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RESEARCH ARTICLE

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Infants preferentially learn from surprising teachers

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Abstract

Infants have sophisticated knowledge about the physical world, and show enhanced learning about objects that violate physical principles. However, it is unknown whether infants also preferentially learn from the *individual* who produces an outcome that violates expectations. We investigated whether 15-month-old infants (N = 48) selectively imitate individuals who produce surprising outcomes. In Experiment 1, infants watched an experimenter hide a ball and produce an expected outcome in which the ball was revealed where it was hidden, or a surprising outcome in which the ball was revealed in a different location. The experimenter then demonstrated a novel action: using her head to activate a light while her hands were free. Infants imitated that novel action more if the experimenter had previously produced a surprising than an expected outcome. In Experiment 2, infants witnessed the experimenter produce the surprising outcome, then use her head to activate the light while her hands were occupied. Infants did not differentially imitate the head-touch action relative to either condition in Experiment 1, perhaps indicating a tension between surprise-induced learning and rational imitation. These experiments show that surprising events are pedagogical opportunities: infants selectively learn from surprising individuals, but also may account for rationality in their surprise-induced social learning.

How do the youngest learners of our species select what information to learn and from whom to learn it, given the enormous amount of input they receive? Preferentially attending to events that fail to accord with one's extant predictions about the world might be one effective way to narrow the learning space. Many previous studies have shown that infants in fact have expectations about the world in place from a young age, including about how objects should behave: for example, infants look longer when objects seemingly disappear or pass through other solid objects (e.g., Baillargeon et al., 1985; Spelke et al., 1992; Wilcox et al., 1996). Not only do infants detect when objects violate their expectations, but they also experience surprise-induced learning about those objects (Stahl & Feigenson, 2015, 2019). For instance, infants were shown an object that either accorded with or violated their expectations (e.g., a ball was either stopped by a wall or appeared to pass through the wall). Infants who saw the non-surprising event did not readily learn new information about that object nor were they motivated to explore it. In contrast, infants who saw the surprising event learned new information about that object, preferred to explore it over novel toys, and tested specific hypotheses about the object's behavior (i.e., they banged objects that violated solidity but dropped objects that violated gravity) (Stahl & Feigenson, 2015; see also Perez & Feigenson, 2022). This surprise-induced learning is not limited to infants or violations of physical principles, as children also preferentially explore and learn about objects that violate a range of expectations (e.g., Bonawitz et al., 2012; Legare, 2012; Legare et al., 2010; Sim & Xu, 2017; Stahl & Feigenson, 2017; van Schijndel et al., 2015).

However, objects do not act in isolation—in nearly every study that demonstrates surprise-induced attention to, learning about, or exploration of surprising objects, a person (or at minimum, a human hand) is present to set that surprising event in motion. It is unknown whether infants process that agent as a component of the surprising event, and whether that individual would also be prioritized by the surprise-induced learning mechanism. If so, infants may therefore also perceive surprising events as unique *pedagogical* opportunities (Csibra & Gergely, 2009) afforded by the individual who produced the surprising outcome. That is, infants may not only preferentially attend to and learn about surprising objects, but they may preferentially attend to and learn *from* surprising individuals.

Indeed, infants are adept at learning from others, but they do not do so indiscriminately. Rather, infants are selective in their teachers. For example, they will learn from or imitate novel actions performed by individuals who are reliable or are members of their in-group, but not those who are unreliable or are members of an out-group (e.g., Altınok et al., 2021; Brooker & Poulin-Dubois, 2013; Buttelmann et al., 2013; Chow et al., 2008; Crivello et al., 2018; Howard et al., 2015; Poulin-Dubois et al., 2011; Tummeltshammer et al., 2014; Zmyj et al., 2010). Thus, infants infer that certain kinds of individuals are effective teachers.

