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# Preschoolers select the relevant information when looking for a hidden present

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## Abstract

Previous research suggests that children's information search remains largely inefficient until age 4. Here, we investigate the early emergence of children's information-search competence using a simplified version of Lindow's (2021) *finding-presents* game. Children (n = 86, 25- to 59-months old) had to find a present hidden in one of three closed boxes. All boxes were identical but for one feature (e.g., all boxes were blue and had a flower icon on top, but one box was round, one heart-shaped, and one squared). To identify the target box, children received three information cards revealing one feature of the target box (i.e., its color, shape, or icon). As the boxes differed in only one feature (e.g., their shape), only one information card contained the relevant information to the decision (i.e., the information card indicating the correct shape). Children could flip one information card to learn about one particular feature before deciding which box to open. This was our dependent measure. Our findings indicate that children as young as 2 years can efficiently search for information to guide their decisions and underline the importance of using age-appropriate paradigms.

**Keywords:** Information-search; decision making; cognitive development; active learning

## Introduction

More information is not always better. Some information is indeed helpful, but some information—even when accurate—may be irrelevant, resulting in a waste of time and resources, or potentially generating confusion even. For example, instead of reading this paper, which will provide the reader with new evidence on young children's information search abilities, potentially relevant for their work, the reader could watch a compilation of the 100 cutest cat videos on YouTube—which would surely also provide a lot of interesting information, though probably (hopefully?) not as relevant. In this sense, being able to tell apart relevant, high-quality information from irrelevant and low-quality information, and relying on the former, is a crucial competence supporting learning in the social, digital, and physical world.

Work from the decision-making literature found that this sensitivity to the informativeness and relevance of different cues (i.e., pieces of information) develops rather late, reaching adult-like efficiency only by adolescence, or even later (Betsch, Lehmann, Jekel, Lindow, & Glöckner, 2018; Davidson, 1991, 1996; Mata, von Helversen, & Rieskamp, 2011).

For example, Betsch et al. (2018) presented 5- to 10-year-old children and adults with a game in which they had to decide which cues to look up to find a treasure. Children were first familiarized with three animals, differing in their ability to predict the treasure's location correctly, and then with the animals' suggestions about the treasure's location. The authors found that preschoolers failed to integrate the probabilistic information about the animals' accuracy in their information-search decisions. This ability improved with age, with children beginning to show information-search strategies comparable to adults' by age 9.

In line with these results, research from educational psychology suggests that 4- to 6-year-old children have difficulties in understanding when enough information has been collected to be sure about something (referred to as *determinacy* or *indeterminacy* of evidence) (Fay & Klahr, 1996; Klahr & Chen, 2003). In particular, children this age often *overestimate* the informativeness of the available evidence. For example, when presented with indeterminate evidence, children are overly optimistic about knowing the answer and tend to ignore that additional evidence would be required to support their answers (Klahr & Chen, 2003).

However, a growing body of work from developmental and cognitive psychology paints a much more optimistic picture, suggesting that the foundations required to support efficient information search may instead emerge very early in life. Research with infants indicates that systematic patterns of efficient information-seeking start emerging during the first months of life and become increasingly explicit and selective between the first and second year of life when infants can promptly and effectively signal their uncertainty and elicit information from the most informative sources available (for an overview, see De Simone and Ruggeri, 2022).

For instance, by 5 months of age, infants are already sensitive to the likelihood of a social partner being informative; that is, they look longer at partners who express willingness to convey information, for instance, by making eye contact, calling their name, and using infant-directed speech (Cooper & Aslin, 1990; Csibra & Gergely, 2009; Senju & Csibra, 2008).

This ability to discriminate partners by their informativeness sets the foundation for young children to *actively search*



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for information from their partners and in their environment. Studies using preferential looking as a measure for information search indicate that pre-verbal infants are sensitive to the novelty and quality of information. In particular, infants' looking-time increases when they encounter new objects (Kutsuki et al., 2007), when two novel objects are labeled with the same label (Hembacher, deMayo, & Frank, 2017; Vaish, Demir, & Baldwin, 2011), or when they encounter something unexpected such as the disappearance of a puppet (Dunn & Bremner, 2017; Walden, Kim, McCoy, & Karrass, 2007).

Beyond being selective in deciding what information and information sources are most likely to be informative, recent work suggests that infants look at other people to *actively solicit* information, suggesting that pretty much the same events and stimuli that trigger infants' perceptual interest (e.g., novelty of objects, violation of expectation, confounded evidence) also result in increased references to their social informants (Dunn & Bremner, 2017; Walden et al., 2007; Hembacher et al., 2017; Vaish et al., 2011; Kutsuki et al., 2007) and enhanced exploration (Stahl & Feigenson, 2015).

