

**Infants Preferentially Approach and Explore the Unexpected**

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**Abstract**

Looking time experiments based on the violation-of-expectation (VOE) method have consistently demonstrated that infants look longer when their expectations are violated. However, it remains an open question whether similar effects will be observed in infants' approach behaviors. Specifically, do infants selectively approach and explore sources that violate their expectations? In the present study, we address this question by examining how infants' looking times are related to their approach and exploration behaviors. Using a traditional VOE method and a crawling paradigm, we demonstrate a strong correspondence between looking time and approach behaviors, which indicates that 13-month-old infants preferentially explore sources of unexpected events. Such spontaneous exploration may provide learning opportunities and allow infants to play an active role in driving their own development.

*Keywords:* looking time, expectancy violation, exploration

### Infants Preferentially Approach and Explore the Unexpected

Over the last few decades, looking time experiments based on the violation-of-expectation (VOE) method have revealed infants' extant knowledge in a variety of domains, such as their physical knowledge (e.g. Baillargeon, Spelke, & Wasserman, 1985; Baillargeon, 2008; Spelke, Breinlinger, Macomber, & Jacobson, 1992), numerical knowledge (e.g. Mccrink & Wynn, 2015; Wynn, 1992), statistical and probabilistic intuitions (e.g. Fiser & Aslin, 2002; Kirkham, Slemmer, & Johnson, 2002; Téglás, Girotto, Gonzalez, & Bonatti, 2007; Xu & Garcia, 2008), and theory of mind (e.g. Gergely, Nádasdy, Csibra, & Bíró, 1995; Onishi & Baillargeon, 2005). Such studies have consistently demonstrated that infants look longer when their expectations are violated, but it remains an open question whether similar effects will be observed in infants' approach behaviors. Specifically, do infants selectively approach and explore sources that violate their expectations?

We hypothesize that infants will do so, as unexpected events are great opportunities for learning since the world is behaving differently from one's representation of it. Learners may thus seek new information that will allow them to possibly revise their beliefs (Griffiths & Tenenbaum, 2007; Leslie, 2004). There is some evidence supporting this hypothesis: in a recent study, researchers demonstrated that 11-month-olds, who were presented with two objects within their reach on their high-chair tray, preferentially explored the object involved in a prior event that violated their "core" physical expectations, over a novel object (Stahl & Feigenson, 2015). In the current study, we contend that this selectivity is not limited to events that violate expectations drawn from core knowledge (Carey, 2009; Izard, Sann, Spelke, & Streri, 2009; Spelke et al., 1992). Expectancy violations involving other types of knowledge can similarly

influence an infant's subsequent exploration. Furthermore, the events do not have to be *impossible*; events that are *improbable* may also result in similar effects on exploration.

Consider the example of watching a sequence of die rolls. When a six-sided die is shown to roll a sequence of “1, 1, 1, 1”, we find this sequence to be more unexpected than when a sequence of “2, 4, 3, 6” is rolled. This reflects our intuition that the former seems like a coincidence – it provides better support for a set of alternative theories (e.g. the die is loaded; or the die has more than a single face showing 1), as compared to the currently favored theory of a fair die (see Griffiths & Tenenbaum (2007) and Sim & Xu (2013) for further discussion). Likewise, we are more inclined towards examining a die for oddities when it produces the former sequence of die rolls, rather than the latter sequence. It thus appears that selectivity in exploration is not limited to having observed an impossible event—it is, after all, possible to obtain the sequence “1, 1, 1, 1” purely by chance.

In the current study, we thus designed a set of events analogous to sequences of die rolls. Infants were familiarized to a box containing 6 different-colored balls. They subsequently saw two sequences generated by random sampling with replacement: a *variable sequence*, in which a different-colored ball fell out of the box over 4 tosses (e.g. blue-green-red-yellow), and a *uniform sequence*, in which the same-colored ball fell out each time (e.g. yellow-yellow-yellow-yellow). Using this set of contrasting events, we conducted two experiments to investigate whether infants preferentially approach sources of unexpected events. More specifically, we hypothesized that like adults, infants would consider the uniform sequence to be more unexpected than the variable sequence, and they would preferentially explore a box that generated the uniform sequence over a box that generated the variable sequence.

