Are two-year-olds intrinsically motivated to explore their own competence?

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Abstract

Children are keen explorers of the outside world: They systematically explore surprising findings and test hypotheses during play. However, less is known about whether toddlers are similarly driven to explore and learn about the self. The present work adapts classic exploratory play paradigms to ask whether toddlers are intrinsically motivated to explore their own competence. In Experiment 1, we selected Montessori practical life toys that were verified to be developmentally appropriate and equally appealing to toddlers (N = 24, ages 24-35 months). In Experiment 2, 2-year-olds (N = 49, ages 24-35 months) played with these toys along with a parent. Toys were presented in pairs. In each pair, the parent guided the toddler's hand while playing with one toy, which provided *confounded* evidence about the toddler's competence, and took turns playing the other toy independently, which provided *unconfounded* evidence. When given a chance to freely explore the toys on their own, toddlers first approached the confounded toy, which suggests that toddlers sought to resolve uncertainty about their competence. As a further test of this idea, Experiment 3 (N = 11, ongoing) asks whether toddlers' exploration is modulated by task difficulty. Preliminary results suggest that toddlers explore confounded toys more often for more challenging tasks compared to easier ones. Together, our work provides insights into children's early motivation to understand the self, and this understanding is an important first step for researchers, educators, and parents to better encourage and scaffold this motivation throughout development.

Keywords: intrinsic motivation; competence; curiosity; exploration; cognitive development; play

Introduction

Children spend much of their time playing in effortful and seemingly useless ways, such as standing on one foot and jumping into water puddles. What makes these activities rewarding? One possibility is that the physical effort itself brings children satisfaction. Indeed, effortful activities are often rewarding precisely because they are effortful (Loewenstein, 1999; Norton, Mochon, & Ariely, 2012; Inzlicht, Shenhav, & Olivola, 2018). From an infant's first wobbly steps, to a child's triumphant crossing of the monkey bars, to an athlete's final sprint across the finish line, mastering physical challenges may bring a sense of accomplishment across development. However, the reward of effort alone cannot explain why some effortful activities are more fun than others. The same child who persistently practices jumping rope might avoid putting away toys or hanging up coats, even though these tasks also require physical effort. Thus, factors beyond pure physical exertion may guide children's decisions about when and where to invest their effort during play.

Another possibility is that play provides children with new information about the world. Over the last two decades, extensive research has demonstrated that children actively explore and learn about the world around them, much like scientists (Gopnik, 1996; Schulz, 2012). This insight has inspired a large body of research on children's exploratory play. For instance, during play, children test hypotheses (Legare, 2012), develop theories (Bonawitz, Ullman, Bridgers, Gopnik, & Tenenbaum, 2019), and seek explanations for surprising or confounded findings (Cook, Goodman, & Schulz, 2011; Schulz & Bonawitz, 2007; Stahl & Feigenson, 2015; Wu & Gweon, 2021). However, this account still cannot fully explain why children enjoy seemingly purposeless physical activities that yield little new information about the world, such as standing on one foot.

Here, we propose that, during play, children may also seek out information about the *self* and explore what they can do (White, 1959; Loewenstein, 1999; Gopnik, 2024; Tomasello, 2024). In many common forms of play, such as hopping into puddles or dangling off the monkey bars, children's learning is fundamentally mediated by their physical capabilities. While these activities often yield information about objects and physical laws (e.g., balance, gravity, and friction), more importantly, they allow children to discover new ways to change and interact with their environment.