This early competence rapidly matures over the first years of life. Ruggeri and colleagues (2019) demonstrated that already by their third year of life, children are able to successfully tailor their information search strategies to the characteristics of the task they are presented with. In this study, children had to find an egg shaker hidden in one of four small boxes, which were, in turn, contained in two larger boxes. They were allowed to open *only one* large box, but they could shake one or both large boxes first if they wanted to. Crucially, before this test, children learned that either the egg was equally likely to be found in any of the four small boxes (uniform condition) or it was most likely to be found in one particular small box (skewed condition). Results show that preschoolers as young as 3 years successfully tailored their exploratory actions to the different likelihood distributions: Compared to the skewed condition, where children had a strong intuition as to where the egg shaker would be hidden, children in the uniform condition were more likely to shake a large box first. This way, they could hear which large box contained the small box with the egg shaker without risking opening the wrong one (Ruggeri et al., 2019).

How could we reconcile these findings from those from decision-making and education reviewed above, describing a much more protracted emergence of efficient information search patterns? We argue that these studies may have failed to capture children's early learning competence because they: (i) implemented paradigms that were too complicated or abstract for children to understand, relate to, or care about. For example, Ruggeri and Feufel (2015) compared the performance of 7-to 10-year-old children with adults in a 20-question game and found that they asked less informative questions when presented with professions rather than animals, highlighting the strong impact of domain-specific knowledge on question-asking competence (Ruggeri & Feufel, 2015; Ruggeri & Katsikopoulos, 2013); (ii) presented instructions, stimuli or tasks that required advanced math skills or verbal competences that just cannot be expected to be mastered until late childhood. For example, succeeding at the treasure hunt game by Betsch (2018) requires a pretty sophisticated understanding of differences across probabilistic distributions that preschoolers (or at least some of them) may still be developing (Betsch et al., 2018); (iii) did not consider that children (and children of different ages, or Socio Economic Status) may be bringing in different assumptions to the task than what the researchers expected, potentially leading children to apply a different, yet ecologically effective, default strategy for active learning. For example, children may ask a question intended to confirm or rule out a hypothesis they believe is more likely than others, even though the researchers assume that all the considered hypotheses should be considered equally likely (Bramley, Jones, Gureckis, & Ruggeri, 2022).

Indeed, recent studies demonstrate how young children's question-asking performance can improve when presented with more child-friendly instructions and paradigms (Ruggeri, Walker, Lombrozo, & Gopnik, 2021; Ruggeri, Sim, & Xu, 2017; Swaboda, Meder, & Ruggeri, 2022; Bonawitz, van Schijndel, Friel, & Schulz, 2012; Domberg, Koskuba, Rothe, & Ruggeri, 2020; Ruggeri et al., 2019). For instance, a recent study compared children's performance in a 20-question game and in a spatial-navigation task, in which they had to discover the path through a maze by removing masks covering its passages, and found that children searched more efficiently when they could make queries non-verbally (Swaboda et al., 2022). Along these lines, Lindow (2021) implemented a more child-friendly version of the treasure hunt game paradigm used in previous work (Betsch, Lang, Lehmann, & Axmann, 2014; Betsch et al., 2018) and found that, in simpler search environments, even 5- to 6-year-old children managed to select information effectively, compared to previous studies indicating ineffective information search until age 9 (Betsch et al., 2014, 2018).

## The current Study

In this project, we developed a novel version of the treasure hunt game developed by Betsch et al. (2014, 2018) and then simplified by Lindow (2021), to examine the emergence of information-search efficiency in 2 - to 4-year-olds. We focused on this specific age range because we wanted to address younger children than in the initial study of Lindow(2021), while making sure that children understand basic verbal instructions and can indicate their information card choices verbally or by pointing at or crawling towards them. In contrast to Lindow's finding-presents game, our game version presented children with three boxes varying *on one specific feature* of the box, instead of four identical boxes with varying icons on top of them. In particular, we held two features constant (e.g., all boxes were blue and carried an icon of a flower on top of them), but we varied one feature (e.g., one box was round, one heart-shaped, and one squared). Three information cards provided information about the color, shape, or icon of the target box containing the present. Two information cards were irrelevant (information about color and icon did not help to disambiguate the location of the toy, as all boxes had the same color and the same icon), but one of the information cards contained the relevant information (the card indicating the specific shape of the target box allowed to find the present). Children indicated their information card choice verbally or by pointing, which allowed us to reduce verbal demands. Our design required no understanding of probabilities and avoided using distractor cards. We believe these simplifications allowed us to reduce verbal demands and thus target younger children while maintaining the overall structure of the task proposed by Lindow (2021). We hypothesized that children would select the informative cue card significantly above chance and that this ability would improve with age.