It is an open question how infants would view an individual who produces an outcome that accords with versus violates physical principles. One possibility is that infants will view a non-surprising individual as reliable (they produced an event that accorded with extant expectations) and a surprising individual as unreliable (they produced an outcome that was abnormal and violated expectations). On this account, infants would be more likely to learn from an individual who showed them a non-surprising event, given infants' preference to learn from reliable teachers (e.g., Poulin-Dubois et al., 2011; Zmyj et al., 2010). Conversely, infants may view a person who produces a non-surprising event as explicitly demonstrating that they possess no special skills or knowledge, and someone who produces a surprising event as having special skills or important information to impart. On this account, infants may be more motivated to learn from the surprising individual, since a surprising person might be viewed as an informative teacher (see Begus et al., 2016). In this way, surprise signals a learning opportunity.

In the current study, we asked whether infants preferentially learn from individuals who produce surprising outcomes. Infants observed an experimenter performing a physically possible expected action or a physically impossible surprising action. To assess whether infants subsequently chose to learn from the experimenter, we used the rational imitation paradigm of Gergely et al. (2002; see also Meltzoff, 1988). They found that infants who observed an experimenter performing an unconventional action (i.e., using her head to push a button to turn on a light) imitated that action, but only when it was rational to do so: if the experimenter's hands were free but she chose not to use them, infants also used their heads to push the button (inferring that she must have had a reason to use her head), but if the experimenter used her head while her hands were occupied, infants primarily used their hands to push the button (inferring that she would have used her hands had they been available). More recent studies have shown that infants imitate this head-touch action when the experimenter demonstrates that they are reliable but not unreliable or are members of the infants' in-group but not out-group (e.g., Buttelmann et al., 2013; Zmyj et al., 2010).

Given that infants preferentially learn from certain kinds of individuals and preferentially learn about surprising objects (Stahl & Feigenson, 2015, 2019), we hypothesized that infants would be more likely to imitate the individual who produces a surprising outcome than an expected outcome (Experiment 1). However, we also predicted that infants would not indiscriminately imitate a surprising individual, but rather would demonstrate *rational learning*, suggesting that they identified the surprising individual as an informative teacher (Experiment 2).

1 | EXPERIMENT 1

In Experiment 1, we presented infants with an event that either accorded with or violated their expectations. Infants watched as an experimenter hid a ball behind one of two screens, then either revealed the ball behind the same screen (Expected outcome) or behind a different screen (Surprising outcome). Infants detect such violations of spatiotemporal continuity by 2.5 months of age (Wilcox et al., 1996). The experimenter then demonstrated the novel action of using her head to push a button to turn on a light while her hands were visibly free (as in Gergely et al., 2002). We subsequently measured infants' imitation of the novel action of using their head to push the button.

1.1 | Method

1.1.1 | Participants

The total sample size of 48 infants was determined prior to the start of the experiment based on prior research with similar sample sizes (e.g., Altınok et al., 2021; Gergely et al., 2002; Howard et al., 2015; Meltzoff, 1988). In Experiment 1, 32 full-term infants between 13 and 17.5 months participated (M = 15 months, 1 day; range = 13 months, 5 days–17 months, 14 days); 19 were female. This age range was selected based on previous studies that have employed the rational imitation paradigm with infants between 13 and 18 months of age (e.g., Altınok et al., 2021; Buttelmann et al., 2013; Gergely et al., 2002; Howard et al., 2015; Meltzoff, 1988; Zmyj et al., 2010). Thirteen additional infants were excluded due to fussiness (4), parental interference (3), sibling interference (1), inattentiveness (such that infants did not watch the Object Event; 3) or equipment failure (2). Sixteen infants participated in either of the two conditions: Expected and Surprising. The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Institutional Review Board at The College of New Jersey. Infants received a certificate and a book for their participation.

1.1.2 | Stimuli

Two identical gray foam-core screens (27 × 29 cm) were used to hide a yellow and red striped ball (7.5 cm in diameter). Each screen had a concealed rear compartment that allowed the experimenter to surreptitiously add or remove objects from the table. The experimenter wore a bracelet with bells to attract infants' attention and help them track the ball as it moved into occlusion. A round button light (14 cm in diameter) that illuminated when pushed (pushing it again turned the light off) was also used (see Figure 1). The light could be affixed to a black-angled platform (attached with Velcro) made out of foam-core so that infants could more easily reach the light while standing at the table.