Understanding one's own competence plays a crucial role in survival and development. As children develop, they learn to take on appropriate challenges, avoid situations beyond their capabilities, and strategically seek help when needed (Adolph, 1997; Lucca, Horton, & Sommerville, 2020; Goupil, Romand-Monnier, & Kouider, 2016). Later, this knowledge also supports more complex social goals—such as managing what others think of them (Zhu, Dweck, & Gweon, 2023) and selectively communicating information to update others' beliefs about their abilities (Asaba & Gweon, 2022). These developing abilities reflect a broader motivation that may be present from early in development: the drive to understand one's competence. Our hypothesis aligns with classic proposals that humans are fundamentally motivated to achieve mastery over their environment—a drive that goes beyond reducing uncertainty about the world (White, 1959; Dweck, 2017). Recent work has characterized this motivation as *empowerment*: the intrinsic motivation to expand one's influence over the world (Gopnik, 2024; Tomasello, 2024).

The present work tests this proposal by adapting classic exploratory play paradigms. For example, Schulz and Bonawitz (2007) examined how preschoolers interact with toys to uncover their causal mechanism. Children were introduced to a toy box with two levers that each caused a different toy (e.g., a toy duck and a flower) to pop out from the center of the box. In the unconfounded condition, the child and the experimenter pressed each lever separately, which provided

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unambiguous information about which lever caused which effect. In the confounded condition, the child and experimenter pressed both levers simultaneously, which provided ambiguous information about what each lever does. Children who received confounded evidence about the causal mechanism of the toy explored the toy more broadly and were more likely to test each lever individually in order to disambiguate its causal structure. This finding suggests that children are motivated to explore and tease apart confounded evidence. However, prior work has primarily focused on children's exploration of physical objects and events, such as figuring out the causal mechanism of a toy (Schulz & Bonawitz, 2007; Legare, 2012; Gopnik & Sobel, 2000). Relatively little attention has been paid to whether children are similarly motivated to explore and tease apart what they can do.

The present study takes inspiration from exploratory play paradigms to investigate whether toddlers are driven to explore their own competence. Critically, rather than providing ambiguous information about the causal mechanism of a toy, we instead provided toddlers ambiguous information about whether they could operate the toy without the aid of a parent. We focused on two-year-olds because this age represents a period of rapid development in both cognitive and motor abilities (Adolph, Robinson, Young, & Gill-Alvarez, 2008), with sufficient motor control to perform simple motor tasks independently while still showing significant variability in their abilities (Adolph & Robinson, 2011). Across three experiments (N = 108 toddlers, aged 24–35 months), we identified Montessori practical life toys that are trivial, difficult, or appropriately challenging for 2-year-olds (Experiment 1) and then tested whether toddlers systematically explore appropriately challenging toys to test what they can do (Experiment 2) and whether this exploration is modulated by task difficulty (Experiment 3). Together, these experiments provide initial evidence that toddlers systematically seek opportunities to learn about their own competence, just as they explore to understand the physical world around them. Data, analysis scripts, and preregistrations for this project can be found at https://osf.io/pj53f.

Experiment 1

To test whether toddlers are motivated to explore their own competence, we first identified toys that are appealing to toddlers and vary in their difficulty. Experiment 1a identified toys that were appealing and appropriately challenging for two-year-olds—that is, neither so easy that all toddlers could operate them on their own, nor so difficult that none could. These toys were then used in Experiment 2. In Experiment 1b, we identified toys that were reliably easy or hard for toddlers, to be used in Experiment 3.

Methods

Participants

24 two-year-olds ($M(SD)_{age} = 2.58(.29)$ yrs, range: 25–35 months, 50% female) were recruited from the local community and tested in a university laboratory space. 3 additional toddlers were excluded from data analysis due to parental interference (n = 1), experimenter error (n = 1), and non-cooperation (n = 1) using preregistered exclusion criteria. Parents in all experiments provided informed consent in accordance with the requirements of the university IRB.

Stimuli

Experiment 1a: Developmentally appropriate toys. The stimuli consisted of six Montessori practical life toys grouped into three pairs, as shown in Fig. 1a: (1) a stuffed animal with a shirt that zips up and a nuts and bolts board (zipper & screws); (2) a Play-doh extruder and a color-matching game where toddlers place clothespins on a painted wooden stick (playdoh & pins), and (3) a transfer game where toddlers use spoons to scoop pompoms into bowls and a lock with a key (pompom & lock). These stimuli were selected from Montessori practical life games that are typically marketed for 2-year-olds; each of these toys tests fine motor skills that are intended to be engaging and appropriately challenging for toddlers.