Given the complexity of these looking time displays, as well as previous research that has shown success with 10- to 14-month-olds using a crawling/choice paradigm (Cherries, Mitroff, Wynn, & Scholl, 2008; Denison & Xu, 2010; Feigenson, Carey, & Hauser, 2002), we chose to test 12- and 13-month-old infants in the current study. In Experiment 1, we used the traditional VOE method to first establish that under conditions of random sampling, 12- and 13-month-old infants consider the uniform sequence to be more unexpected than the variable sequence. In Experiment 2, we examined whether the selectivity observed in looking time will be similarly observed in infants' crawling/choice behavior, which may be more reflective of their real-world behaviors (Hamlin, Wynn, & Bloom, 2008; Hespos & Baillargeon, 2006, 2008; Stahl & Feigenson, 2015).

### Experiment 1

#### Method

**Participants.** Forty infants (18 males and 22 females,  $M = 12; 27$  [months; days],  $R = 12; 3$  to  $14; 3$ ) were tested. An additional 6 infants were tested but excluded due to fussiness ( $N = 3$ ), parental interference ( $N = 1$ ) or experimenter error ( $N = 2$ ).

**Materials.** Balls (7 cm in diameter) of 6 colors (red, purple, blue, green, yellow and orange) were used. There was also a small white box (28 cm x 10 cm x 7.5 cm), a transparent container with an open top (16.5 cm x 7.5 cm x 9 cm), and a large box (30 cm x 26 cm x 21 cm) with a Plexiglas window that displayed the population of balls within it. The large box had two hidden back compartments. From the infants' perspectives, the box appeared as one single unit, filled only with 6 different colored balls. The Plexiglas display window was covered with a fabric curtain.

**Design and Procedure.** Infants sat in a high chair about 70 cm from a display stage, with their parents sitting next to them while facing the opposite direction. Each infant was randomly assigned to a Sampling condition or a Control condition. In the former, the experimenter tilted the large box to toss out sequences of balls. In the latter, the experimenter pulled the sequences of balls out of her pocket instead. Both conditions consisted of a Calibration phase, a Free Play phase, a Familiarization phase, and a Test phase.

**Sampling Condition.** To calibrate each infant's looking window, a squeaky toy or keys was used to direct the infant's attention to the outside parameters of the stage. In the subsequent Free Play phase, the infant was shown a white box containing three different colored balls. She was encouraged to play with the balls for approximately 30 seconds.

The Familiarization phase that followed consisted of two trials. To begin each trial, the experimenter placed the large box on the stage and lifted the curtain to reveal a population of 6 different-colored balls. She then shook the box 4 times. While the infant was looking at the stage, the experimenter said "Look, [baby's name], look!" and dropped the back curtain to conceal herself. Upon hearing the second "look," a second observer, who was blind to the infant's assigned condition, began timing looking behavior by viewing a live feed of the infant's face from a video camera that was set up below the stage. The observer used JHAB (R. Casstevens, 2007) to record looking times. Trials ended when the infant looked away for 2 consecutive seconds. These trials familiarized the infants to the population of balls in the large box.

The Test phase consisted of a Uniform trial and a Variable trial. On each test trial, the experimenter placed the large box and the small transparent container on the stage, 8 cm apart. The experimenter then lifted the front curtain of the large box, saying "What's this?" She

lowered her head and directed her eye gaze at the box for 1 second. She then shook it 4 times. After the box was set down, the experimenter lowered the front curtain to conceal the box's contents. Then, the box was tilted to its side, allowing one ball to fall out into the small container. Although it appeared that the ball had been randomly sampled, it actually fell out of the back compartment of the box, which contained balls that had been previously set up. The experimenter then directed her gaze towards the "sampled" ball, saying "Look at that!" After 1 second, the ball was returned into the box. This process of revealing the population, shaking the box and tossing a ball out was repeated 3 more times, to make a total of 4 "sampled" balls. When the 4th ball was tossed out, the experimenter said "Look, [baby's name], look!" and dropped the back curtain of the stage. The observer began timing upon hearing the second "look," and ended the trial after the infant looked away for 2 consecutive seconds.

Each infant participated in a Uniform trial and a Variable trial (Figure 1A). In the Uniform trial, the 4 "sampled" balls were all of the same color, while in the Variable trial, the 4 "sampled" balls were all of a different color. The last ball tossed out in the two trials was always identical. Trial order and the colors of the sampled balls were counterbalanced across infants.