1.1.3 | Procedure

Infants began the experiment by sitting on their parent's lap while the experimenter kneeled at the table across from them. The table was covered with a black cloth. Prior to starting the experiment, parents were instructed to remain silent throughout the duration of the experiment, but that if the light moves out of the infant's reach during the Exploration Phase, to neutrally slide it back to the edge of the table so that the infant could continue to explore it if they wished.

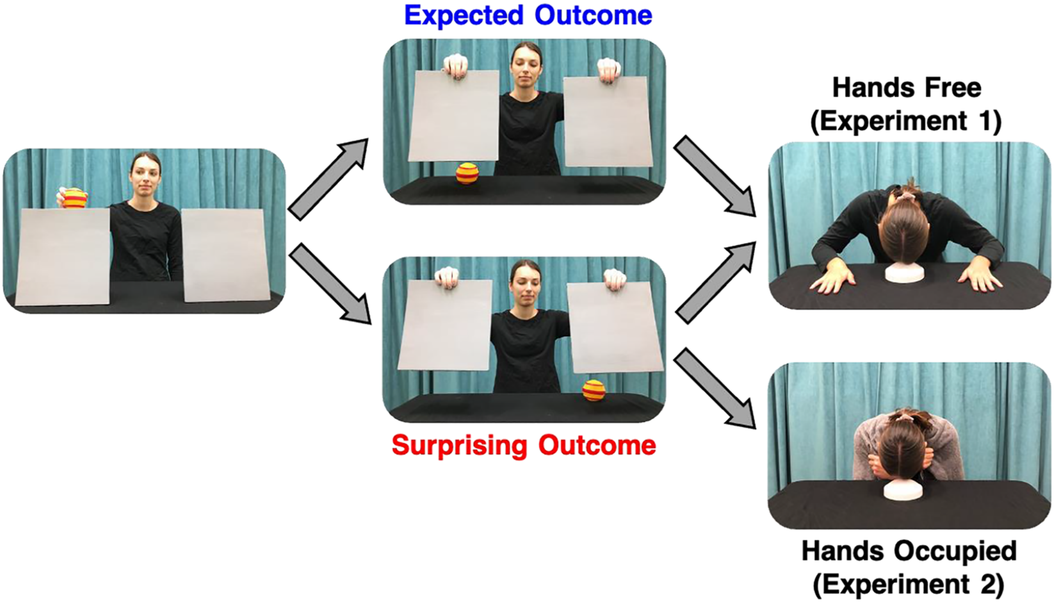

FIGURE 1 In Experiment 1, infants watched an experimenter hide a ball behind the left-hand screen. She then lifted the screens to reveal either an Expected outcome, in which the ball was revealed behind the same left-hand screen, or a Surprising outcome, in which the ball was revealed behind the right-hand screen. Next, infants watched the experimenter use her forehead to push a button to turn on a light while her hands were free. In Experiment 2, infants witnessed the Surprising outcome, then watched the experimenter use her forehead to turn on the light while her hands were occupied. All infants were then given 60 s to explore the light

Event phase

As in Stahl and Feigenson (2015), infants first viewed two Familiarization trials followed by the Object Event in which they saw the experimenter produce an Expected or a Surprising outcome.

Familiarization

Infants watched two identical familiarization trials. The experimenter first placed one gray screen in the center of the empty table while saying, “Look!” She then reached under the table and pulled out the ball, wiggling it in front of the screen (so that the bells on her wrist jingled) as she said, “Wow, look at this! Watch this!” While still wiggling her wrist to shake the bells, she slowly hid the ball behind the screen. Her eyes tracked the ball as it became occluded from the infants' view. She then lifted the screen to reveal the ball resting on the table and placed the screen under the table. This entire process lasted approximately 9 s, and then the experimenter looked at the ball for 5 s. She removed the ball from the table, and repeated this process once more.