Experiment 1b: Easy and hard toys. We also tested two pairs of toys that are intended to be trivial or unworkable for toddlers. The *easy* toys consisted of a rattle and a tambourine. The *hard* toys consisted of a fastenings game where toddlers used buttons to attach spikes onto the back of a dinosaur, and a carabiner with a screw-lock mechanism that needed to be opened to detach a small stuffed animal (adapted from Leonard, Lee, & Schulz, 2017).

Procedure

Each session began with a warm-up game where the experimenter and toddler passed a ball through a tube back and forth, establishing rapport and familiarizing toddlers with turn-taking (Cortes Barragan & Dweck, 2014). After approximately five minutes of playing, the experiment began. The experimenter presented toys in pairs, asking toddlers which toy they preferred to play with first. After toddlers made their selection, the experimenter demonstrated how to operate the toy before allowing them to play independently. This procedure was repeated with the second toy. At the end of each pair, both toys were presented again with the question, "Which one did you like better?"

Coding

Two coders independently coded: (1) which toy toddlers selected at the beginning and end of each toy pair, (2) whether toddlers could operate the toy on their own, which was rated on a 3-point scale where a score of 1 indicated that the toddler was unable to complete the task (e.g., unable to insert the key or open the lock), 2 indicated partial completion (e.g., successfully inserting the key without turning it), and 3 indicated full completion (e.g., successfully opening the lock with the key), (3) help-seeking behavior (coded as 1 if requested help while playing with the toys independently, 0 if not), (4) Child Development Inventory scores (CDI) for fine, gross, and total