# Methods

## Participants

To ensure that children understood the task instructions and found the materials and procedure engaging, we piloted the experiment prior to data collection. The pilot sample included 54 participants (30 female; $M = 41.16$ months; $SD = 9.77$ months) tested at a local museum in Berlin, Germany.

In the final study, we tested 86 children between 25 and 59 months (46 girls, $M = 41.50$ months, $SD = 8.81$ months). They were recruited at a local museum or via the internal participant database of the Max Planck Institute for Human Development. We tested participants in the museum right after recruitment or in the lab. An additional 28 children (15 female; $M = 34.78$ months; $SD = 8.48$ months) were tested but excluded from the analysis because they were not concentrating on the task (n=8), they were too shy to interact with the experimenter (n=3), had language difficulties (n=2), failed to pass the training phase (n=1), because of experimenter error (n=8), parental intervention (n=2), or technical problems (n=4; in total: 17 2-year-olds, 8 3-year-olds, 2 4-year-olds, one participant did not provide a date of birth).

Written informed consent of legal guardians was obtained prior to participation. Children were asked for verbal assent before the study and received stickers as a reward for their participation after the study (see Design and Procedure). The study was approved by the ethics committee of the Max Planck Institute for Human Development. The sample size was determined by conducting a-priori power calculations via simulation for each planned statistical test. The most conservative estimate indicated an overall sample of 80 children to detect the estimated effect size (Cohen's $h = 0.6$) with 90% power using binomial logistic regression with a 0.05 criterion for statistical significance.

## Materials

All materials were specifically built and consisted of three sets of cardboard boxes with corresponding information cards (see Figure 1 for pictures of all three sets). Each set of boxes consisted of three individual small boxes with removable lids, each with a particular color, shape, or icon on its lid. Within each set, all three boxes shared exactly two features but differed in one specific feature. Each set contained one distinguishing feature (see Figure 1). For example, in one set all boxes were blue, had a flower icon on top, but differed in the shape of the box (see example Set 2 in Figure 1).

Each set of boxes was accompanied by a set of information cards, which showed all available variants of each feature on their backside as many times as they occurred among the boxes, and the feature variant of the target box on their front side (see Figure 1). For example, in Set 2, the *color card* showed three blue splashes of color (since there were three blue boxes) on its back and one splash of blue on its front. The *icon card* showed three flowers on its back (since all three boxes had flowers on top) and one flower on its front. The *shape card* showed a square, a circle, and a heart on its back, and one of these shapes indicated the critical image to find the critical box on its front (e.g., a circle if the target box was round-shaped). One box in each set contained a feather or sticker as a present.

## Design and Procedure

We presented children with three boxes, of which one contained a present. The boxes were identical in two features (e.g., all three boxes had the same color and the same sticker on top of them) but differed in one feature (e.g., each had a different shape; as an example, see Set 2 in Figure 1). To find out which box contained the present, children could pick one of three information cards, each revealing one of the target box's features (i.e., the color, shape, or icon on top of the box). Only one of the cards revealed the crucial feature necessary to find the target box (in this example, the card identifying the correct shape of the box is the informative card as it is the only feature that allows inferring the target box). Children were allowed to flip only one card but had up to two attempts per test. The experiment consisted of a training phase, familiarizing children with the boxes and the cue cards, and two tests. Sets and target boxes were counterbalanced.