Object event

Next, infants watched the experimenter place two screens on the empty table, approximately 17 cm apart. She retrieved the ball from under the table and wiggled it in front of the screen on the infants' left, saying, “Hey, look! Look at this! Watch this!” then hid it behind that screen as she wiggled her wrist to shake the bells. She tracked the ball with her eyes as it became occluded from the infants' view. Half of the infants viewed the Expected condition, in which the experimenter placed the ball on the table behind the same left-hand screen (as she did this, she used her other hand to surreptitiously reach behind the other screen, so as to match the movements required to implement the Surprising outcome). When the experimenter lifted the screens, the ball was revealed in the Expected location, behind the same left-hand screen (Figure 1). The other half of the infants viewed the Surprising condition, in which the experimenter also hid the ball behind the left-hand screen, but placed it inside the concealed rear compartment of the screen (rather than on the table) as she used her other hand to surreptitiously reach behind the right-hand screen and remove a duplicate ball that was hidden in that screen's concealed compartment, which she placed on the table. When the experimenter lifted the screens, the ball was revealed in the Surprising location, behind the right-hand screen (as though it had teleported), thereby appearing to violate spatiotemporal continuity (Figure 1). Regardless of the condition, once the ball was revealed the experimenter placed the screens under the table. This entire process lasted approximately 9 s, and then the experimenter looked at the ball for 10 s before removing the ball from the table.

Teaching phase

The experimenter removed the bracelet with the bells and placed it under the table. She then placed the round button light (in the off setting) in the center of the empty table. In order to demonstrate that her hands were free, the experimenter waved to infants with both hands while saying “hi” twice. She then placed her hands flat on the table, and bent over and used her forehead to push on the button, thereby activating the light (Figure 1). She looked directly at the infant with a neutral expression for 3 s, then looked down at the light and used her forehead to turn it off. She paused for 2 s, then turned the light on and off a second time in the same manner. The experimenter looked back to the infant, said “hi” while waving once more with both hands and placed her hands back on the table, then turned the light on and off two more times as she did before. This process took approximately 30 s.

Exploration phase

The experimenter then removed the light from the table and instructed the parent to stand the infant between their legs so that the infant could freely explore the light. The experimenter affixed the light to an angled platform under the table, then placed the light at the edge of the infants' side of the table while saying, "Now it's your turn!" The experimenter quickly walked behind the curtain in the room out of the infants' view so as not to influence their behavior. Infants were given 60 s to explore the light (as in Howard et al., 2015; additionally, pilot testing revealed that longer exploration phases led to fussiness and/or disengagement).

1.2 | Coding

Two cameras were used to record infants' attention and behavior. A camera directly across from the infant allowed us to code their attention and eye movements, and one camera to the side of the infant allowed us to see different angles of their behavior when interacting with the light.

We coded infants' attention frame by frame in the different phases of the experiment using the Preferential Looking Coder (Libertus, 2011). In the Object Event, infants were considered to be looking if they looked at the table (where the ball was hidden or revealed) or the experimenter. We also coded infants' attention during the Teaching Phase by coding their looking time to the experimenter or the light as well as their interest in the Exploration Phase by coding how much time they spent visually and/or manually exploring the light.

Our main measure of interest was infants' use of their head during the Exploration Phase. Infants were coded as using their head if they used any part of their head or face to make contact with the light in an attempt to push the button (whether they were successful in activating it or not). Two observers, naive to condition, independently coded infants' head-touch actions across both experiments, $r = 0.98$, $p < 0.001$.

1.3 | Results

We compared infants' behavior in the Expected and Surprising conditions. Preliminary analyses revealed no effects of sex or age (p's > 0.05) and so all subsequent analyses were collapsed across these variables. First, we examined whether infants' attention throughout the duration of the experiment varied by condition using independent samples t-tests. There were no differences in how long infants looked at the outcome of the Object Event in the Expected condition ($M = 7.3$ s, 95% CI [6.44, 8.16]) or the Surprising condition ($M = 7.57$ s, 95% CI [6.34, 8.79]), $t(30) = 0.38$, $p = 0.705$. The lack of difference across conditions is expected, given that infants viewed only a single Object Event that was capped at 10 s (see Stahl & Feigenson, 2015).