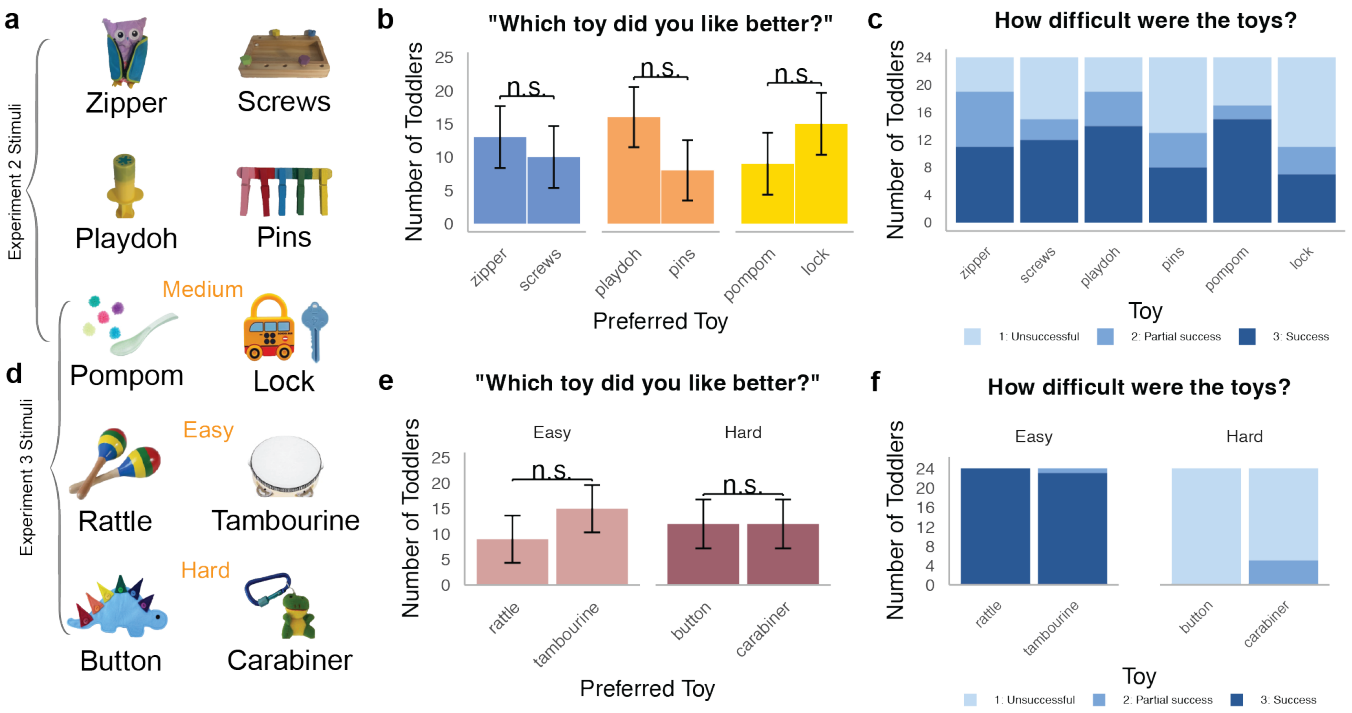

Figure 1: Experiment 1a & b Stimuli and Results. (a) Stimuli used in Experiments 1a, 2: Six Montessori practical life toys were grouped into three pairs: Zipper & Screws, Play-Doh & Pins, and Pompom & Lock. (b–c) Experiment 1a results, showing (b) which toy toddlers preferred within each pair, and (b) how many toddlers were unsuccessful, partially successful or successful in operating the toys on their own. (d) Stimuli used in Experiments 1b, 3. Toys were grouped into three difficulty levels: Easy, Medium, and Hard. (e–f) Experiment 1b results, showing (e) toy preferences within each pair, and (f) toddler's performance. Errors bars denote 95% CI; brackets indicate the results of pairwise comparisons using binomial test.

motor skills, based on parent report, and (5) time spent playing with each toy. Below, we report results on toddlers' toy preferences at the end of each toy pair and their performance when playing with each toy independently (measures 1–2).

Results

Interrater reliability was high in both experiments for all categorical measures (Cohen's $\kappa = 1$ for measures 1–4) and for time spent playing with each toy (measure 5, mean ICC: .99, 95% CI: [.98, 1.00]). Below, we report which toys toddlers preferred at the end of the play phase.

Experiment 1a: Developmentally appropriate toys. Toddlers' toy preferences and performance on each toy pair are shown in Figure 1b–c. Toddlers did not systematically prefer one toy over another for any of the toy pairs tested (binomial test; zipper & screws: $p = .18$, playdoh & pins: $p = .18$, pompom & lock: $p = 1.00$). Their performance scores were also variable, with only 7–15/24 successful completions per toy.These results suggest that these toys are equally appealing and appropriately challenging for 2-year-olds.

Experiment 1b: Easy and hard toys. Toddlers' toy preferences and performance on each toy pair are shown in Figure 1e–f. Toddlers did not systematically prefer one toy over another for any of the toy pairs tested (binomial test; easy: $p = .31$, hard: $p = 1$). Nearly all toddlers successfully completed both easy toys (range: 23–24/24 successful completions per toy), while no toddlers successfully completed either of the hard toys (0/24 successful completions per toy. These results suggest that toys within the easy and hard pairs are equally appealing to toddlers, but the two toy pairs differ dramatically in difficulty (Fisher's exact test on performance scores by difficulty, $p < .001$).

Experiment 2

The goal of Experiment 2 is to test whether toddlers seek out opportunities to discover their competence. Toddlers played with the toys in Experiment 1a alongside a parent. The parent and child took turns playing with one toy, which provided unambiguous or *unconfounded* evidence about whether the child could operate the toy on their own, and the parent held the child's hand while playing with one toy, which provided ambiguous or *confounded* information. Here, we test whether children first explore the confounded toy when given a chance to play with both toys on their own.