***Control Condition.*** The purpose of this condition was to ensure that any differences in looking times found for the Uniform and Variable trial in the Sampling condition was due to the infants observing unexpected vs. expected sequences being generated by a *random sampling process*. As such, the procedure was identical to that in the Sampling condition, except that the balls were drawn out by the experimenter after she looked into the box. Since the experimenter had visual access while sampling from the box, this violates the random sampling assumption: the experimenter could pick and choose which balls she wanted to draw from the population box. This condition thus provided a measure of infants' preferences for the two different sequences of

balls, Uniform vs. Variable, when the assumption of random sampling does not hold. The Control condition also ensured that any difference found between the looking times for the sequences presented in the Sampling condition was not due to an intrinsic preference for a certain type of sequence.

## Results

A second observer coded 50% of the infants' videos offline. Reliability was calculated as the proportion of total time both observers agreed that infants were looking at the displays. Thus, percentage agreement =  $1 - [(\text{absolute difference in time between original and second coder}) / \text{original coder}]$ . Interscorer reliability averaged 95%. Preliminary analyses found no effect of gender on looking times. Subsequent analyses were collapsed over this variable.

Looking times for the test trials were analyzed using a 2 x 2 repeated-measures ANOVA with Condition (Sampling vs. Control) as a between-subjects factor and Trial Type (Uniform vs. Variable) as a within-subjects factor. There was a significant interaction between Condition and Trial Type,  $F(1, 38) = 9.48, p = .004, \eta_p^2 = .20$ . There were no main effects.

We then conducted planned comparisons to examine the effect of Trial Type (Uniform vs. Variable) for each Condition separately (See Figure 2 for mean looking times). In the Sampling condition, infants looked significantly longer in the Uniform trial ( $M = 11.75s, SD = 9.90$ ) than the Variable trial ( $M = 9.14s, SD = 8.07$ ),  $t(19) = 2.64, p = .016, d = .64$ . A non-parametric Wilcoxon signed-rank test also showed a significant difference in the infants' looking times in the Uniform and Variable trial,  $z = 2.05, p = .04$ . Fourteen out of 20 infants in this condition looked longer in the Uniform trial, while the remaining six infants looked longer in the Variable trial.

In contrast, infants in the Control condition looked significantly longer in the Variable trial ( $M = 15.55s$ ,  $SD = 9.43$ ) than the Uniform trial ( $M = 10.46s$ ,  $SD = 5.09$ ),  $t(11) = 2.21$ ,  $p = .039$ ,  $d = .52$ . The result from the Wilcoxon signed-rank test was also significant,  $z = 1.98$ ,  $p = .048$ . Thirteen out of 20 infants in this condition looked longer in the Variable trial, while the remaining seven infants looked longer in the Uniform trial.

## Discussion

In the Sampling condition, infants looked reliably longer when 4 randomly generated balls were all of the same color, rather than of different colors. This pattern was not observed in the Control condition, suggesting that it was the presentation of a random sampling process that led infants to show longer looking times at the Uniform trial in the Sampling condition; infants did not intrinsically prefer sequences of identical balls. Hence, infants' reactions are consistent with those of adults: under random sampling, the uniform sequence is more unexpected than the variable sequence.

## Experiment 2

### Method

**Participants.** Forty infants (22 males and 18 females,  $M = 13; 4$  [months; days],  $R = 12; 14$  to  $13; 29$ ) were tested. An additional 5 infants were tested but excluded due to parental interference ( $N = 4$ ) or failure to make a choice ( $N = 1$ ).

**Materials.** The materials were identical to those used in Experiment 1, except that there were now two large population boxes (29 cm x 23 cm x 22 cm). The display window of one box was covered with a black fabric curtain, and the other a white one. When the curtains were lifted, both boxes revealed identical populations of 6 different-colored balls.

**Design and Procedure.** Infants were tested in a forced-choice paradigm. Each infant sat on her parent's lap on the floor facing an elevated display stage approximately 1.2 meters away. The stage was about 75 cm above the ground and the base of the stage was covered with cloth. Parents were instructed to hold on to their infant, and then to set their infant on the floor when they heard the instruction, "Do you want to come and play?" Infants were randomly assigned to a Sampling condition or a Control condition. Both conditions consisted of a Free Play phase, a Demonstration phase, and a Test phase.