Next, we compared infants' looking times during the Teaching Phase when the experimenter was using her head to turn the light on and off. Infants were highly interested in this event and rarely looked away. Infants were equally attentive across the Expected ($M = 29.04$ s, 95% CI [28.21, 29.87]) and Surprising conditions ($M = 28.78$ s, 95% CI [27.65, 29.90]), $t(30) = 0.41$, $p = 0.685$. We also examined whether infants were differentially interested in the light during the Exploration phase. There were no differences in how long infants looked at and/or touched the light in the Expected ($M = 38.35$ s, 95% CI [31.55, 45.15]) or Surprising conditions ($M = 44.63$ s, 95% CI [39.03, 50.23]), $t(30) = 1.52$, $p = 0.139$. Thus, any differences in infants' imitation (i.e., whether they used their head) cannot be attributed to increased exposure to or interest in the Object Event, the Teaching Phase, or infants' general motivation to explore the light in the Exploration Phase.

Finally, we compared infants' interactions with the light during the Exploration Phase. All infants used their hands to attempt to activate the light (as in previous studies, e.g., Gergely et al., 2002). Our critical measure was whether they also used their head in an attempt to activate the light, which would demonstrate their desire to learn from and imitate the experimenter. As in previous studies (e.g., Gergely et al., 2002), we first measured how many infants used their head at least once across the duration of the Exploration Phase. A Fisher's exact test found that significantly more infants in the Surprising condition (10 out of 16) used their head than in the Expected condition (3 out of 16), $p = 0.029$. Another conceptually informative measure of infants' social learning is *how many times* they used their head during the Exploration Phase. Such a measurement provides important insight into the strength of infants' motivation to persist in imitating the experimenter. Indeed, infants used their head more times across the Exploration Phase when the experimenter produced a Surprising outcome prior to teaching ($M = 2.44$, 95% CI [0.68, 4.20]) than when the experimenter produced an Expected outcome ($M = 0.25$, 95% CI [−0.06, 0.56]), Mann–Whitney $U = 64$, $p = 0.015$ (Figure 2).

1.4 | Discussion

Infants produced nearly 10 times as many head-touch actions when they were taught by someone who had produced a surprising outcome relative to someone who produced an expected outcome, therefore confirming that infants were highly motivated to imitate the surprising experimenter. These results

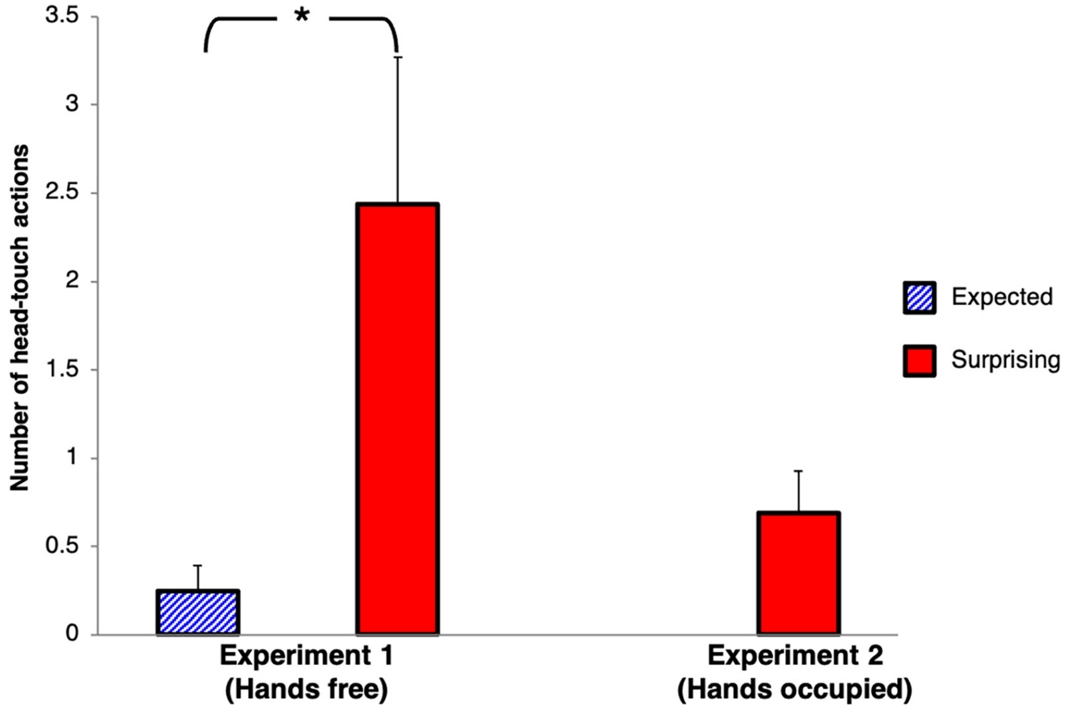

FIGURE 2 Bars represent the average number of times infants attempted to use their head to activate the light in Experiments 1 and 2. Error bars represent standard error of the mean. *$p < 0.05$