Methods

Participants 49 two-year-olds ($M(SD)_{age} = 2.44$ (.08) yrs, range: 27–31 months, 49% female) were recruited from the local community and tested in a university laboratory space. 6 additional toddlers were excluded from data analysis due to

interference (n = 2), unsustained attention (n = 3), and non-cooperation (n = 1) using preregistered exclusion criteria.

Stimuli Toddlers played with the toys that were normed in Experiment 1a to be equally appealing and challenging.

Procedure At the start of each session, toddlers played the warm-up game described in Experiment 1 while the parent covertly watched an instructional presentation. The presentation included six videos demonstrating how to play with each toy—either by guiding the toddler's hands or by taking turns and playing independently. It also provided guidelines for parents, such as refraining from offering help unless the toddler requests it, to minimize parental interference.

After the warm-up, parents and toddlers played with three pairs of toys. Each toy pair was presented in two phases. In the *Play Phase*, the experimenter brought out each toy in the pair separately. For the unconfounded toy, the experimenter announced that the parent and child would take turns and instructed the parent to go first (e.g., "Can you use this spoon to move all the pompoms from this bowl to the other? [Parent], can you go first?"). For the confounded toy, the experimenter announced that the two would play together (e.g., "Can you use this spoon to move all the pompoms from this bowl to the other *together*?"). These prompts explained away why the parent held the toddler's hand, preventing toddlers from inferring that the parent intervened because the confounded toy was particularly challenging. Each toy was presented only once during the Play Phase, and the experimenter removed the toy after the child's attempt, regardless of whether they succeeded or not. Figure 2a shows a schematic of parent-toddler interactions during this phase.

Finally, in the *Exploration Phase*, the experimenter placed both toys side by side and said, "Now you can play with both of these toys *all by yourself*!" This phase was open-ended, with no time limit or explicit instructions; children explored the toys freely until they indicated that they were done playing or pushed the toys back.

Coding The coding procedure was identical to Experiment 1, with the exception that we measured toddlers' toy preferences (measure 1) and time spent playing with each toy (measure 5) based on their behavior in the Exploration Phase. Our key outcome measure—toddlers' toy preferences—was coded based on which toy they approached first during exploration. As in Experiment 1, inter-rater reliability was high across all categorical measures (Cohen's $\kappa = 1$ for measures 1–4) and for time spent playing with each toy (measure 5, average ICC: .95, 95% CI [.94, .96]). In Experiments 2–3, we report toys that children first approached during the Exploration Phase, as well as a categorical measure indicating whether toddlers spent *any* time exploring each toy.

Results

Overall, toddlers explored the confounded toy first in 62% of trials (Figure 2b, 95% CI [.54, .70]). We used a mixed-effects logistic regression to confirm that toddlers consistently explored the confounded toy first over the unconfounded one ($\beta = 0.48$, $z = 2.77$, $p < .01$); this effect remained significant after statistically adjusting for age ($\beta = 0.49$, $z = 2.80$, $p < .01$). Additional analyses revealed that demographic factors, including age, gender, race, ethnicity, parental education, and household income, did not significantly predict children's toy choices (all $ps > .54$). We additionally found no effect of children's motor skills on toy preferences, based on parent report on the CDI (all $ps > .05$), and no effect of how appealing these toys are at baseline, as measured based on the proportion of toddlers who selected each toy in Experiment 1 ($\beta = -4.03$, $z = -0.88$, $p = .38$).