**Sampling Condition.** The Free Play phase was identical to that of Experiment 1. To begin the Demonstration phase, the experimenter placed the two large boxes on the stage about 20 cm apart. One of the boxes was randomly assigned to be the Uniform box, which meant that it was set up beforehand to produce a uniform sequence (i.e., 4 same-colored balls), while the other box was assigned to be the Variable box, which meant that it was set up beforehand to produce a variable sequence (i.e., 4 different-colored balls; Figure 1B). Regardless of its assignment, the boxes both appeared to contain 6 different-colored balls from the infant's perspective.

The large box placed on the left side of the stage (infant's view) was always the box with black fabric, and the large box on the right was always the box with white fabric. The experimenter always started the Demonstration phase with the box on the left, but whether this box was the Uniform box or a Variable box was counterbalanced across infants. For half of the infants, the black box on the left was the Uniform box and the white box on the right was the Variable box, and for the other half of the infants, the black box on the left was the Variable box and the white box on the right was the Uniform box.

The experimenter also placed a transparent container in the space between the two boxes. She then drew the infant's attention to the box on the left, saying "What's in this box?" The front

curtain of this box was lifted, revealing a population of 6 different-colored balls. The procedure that followed was identical to the test trials in Experiment 1, in which the experimenter seemingly tosses out 4 balls from the box at random, one after another with replacement. The only exception was that the 4<sup>th</sup> ball was returned to the box after 1 second, as looking behaviors were not of interest here. She then pointed to the other box, and said “Let’s see what’s in this box!” The experimenter then repeated the steps performed on the previous box.

In the test phase, the experimenter always first placed the left box down on the ground to the left side of the stage, and then the right box down on the ground to the right side of the stage. The infant was equidistant from the two boxes, which were each approximately 1 meter away. The experimenter then returned to the center of the stage. After ensuring that the infant was looking directly at her, she said, “Do you want to come and play?” She then discontinued the joint attention with the infant by looking downwards towards the stage. When the infant touched one of the boxes, the experimenter started a timer and the test trial ended after 60 seconds.

If the infant did not touch either of the two boxes after 30 seconds, the experimenter retrieved the two boxes and sat on the floor approximately 60 cm from the infant. Using both hands, the experimenter then brought the two boxes forward simultaneously, keeping each box about 30 cm away from the infant. She repeated the instruction, “Do you want to come and play?” Once again, the experimenter only started a timer when the infant touched one or both of the boxes, and the test trial ended after 60 seconds.

***Control Condition.*** The purpose of this condition was to ensure that any differences in the approach and exploration behaviors for the two boxes presented in the Sampling condition was due to the infants observing unexpected vs. expected sequences being generated by a *random sampling process*. As such, the procedure was identical to that in the Sampling

condition, except that the balls were drawn out by the experimenter after she looked into the box. Since the experimenter had visual access while sampling from the box, this violates the random sampling assumption: the experimenter could pick and choose which balls she wanted to draw from the population box. This condition thus provided a measure of infants' approach and exploration behaviors for the two boxes when the assumption of random sampling does not hold. Again, the Control condition also ensured that any difference found in the Sampling condition was not due to an intrinsic preference for a certain type of sequence/box.

**Coding.** All of the infants' behaviors were coded offline. We had two measures: *touching the boxes*, and *reaching into the boxes*. The touching measure was operationalized as the amount of time that an infant's either or both hands were in contact with each of the two boxes. All time periods with the infant contacting the boxes were included in the analysis, i.e., the infant could be touching the boxes individually or both boxes simultaneously. However, times in which an infant was in contact with the boxes through her body or her legs were not included within this measure. The reaching measure was operationalized as the amount of time that an infant's hand was inserted into one of the openings present on the surfaces of the two boxes, such that the hand is no longer fully visible. Note that the two measures were not mutually exclusive. The video coding was performed using Datavyu (Datavyu Team, 2014).