**Training phase.** Children were presented with one set of boxes placed on a blanket on the floor (see Figure 1, box sets were counterbalanced between participants). They were told that there was a small present hidden in one of the boxes and that the goal of the game was to find out which box contained it. Next, the experimenter familiarized the children with the features of boxes, saying *"Look, all boxes have the same color/shape/icon. They are all [...]."*, for the shared features, or *"Look, all boxes have a different color/shape/icon. This box is [...], this one is [...], and this one is [...]."*, for the one differentiating feature. The differentiating feature was

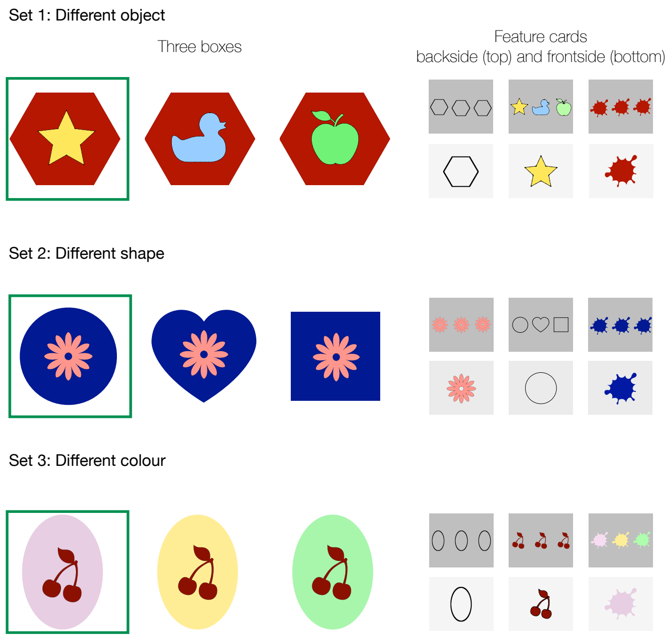


Figure 1: Picture showing all sets of boxes and the corresponding information cards used in the experimental procedure. A sticker or a feather were placed in one box of each set as a present.

presented either first or last (counterbalanced between participants).

The experimenter then took the cue cards and shuffled them, saying *"We do not know yet in which of the boxes the present is hidden. But to find out, I brought these cards with me. They can help us finding out what the box with the present looks like."*. Next, she placed one by one the cue cards in front of the child, saying, *"Look, this card tells us the color/shape/icon of the box with the present* (see Figure 1). Once all cards had been placed down, she turned over the three cards one after the other, from right to left, to demonstrate how they revealed the features of the target box. The procedure for each card was identical: First, the experimenter turned over the card and said, *"When we turn over this card, we know the color/shape/icon of the box with the present."* and pointed out the revealed feature (*"Look, the box with the present is [color/shape/icon]*), and then asked children to indicate all boxes possessing that feature (*"Can you show me all the [color/shape/icon] boxes?"*). If children failed to answer (e.g., because they were shy), the experimenter pointed at the boxes one by one, asking children if that box had the queried feature. For each revealed card, the experimenter emphasized whether the feature was shared by all boxes (*"So, all boxes are [color/shape/icon], right?"*) or different across all boxes (*"Only this box is[color/shape/icon], right?"*).

Once all cards had been turned over, the experimenter summarized what they had learned about the features of the box (*"Now we know that the box with the present is [color/shape/icon]"*) and asked children to point at the target box. If children failed to identify the target box, the experimenter repeated the summary of the features and highlighted once more how they indicated the target box. This was repeated until children were able to successfully indicate the correct box (verbally or by pointing). One child (age 37 months) failed to do so on their own even after several explanations and was excluded from the analysis.

**First test.** The first test presented children with the *same* set of boxes used in the training phase. The experimenter removed the cards and hid a new present in one of the three boxes while the child looked away. Next, she told the children that there was a new present in one of the boxes and that it could be in the same or a different box than before (we counterbalanced the order in which we said "same" and "different" between participants). Then, as before, she said that children could not know where the present was hidden and that they could look up the cue cards to find out, which she shuffled and placed in front of the child, saying *"Would you like to know about the color, shape, or icon of the box with the surprise?"* (following the order of placement).

Children were then allowed to look up *only one* card, which the experimenter commented, revealing the related feature. If children looked up the cue card with the differentiating feature, she prompted children to point to the target box and retrieve the present.

If children looked up one of the features shared by all boxes, the experimenter commented, saying *"Ah, the box with the present is [color/shape/icon]. But all boxes are [color/shape/icon], aren't they? So you can not really know yet where the present is. Let's try again."*. In this case, the experimenter reshuffled the cards and repeated the procedure.

**Second test.** To investigate children's information search abilities across different contexts, we conducted a second test. In the second test, we used a different set of boxes than the one used for training and in the first test, with a new differentiating feature. The experimenter introduced the new boxes as she did before and then moved to the test phase, which procedure was identical to the first test.

## Results

In the first test, 52 out of 86 (60.47%) children picked the relevant cue card on their first attempt. An exact binomial test revealed that children's choices significantly differed from chance (33%, $p < .001$, binomial test). A logistic regression analysis with age in months as a predictor revealed no significant effect of age ($p = .390$ , OR = 1.02 [0.97 – 1.08]).