Because these toys were selected to be challenging for toddlers to operate on their own, it is possible that toddlers approached the confounded toy not to test whether they can operate it on their own, but rather to *avoid* repeating a frustrating experience with the unconfounded toy. We carried out two exploratory analyses to rule out this alternative interpretation. First, we compared toddlers' performance scores on the unconfounded toy in each pair, based on whether the toddler later chose to first approach the confounded or unconfounded toy. If toddlers are trying to avoid repeating past failures, then we may expect to see lower performance scores among the toddlers who first approached the confounded toy. Instead, we found no differences in performance among toddlers who eventually approached the confounded ($M(SD) = 2.19(.85)$) and unconfounded toy first ($M(SD) = 2.47(.84)$, $t(43) = 1.10$, $p = .277$). Second, we found that 57% of toddlers explored both toys at some point during the Exploration Phase (Figure 2c), which indicates they were not avoiding the unconfounded toy altogether. Our results provide initial evidence that toddlers explore toys to seek out information about their own competence.

Experiment 3 (Ongoing)

Our results thus far are consistent with two alternative, low-level interpretations: toddlers could have approached the confounded toy first not to seek out information about their own competence, but simply because they have not yet had a chance to play with it on their own (novelty) or because the parent's guidance makes the confounded toy more salient (stimulus enhancement). In Experiment 3, we directly tested these possibilities by presenting toddlers with toy pairs that were trivial, unworkable, or appropriately challenging for typically-developing 2-year-olds. If toddlers' exploration is driven by these low-level factors, then we would not expect toddlers to vary their exploration by difficulty, as these low-level factors are matched across all conditions. Conversely, if toddlers explore to seek out information about their competence, then we may expect them to modulate their exploration by task difficulty—e.g., by selectively exploring challenging toys, as opposed to trivial ones. Data collection is ongoing; below, we report descriptive results from a pilot sample.