## Results

A second observer coded 50% of the infants' videos offline. Reliability was calculated as the proportion of total time both observers agreed that infants were touching/reaching into either the Uniform box or the Variable box. Thus, percentage agreement =  $1 - [(absolute\ difference\ in\ time\ between\ original\ and\ second\ coder)/original\ coder]$ . Interscorer reliability averaged 93% for the touching measure, and 96% for the reaching measure. Preliminary analyses found no effect

of gender or demonstration order (Uniform box or Variable box presented first) on the two measures; subsequent analyses were collapsed over this variable.

We first analyzed the time infants spent *touching* the boxes by performing a 2 (Condition: Sampling vs. Control) x 2 (Box Type: Uniform vs. Variable) ANOVA with repeated-measures on the second factor. As hypothesized, the analysis yielded a significant interaction between Condition and Box Type for the amount of time infants spent touching the boxes,  $F(1, 38) = 26.52, p < .001, \eta_p^2 = .41$ . No main effects were found.

Planned comparisons to analyze the significant interaction revealed that infants in the Sampling condition *touched* the Uniform box ( $M = 29.52s, SD = 25.44$ ) significantly longer than the Variable box ( $M = 5.72s, SD = 10.47$ ) at test,  $t(19) = 3.33, p = .004, d = .76$  (Figure 3). The result of a Wilcoxon signed-rank test was significant,  $z = 2.46, p = .014$ . Fourteen out of 20 infants preferred touching the Uniform box to the Variable box, while the remaining 6 infants preferred touching the Variable box. In contrast, infants in the Control condition touched the Variable box ( $M = 32.57s, SD = 20.68$ ) significantly longer than the Uniform box ( $M = 8.52s, SD = 9.65$ ),  $t(19) = 4.05, p = .001, d = .92$ . A Wilcoxon signed-rank test also showed a significant difference between the amount of time infants in this condition touched the two boxes,  $z = 3.02, p = .002$ . Fifteen out of 20 infants in this condition preferred touching the Variable box, while the remaining five infants preferred the Uniform box.

Furthermore, there was no difference found in the overall amount of time that infants spent touching the two boxes between conditions (Sampling condition:  $M = 35.25s, SD = 22.18$ ; Control condition:  $M = 41.09s, SD = 18.35$ ),  $t(38) = .91, p = .37$ .

We next analyzed the time infants spent *reaching* into the boxes by performing a 2 (Condition) x 2 (Box Type) ANOVA with repeated-measures on the second factor. The analysis

yield a significant interaction between Condition and Box Type,  $F(1, 38) = 14.06, p < .001, \eta_p^2 = .27$ . There were no main effects.

Planned comparisons on the amount of time infants spent *reaching* into the boxes revealed that infants in the Sampling condition spent a significantly longer time reaching into the Uniform box ( $M = 10.96s, SD = 15.04$ ) than the Variable box ( $M = 0.70s, SD = 2.24$ ) during the 60s test period,  $t(19) = 2.93, p = .009, d = .76$ . The result of a Wilcoxon signed-rank test was significant,  $z = 2.51, p = .012$ . Ten out of 20 infants preferred reaching into the Uniform box than into the Variable box, while only two infants preferred reaching into the Variable box over the Uniform box. The remaining 8 infants did not reach into either boxes. An additional analysis that excluded infants who did not reach into either of the two boxes similarly showed that infants in the Sampling condition spent a significantly longer time reaching into the Uniform box,  $t(11) = 3.44, p = .006, d = 1.85$ .

According to these reaching times, 37.12% of the time that these infants were in physical contact with the Uniform box was spent reaching into it, while only 12.23% of the time that they were in physical contact with the Variable box was spent reaching into it.

In contrast, infants in the Control condition reached into the Variable box ( $M = 8.97s, SD = 13.86$ ) for a significantly longer time than the Uniform box ( $M = 1.52s, SD = 3.45$ ),  $t(19) = 2.35, p = .03, d = .59$ . The Wilcoxon signed-rank test showed a significant difference in the amount of time infants spent reaching into the two boxes,  $z = 2.29, p = .022$ . Eleven out of the 20 infants preferred reaching into the Variable box over the Uniform box, while only three infants preferred reaching into the Uniform box than into the Variable box. The remaining 6 infants did not reach inside of either boxes. Likewise, an additional analysis excluding infants who did not reach into either of the two boxes showed that infants in the Control condition spent a

significantly longer time reaching into the Variable box,  $t(13) = 2.49$ ,  $p = .027$ ,  $d = .83$ . These infants in this condition spent 27.54% of the time that they were in contact with the Variable box on reaching inside of it, but only spent 8.22% of the time that they were in contact with the Uniform box on reaching inside it. (See Figure 4 for mean reaching times).

