiment 4									
Knowledge-Consistent *Solidity*	4.37	26.04	44.91	**-18.87**	0.6	0.4	-0.43	-0.14	**-0.29**
Knowledge-Violation *Solidity*	4.41	45.79	28.81	**16.98**	3.9	0.4	0.83	-0.14	**0.97**
Knowledge-Consistent *Support*	4.49	41.53	38.73	**2.80**	1.7	0.1	-0.01	-0.38	**0.37**
Knowledge-Violation *Support*	5.59	34.90	23.05	**11.85**	0.7	1.4	-0.39	0.65	**-1.05**

Table S2. Infants' performance in Experiment 4.

Movie S1.mov
Movie S1: Experiment 1 Knowledge-Consistent solidity event

This movie shows the Knowledge-Consistent solidity event in Experiment 1, in which an object appears to have been stopped by the solid wall in its path.

MovieS2.mov
Movie S2: Experiment 1 Knowledge-Violation solidity event

This movie shows the Knowledge-Violation solidity event in Experiment 1, in which an object appears to pass through the solid wall in its path.

MovieS3.mov
Movie S3: Experiment 1 Knowledge-Consistent continuity event

This movie shows the Knowledge-Consistent spatiotemporal continuity event in Experiment 1, in which an object is hidden behind the left screen and is revealed behind the left screen.

MovieS4.mov
Movie S4: Experiment 1 Knowledge-Violation continuity event

This movie shows the Knowledge-Violation spatiotemporal continuity event in Experiment 1, in which an object is hidden behind the left screen but is revealed behind the right screen.

Movie S5.mov
Movie S5: Experiment 1 Knowledge-Consistent support event

This movie shows the Knowledge-Consistent support event in Experiment 4, in which an object is pushed to a surface edge while remaining completely supported.

MovieS6.mov
Movie S6: Experiment 1 Knowledge-Violation support event

This movie shows the Knowledge-Violation support event in Experiment 4, in which an object is pushed over a surface edge but does not fall.