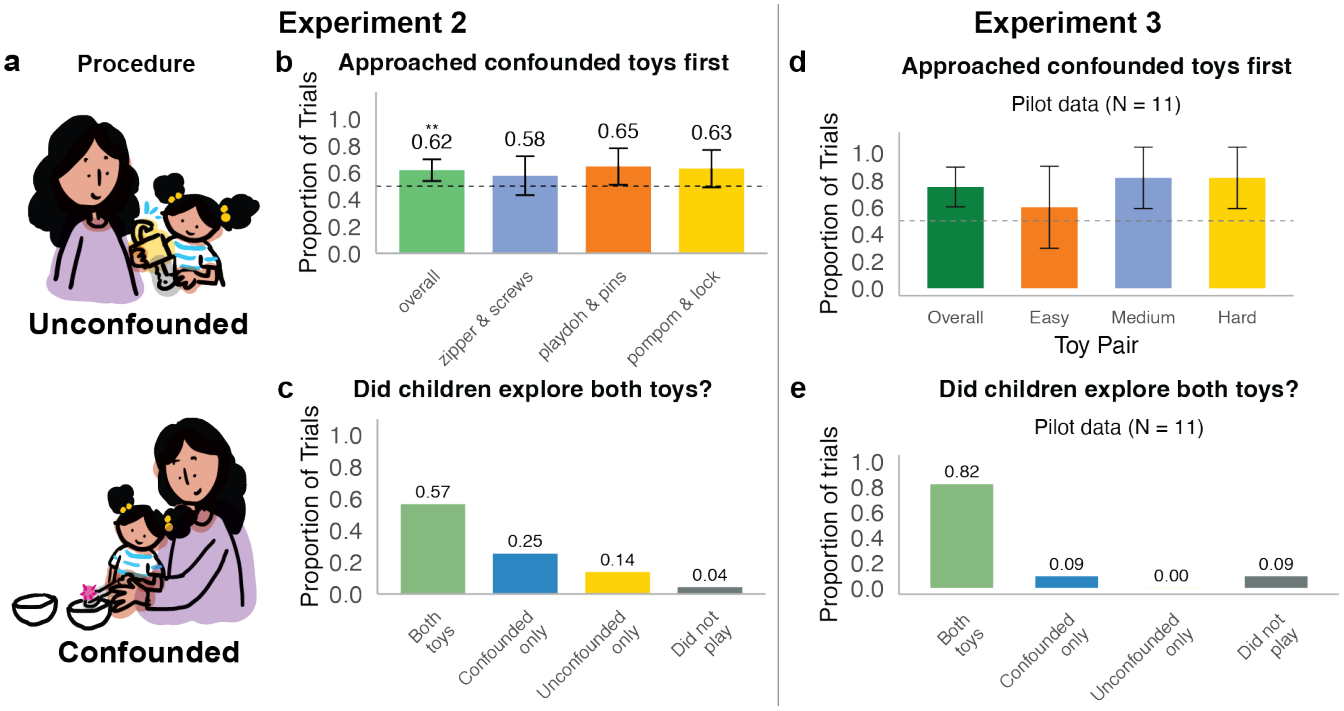

Figure 2: Experiment 2 & 3 procedure and results. (a) Schematic of procedure. Parents and toddlers took turns playing with the *unconfounded* toy independently, and held hands to play with the *confounded* toy together. (b–c) Experiment 2 results showing (b) the proportion of trials where children approached the confounded toy first during exploration across all toy pairs (leftmost bar) and split by toy pair. Asterisk above the overall bar denotes significance level based on a binomial test against 0.50 (* = $p < .05$, ** = $p < .01$, *** = $p < .001$). (c) the proportion of trials in which children explored both toys, only the confounded toy, only the unconfounded toy, or did not play with either toy. (d–e) Preliminary, descriptive results from Experiment 3, showing (d) the proportion of trials in which children explored the confounded toy, both across all toy pairs (leftmost bar) and split by difficulty level (Easy, Medium, Hard), and (e) the proportion of trials in which children explored both toys, only the confounded toy, only the unconfounded toy, or did not play with either toy. Errors bars denote 95% CI.

Methods

Participants A pilot sample of 11 two-year-olds ($M(SD)_{age}$ = 2.58(.29) yrs, range: 24–34 months, 50% female) were recruited from the local community and tested in a university laboratory space.

Stimuli Children played with three toy pairs: the easy and hard toys tested in Experiment 1b, and one medium-difficulty toy from Experiment 1a (pompom & lock).

Procedure The procedure was identical to Experiment 2, albeit with different stimuli.

Coding Coding procedures and measures were identical to Experiment 2.

Results

Our pilot provides preliminary evidence that toddlers' exploration is modulated by task difficulty. Toddlers approached the confounded toy in 60% of trials for the easy toy pair, compared to 81.8% of trials for the medium and hard toys, respectively (Figure 2d). As in Experiment 2, toddlers explored both the confounded and unconfounded toys during the Exploration Phase in 82% of trials, which suggests that they were not specifically avoiding the unconfounded toy (Figure 2e). We are currently replicating this effect using a preregistered sample of N = 64 two-year-olds.

General Discussion

For decades, scholars have proposed that the desire to achieve mastery over one's environment—or *competence*—is a fundamental driver of human behavior (White, 1959; Loewenstein, 1999; Dweck, 2017; Gopnik, 2024; Tomasello, 2024). Here, we set out to test this long-standing proposal by examining whether two-year-olds seek out opportunities to explore what they can do. Our task is inspired by classic exploratory play paradigms, which have been used to study how children uncover information about the world by testing hypotheses, teasing apart confounded evidence, and searching for explanations for surprising findings (Cook et al., 2011; Schulz & Bonawitz, 2007; Legare, 2012; Stahl & Feigenson, 2015; Wu & Gweon, 2021). However, rather than providing children with confounded information about how a toy works, here we provided confounded information about whether the child could have operated the toy *on their own*. In Experiment 1,

we identified pairs of Montessori practical life toys that are appropriately challenging and appealing for two-year-olds. In Experiment 2, we found that toddlers first approached toys for which they had received confounded information about their competence. This result provides initial evidence that, much as young children tease apart confounded evidence about the world, toddlers similarly tease apart confounded evidence about the self. In Experiment 3 (ongoing), we find preliminary evidence that toddlers' exploratory play is modulated by task difficulty—namely, that toddlers are more likely to explore confounded toys when they are of medium or high difficulty rather than when they are easy.