### **Discussion**

Infants in the Sampling condition preferentially explored the box that was the source of an unexpected event. Not only did they touch the Uniform box for a longer time than the Variable box, they also spent more time reaching inside of it, which is a behavior that could yield information about the mechanics of the sampling process. These results correspond with the findings in Experiment 1, demonstrating that infants selectively approach and explore sources that violate their expectations. The pattern of exploration behaviors was reversed in the Control condition, demonstrating it was the presentation of a random sampling process that led infants to preferentially approach and explore the Uniform box; infants did not show an intrinsic preference for a box generating a uniform sequence.

### **General Discussion**

Using a probability task over two experiments, we demonstrate that infants preferentially approach and explore sources of unexpected events. In Experiment 1, 13-month-old infants saw balls ostensibly being randomly sampled from a population of 6 different-colored balls, creating an expectation that different-colored balls should be produced. Infants looked longer when the box generated four identical balls, establishing that infants share adult intuitions towards such events: under conditions of random sampling, a uniform sequence of ball tosses is more unexpected than a variable one. Experiment 2 demonstrated that infants spent more time touching and reaching into a box that generated a uniform sequence instead of a variable

sequence. Thus, the selectivity observed in infant looking time in VOE experiments is similarly observed in infant approach behaviors in action tasks.

Our findings replicate and extend recent results by Stahl and Feigenson (2015), demonstrating that when infants observe events that defy their expectations, they show preferential approach and exploration – they are drawn towards the source of the anomaly. This selectivity in exploration is not limited to domains of core knowledge or only to events that are impossible. The consequences of observing an expectancy violation may apply across many different domains of knowledge, placing infants in good stead to learn about different aspects of their world.

It is interesting that we also found a strong correspondence between the Control conditions in the two experiments: 13-month-olds looked longer at the variable sequence in Experiment 1, and they also spent more time with the Variable box in Experiment 2. We speculate that other factors, such as novelty and perceptual salience, may drive infants' looking and exploration patterns as well. This explanation is consistent with the well-established finding that many animals, including children, selectively explore novel stimuli (Berlyne, 1966; Dember & Earl, 1957; Henderson & Moore, 1980; Hutt & Bhavnani, 1972).

The current work also makes a novel contribution to the field of research examining infants through the use of action tasks. Previous studies have largely focused on tasks that provide converging evidence for early competencies demonstrated in VOE experiments. For example, researchers show that infants reach towards helpful characters (Hamlin et al., 2008), or containers/occluders that should contain a retrievable toy (Hespos & Baillargeon, 2006, 2008). They also crawl towards a bucket that has a greater amount of crackers (Feigenson et al., 2002) or a jar that has a higher probability of obtaining a preferred lollipop (Denison & Xu, 2010,

2014). Although these tasks involve approach, they do not shed light on the downstream consequences of observing an expectancy violation. Our results indicate that infants spontaneously explore sources that violate their expectations, potentially providing themselves with new learning opportunities. This claim is corroborated by several recent studies demonstrating the children can actively influence their own learning outcomes by allocating their attention in systematic ways (Cook, Goodman, & Schulz, 2011; Gerken, Balcomb, & Minton, 2011; Kidd, Piantadosi, & Aslin, 2012; Schulz & Bonawitz, 2007).

In summary, our experiments provide strong evidence that infants preferentially explore sources of unexpected events. Future work is necessary to examine the information that infants might be gathering from their physical exploration, and how such evidence might be incorporated into their knowledge base. This line of research may shed light on how infants play an active role in driving their own development, providing new insights for characterizing the learning infant.