align with previous results showing that infants also prefer to learn about surprising objects (e.g., Stahl & Feigenson, 2015). However, an open question is whether infants indiscriminately imitate surprising individuals, or if they integrate rationality principles in their surprise-induced imitation.

2 | EXPERIMENT 2

In Experiment 2, we asked whether infants will persist in imitating surprising individuals regardless of context or if they are more restrained in their surprise-induced imitation. Stahl and Feigenson (2015) showed that infants' surprise-induced learning is not indiscriminate—following a surprising event, infants do not learn about objects unrelated to the surprise itself. Here, we investigated whether infants imitate surprising individuals indiscriminately, or if they are selective in learning from surprising teachers by integrating rationality principles into their surprise-induced imitation. The experimenter produced the Surprising outcome from Experiment 1, but when she demonstrated the head-touch action, her hands were visibly occupied (as in Gergely et al., 2002). If infants indiscriminately imitate surprising individuals, they should still imitate the head-touch action at levels similar to the Surprising condition of Experiment 1. However, if infants prioritize rationality in their surprise-induced imitation, they should not persist in imitating the head-touch action (because despite having the ability to produce surprising events, the experimenter had an alternate reason for using her head).

2.1 | Method

2.1.1 | Participants

Sixteen full-term infants between 13 and 17.5 months participated (M = 15 months, 22 days; range = 13 months, 4 days–17 months, 20 days); 6 were female. Four additional infants were excluded due to parental interference (2), sibling interference (1), or equipment failure (1). This study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Institutional Review Board at The College of New Jersey. Infants received a certificate and a book for their participation.

2.1.2 | Stimuli

The stimuli were identical to Experiment 1. In addition, a small gray blanket was used for the experimenter to wrap around herself and hold with her hands during the Teaching Phase.

2.1.3 | Procedure

The procedure was identical to the Surprising condition of Experiment 1, with the exception of the Teaching Phase. That is, in the Event Phase, all infants viewed two identical familiarization trials in which the experimenter hid and revealed the ball behind one screen, followed by the Surprising outcome in which the ball was hidden behind one screen and appeared to teleport to behind the other screen. In the Teaching Phase, instead of waving with her hands and saying “hi” before placing her hands flat on the table, the experimenter said, "Brr, I'm cold!" with a positive affect (so as to match Experiment 1) and wrapped herself in a blanket, using her hands to hold it in place (see Gergely et al., 2002). She then proceeded to turn on and off the light twice with her head as in Experiment 1 (Figure 1). Instead of waving and saying "hi" again, she said "Brr, I'm cold!" and wiggled her shoulders to emphasize that her hands were still holding the blanket. She then turned on and off the light with her head two more times. The Exploration Phase was identical to Experiment 1 in which infants were given 60 s to explore the light in the absence of the experimenter.

2.2 | Results

Preliminary analyses revealed no effects of sex or age (p's > 0.05) and so all subsequent analyzes were collapsed across these variables. As in Experiment 1, we first analyzed infants' attention throughout each phase of the experiment. Univariate analyses of variance (ANOVAs) were used to compare behavior across our 3 experimental conditions in both experiments (Experiment 1, Expected outcome; Experiment 1, Surprising outcome; and Experiment 2, Surprising outcome). We did not find any differences in infants' attention to the Object Event in Experiment 2 (M = 7.71 s, 95% CI [6.76, 8.68]) compared to Experiment 1, $F(2,45) = 0.19$, $p = 0.825$. Similarly, infants were equally attentive during the Teaching Phase in Experiment 2 (M = 29.67 s, 95% CI [28.96, 30.38]) as in Experiment 1, $F(2,45) = 1.16$, $p = 0.322$. They also interacted with the light during the Exploration Phase equally in Experiment 2 (M = 43.21 s, 95% CI [36.73, 49.68]) as in Experiment 1, $F(2,45) = 1.24$, $p = 0.300$.