One alternative interpretation for these findings is that children may approach the confounded toy not to test out whether they can operate it, but rather to avoid repeating a frustrating experience with the unconfounded toy. However, this interpretation is unlikely, given toddlers' exploratory and help-seeking behaviors during free-play. Toddlers actively engaged with both toys, and help-seeking was relatively rare. In addition, toddlers who successfully operated the unconfounded toy on their own during the play phase were no more likely to approach the unconfounded toy first during exploration, compared to toddlers who failed to operate the unconfounded toy. Thus far, this trend holds in pilot data for Experiment 3, which suggests that toddlers do not specifically avoid the unconfounded toy—even when the toys are so challenging that *no* toddler could operate them on their own. Rather than avoiding difficult tasks, toddlers appear to actively engage with challenges in ways that could provide valuable information about their competence.

This motivation to resolve uncertainty aligns with growing evidence that young children are sensitive to their performance and use this information to choose which challenges to pursue. For example, infants monitor their uncertainty and ask for help when needed (Goupil et al., 2016), and preschool-aged children persist with challenges when they see their performance improve over time (Leonard et al., 2020; Leonard, Cordrey, Liu, & Mackey, 2022). Beyond tracking their own progress, preschoolers also show curiosity about how others evaluate their performance (Zhu et al., 2023), suggesting that self-directed exploration may support both personal and social learning goals. Future work should explore how toddlers integrate various sources—including firsthand experience and social context—to decide when to explore new skills and which skills are worth pursuing.

Several alternative interpretations for our findings remain. Based on Experiment 2 alone, we cannot yet rule out the possibility that toddlers explored the confounded toy because they have not yet had the chance to play with the toy on their own (novelty), or because the parent holding their hand makes the confounded toy more salient (stimulus enhancement). We are currently addressing these alternative interpretations in Experiment 3, where toddlers are introduced to toys of varying difficulty. If toddlers selectively explore toys that are challenging for them—as opposed to toys that are trivial to operate, such as baby rattles—this would suggest that toddlers' exploratory behavior is not solely driven by these low-level confounds, and instead reflect toddlers' expectations about whether exploring a toy is likely to yield new information about their competence.

The current work raises several questions for future research. First, to what extent do children's representations of their competence align with their actual abilities? Decades of research suggest that young children systematically overestimate what they can do (Plumert, 1995; Leonard & Sommerville, 2025; Xia, Poorthuis, & Thomaes, 2024). One intriguing possibility raised by our work is that—when coupled with a motivation to explore their competence—this optimism may be adaptive for learning by motivating children to take on challenges that they may not attempt if they had a more accurate sense of their competence. This view aligns with recent theoretical work, which suggests that optimism may serve as an adaptive bias—one that reflects the structure of children's environments rather than a simple miscalibration (Leonard & Sommerville, 2025). Declines in optimism over development may not just reflect more accurate representations of one's own competence, but also the shifts in the kind of social feedback children receive from parents, teachers, and peers. Future research should examine how this optimism influences children's exploration and understanding of the self, and how parental responses to children's exploration shape their motivation to pursue challenges and reflect on their own abilities.

The present work provides converging evidence that, just as young children are curious to learn about the world, they are also curious to learn about the *self*. The natural next question, then, is how the adults around them—e.g., caregivers, educators, and practitioners—can best encourage and preserve that motivation over the course of development. For instance, providing opportunities for guided exploration that gradually increases in difficulty could allow children to systematically test and expand their abilities. Moreover, understanding that children actively seek to resolve uncertainty about their competence could inform how we provide feedback and assistance, striking a balance between offering support and allowing for self-directed exploration.

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