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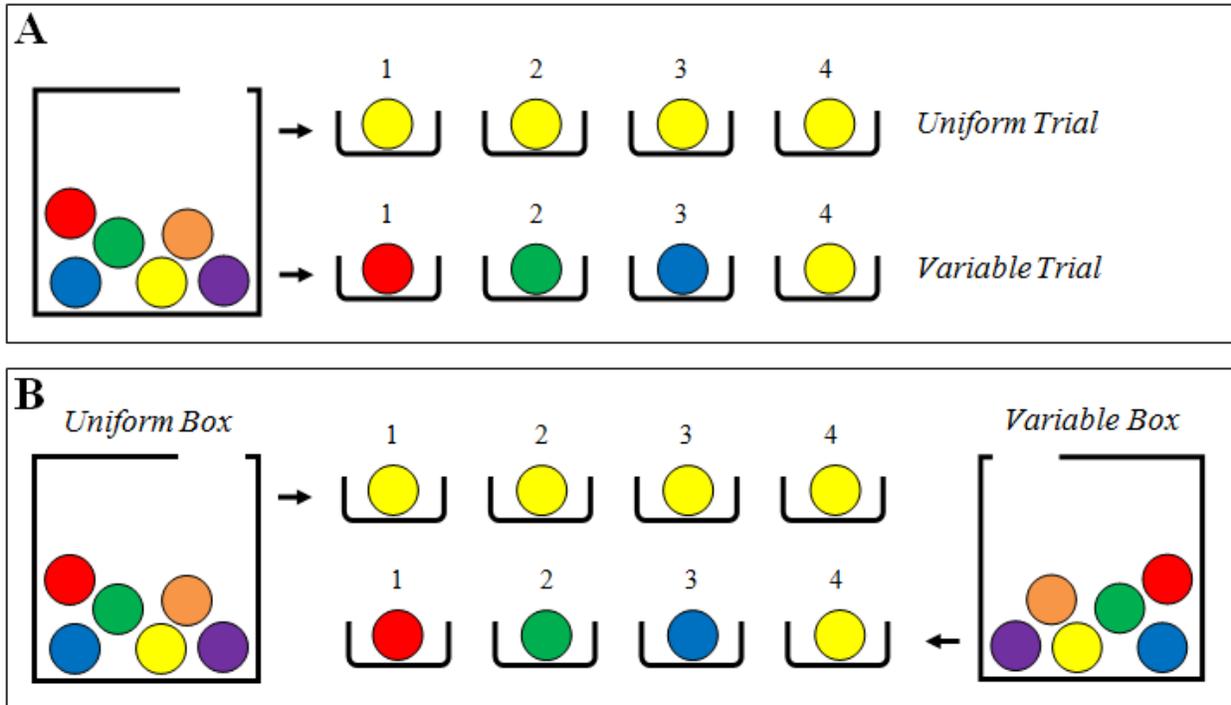
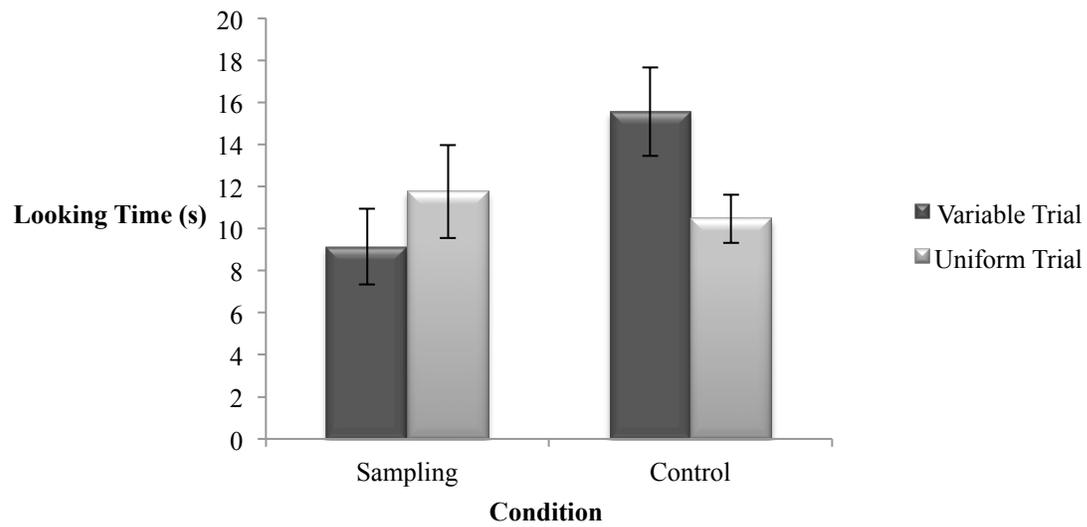
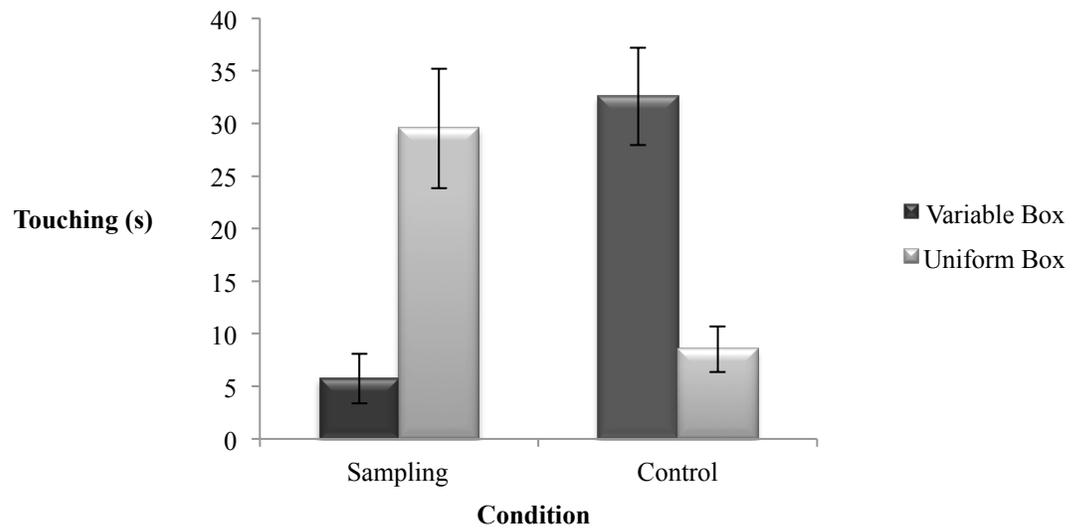