Next, we compared infants' production of the novel head-touch action during the Exploration Phase. Fisher's exact tests did not show differences in the number of infants who used their head at least once in Experiment 2 (7 out of 16) compared to the Expected condition of Experiment 1 ($p = 0.252$) or the Surprising condition of Experiment 1 ($p = 0.480$). A Kruskal–Wallis test comparing the number of times infants used their head across both experiments showed a significant effect of condition, $\chi^2(2) = 8.09$, $p = 0.017$. However, pairwise comparisons with a Bonferroni correction for multiple comparisons show that this effect was driven by the difference between the Expected and Surprising conditions of Experiment 1 ($p = 0.013$). As predicted, there was no difference in how many times infants used their head in Experiment 2 when the experimenter's hands were occupied (M = 0.69, 95% CI [0.18, 1.19]) compared to the Expected condition of Experiment 1 ($p = 0.577$); despite our predictions, however, there was also no difference in how many times infants used their head following a surprising event in Experiment 2 when the experimenter's hands were occupied relative to following a surprising event in Experiment 1 when her hands were free ($p = 0.372$).

2.3 | Discussion

We found no difference between infants' head-touch actions in Experiment 2 when the experimenter's hands were occupied relative to either condition of Experiment 1. Although difficult to interpret non-significant comparisons (especially given our sample size), that infants' head-touch actions were quantitatively intermediate between the Expected and Surprising conditions of Experiment 1 may indicate that infants in Experiment 2 were motivated to imitate the surprising experimenter, but their surprise-induced imitation was tempered by rationality principles (her hands were occupied and thus she had a reason to use her head).

3 | GENERAL DISCUSSION

We found that surprise drives infants' social learning. In Experiment 1, infants saw an experimenter produce either an expected or a surprising outcome, then she used her head to push a button to activate a light while her hands were visibly free. Infants who saw the surprising outcome were more likely to use their head to activate the light than those who saw the expected outcome. Thus, infants were more motivated to learn from the individual who produced the surprising event relative to the individual who produced the expected event.

In Experiment 2, infants saw the experimenter produce the same surprising outcome, but her hands were occupied when she used her head to activate the light. Here, infants' imitation of the head-touch action did not differ from either condition of Experiment 1. Although we are statistically underpowered to be able to draw strong conclusions about infants' intermediate amount of head-touch actions in Experiment 2, we speculate that there may be a conflict between surprise acting as a catalyst for learning and rationality principles. That is, infants are perhaps motivated to imitate the surprising experimenter, yet recognize that there was an alternative explanation for using her head when her hands were occupied. This potential tension may reveal that infants are discerning learners who can integrate the experimenter's qualities (whether or not she produced a surprising event) with context (whether the experimenter had a reason to use her head).

Our results complement existing findings showing that infants and children pay more attention to, learn better about, and prefer to explore surprising objects and events (e.g., Baillargeon et al., 1985; Perez & Feigenson, 2021, 2022; Spelke et al., 1992; Stahl & Feigenson, 2015, 2017). This is the first study to directly examine the role of the individual who produces such surprising outcomes, demonstrating that infants view surprising individuals as effective teachers who present pedagogical opportunities, confirming that infants are biased to attend to informative teachers (Begus et al., 2016).

However, these results raise the question of why infants did not imitate the head-touch action in the expected condition, given previous results that as a baseline, infants are willing to produce that action when the experimenter does not provide any information about her abilities (e.g., Gergely et al., 2002; Meltzoff, 1988). Here, it is possible that when the experimenter produced the expected outcome, she is explicitly demonstrating that she possesses no special qualities, thereby *depressing* infants' motivation to imitate her unconventional action. A previous study demonstrated that infants prefer to copy individuals who like interesting over boring toys (Fawcett & Markson, 2010), and thus perhaps infants deem our non-surprising experimenter as uninteresting and not worthy of imitation. On this account, infants' willingness to imitate the surprising experimenter may represent their baseline level of imitation. To investigate whether infants in fact imitate less than baseline following an expected outcome, future experiments could include a comparison control group in which the experimenter does not produce an expected or surprising event prior to demonstrating the head-touch action, and a within-subjects design to compare performance across conditions. Nevertheless, that infants readily imitate an experimenter who produces a surprising but not an expected outcome provides strong evidence that surprising events serve as a signal to learn (Stahl & Feigenson, 2015, 2017, 2019)—otherwise, infants would not imitate this individual. This rules out the possibility that infants view individuals who produce surprising events as unreliable or untrustworthy, and instead shows that infants demonstrate readiness to learn from these individuals whom they deem to be worthy teachers.

Another possibility for why infants produce low levels of imitation following the expected event is that infants are detecting an incongruency between the Object Event and the Teaching Phase, thereby perceiving the experimenter as inconsistent. That is, the experimenter behaved as expected by producing an outcome that accorded with expectations during the Object Event (she hid a ball and revealed it in the same location), then she may have violated infants' expectations in the Teaching Phase by producing an inefficient and strange action when she used her head to turn on the light (Langeloh et al., 2020). Therefore, infants may view the experimenter as unreliable and not worthy of imitation given this inconsistency (e.g., Zmyj et al., 2010). In contrast, infants who witnessed the surprising event may have detected a congruency between the surprising Object Event and the potentially surprising event of using one's head to turn on a light during the Teaching Phase. That is, the experimenter first violated infants' expectations by making a ball teleport, followed by the inefficient head-touch action that may have also violated infants' expectations. Perhaps it is this congruency (i.e., the consistency of being surprising) that infants find worthy of imitation. However, congruency is not likely the driving factor for our results—when infants witness events they might find novel and surprising due to the experimenter's incompetence (e.g., putting their shoes on their hands as in Zmyj et al., 2010; labeling familiar objects incorrectly as in Brooker & Poulin-Dubois, 2013), they do not imitate the novel and surprising head-touch action. As such, not all kinds of surprising events lead to selective imitation, nor does mere novelty (see also Stahl & Feigenson, 2015, 2017, 2019). A future experiment could instead implement a different type of teaching that does not violate infants' expectations (e.g., teaching them a novel word rather than an inefficient action) following our surprising event—infants should still learn more effectively following the surprising event despite the lack of congruency between the Object Event and the Teaching Phase.

Additionally, there are a number of open questions ripe for future investigation. For example, the current experiment does not uncover the source of infants' motivation to imitate the surprising experimenter. That is, infants may imitate the surprising individual because they assume that she possesses special skills or knowledge, thereby making her an informative teacher. Another possibility, though not mutually exclusive, is that infants are seeking social affiliation with her due to her ability to make an object violate physical principles. Many studies have shown that infants and children imitate with the goal of social affiliation (Over et al., 2013; Reyes-Jaquez & Echols, 2013; see Over & Carpenter, 2013 for review), and thus infants might be motivated by a desire to be part of the experimenter's in-group. On either account, our results do show that infants view surprising individuals as effective teachers.

Another open question is which component of a surprising event—the object that behaved surprisingly or the person who produced that surprising outcome—would be prioritized by the surprise-induced learning mechanism. That is, if given a choice to learn about the surprising object (e.g., the ball that appeared to teleport) versus the surprising individual (e.g., the individual who hid and revealed the ball), which would infants choose? Most prior studies focus on the surprising object as the source of infants' attention and learning, and one study has shown that older children who believe in magic selectively trust surprising informants (Kim & Harris, 2014), but no study to our knowledge has investigated how infants prioritize different components of surprising events.

Much like infants in previous studies preferentially learn about surprising objects (Stahl & Feigenson, 2015) and from certain kinds of individuals (e.g., Buttelmann et al., 2013; Zmyj et al., 2010), the current experiments reveal that infants can use their predictions about the world to identify and select informative teachers for subsequent learning. These results highlight how infants' object knowledge and social cognition interact to exploit surprising events as pedagogical opportunities.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest with respect to authorship or publication of this article.

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