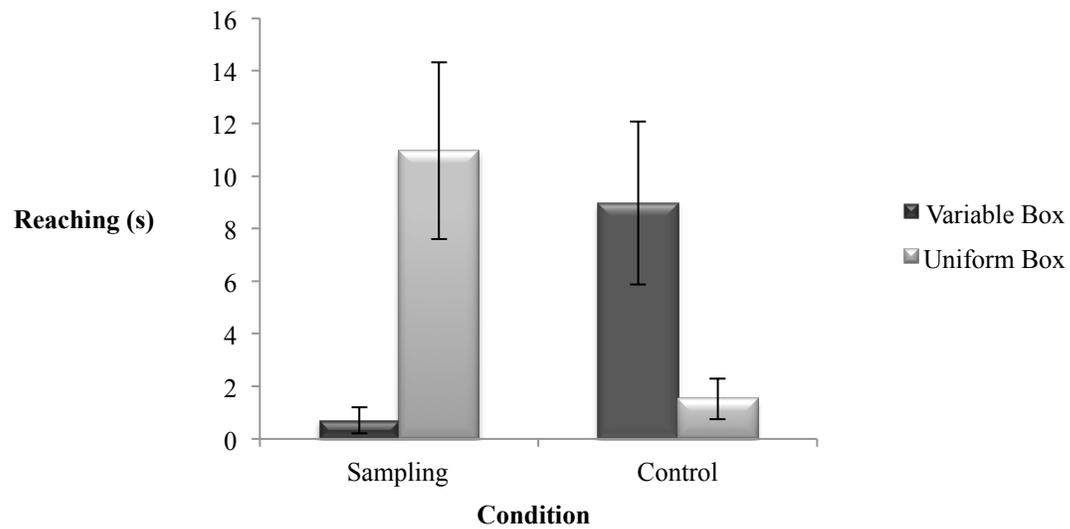
Figure 1. (A) Schematic representation of Experiment 1. (B) Schematic representation of Experiment 2.



*Figure 2.* Mean looking times in the Sampling condition and the Control condition. Error bars represent standard error.



*Figure 3.* Mean amount of time spent touching the Variable box and the Uniform box in the Sampling condition and the Control condition. Error bars represent standard error.



*Figure 4.* Mean amount of time spent reaching into the Variable box and the Uniform box in the Sampling condition and the Control condition. Error bars represent standard error.