In the second test, 52 out of 86 (60.47 %) children picked the relevant cue card on their first attempt. An exact binomial test revealed that children's choices significantly differed from chance (33%, $p < .001$, binomial test). A logistic regression analysis with age in months as predictor revealed a significant effect of age ($p = .003$ , OR = 1.09 [1.03 – 1.16]), indicating that older children were more likely to look at the relevant informative cue card compared to younger children.

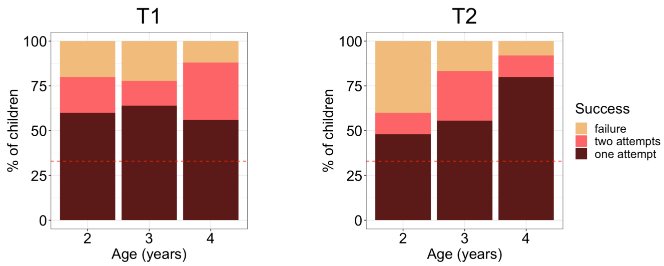


Figure 2: Proportion of children looking up the informative cue card by age group in the first (left) and second test (right). Colors indicate whether children looked up the informative cue card on the first or second attempt or not at all. The dashed red line indicates the chance level (33%).

To analyze children's ability to pick the correct information card at the first attempt in *both tests*, we created a dummy variable indicating success in both tests. 32 out of 86 children (37%) picked the correct card on the first attempt in both tests. An exact binomial test revealed that children's choices significantly differed from chance (11%, $p < .001$, binomial test). A logistic regression analysis with age in months as a predictor to choose the correct information card at the first attempt in both tests revealed a significant effect of age ($p = .019$, OR = 1.07 [1.01 – 1.13]), indicating that older children were more likely to look up the informative cue cards in both tests compared to younger children.

We controlled for the possibility that children's performance was influenced by the specific set they were presented with, thereby making sure that children were not more likely to pick the correct information card because one of the features was more salient to them than others. A logistic regression with the target feature (color vs. shape vs. icon) as a predictor and success in the first test as the dependent variable revealed no significant effect (object: $p = .492$, OR = 0.64 [1.17 – 2.25]; shape: $p = .413$, OR = 0.54 [0.12 – 2.49]). We found similar results when considering success in the second test as the dependent variable (object: $p = .893$, OR = 1.10 [0.29 – 4.31]; shape: $p = .859$, OR = 0.89 [0.25 – 3.09]).

## Discussion

In this study, we investigated the emergence of 2 - to 4-year-old children's information-search efficiency. To do so, we developed a simplified version of the *finding-presents* game implemented by Lindow (2021). Our findings indicate that all age groups performed significantly above the chance level. Even the youngest children in our sample engaged in efficient information search by selecting the informative information cards. When children were presented with a new set of boxes and information cards (i.e., in the second test phase), performance for all age groups remained above chance level, with 4-year-olds performing near ceiling (see Figure 2).

Previous studies have stressed young children's ineffective information search (Betsch et al., 2018; Davidson, 1991, 1996; Fay & Klahr, 1996; Herwig, 1982; Klahr & Chen, 2003; Mata et al., 2011; Ruggeri & Feufel, 2015; Ruggeri & Lombrozo, 2015; Ruggeri, Lombrozo, Griffiths, & Xu, 2016). However, our results add to a growing body of literature highlighting young children's emerging abilities to search for information efficiently across different contexts, once tested using paradigms that are sufficiently simple, clear, and child friendly (Bonawitz et al., 2012; Domberg et al., 2020; Ruggeri et al., 2019, 2021, 2017; Swaboda et al., 2022). Indeed, our findings provide strong evidence that even 2-year-olds are competent active learners, able to select the relevant and informative cues they need to support their decisions. This work further highlights the importance of developing age-appropriate paradigms that capture children's early competence in order to gain a more fair and comprehensive picture of their emerging information-search abilities.

Our task addressed three shortcomings of previous-research designs, which often present i) children with tasks that are not suitable for the age groups targeted (e.g., seven to 9- year-old children ask less informative questions in a 20-question game when they have to guess professions rather than animals (Ruggeri & Feufel, 2015)), ii) rely on an advanced understanding of math and probabilities (Betsch et al., 2018), or iii) ignore the fact that children may have different assumptions about the task structure and goals than what expected by the researchers (Bramley et al., 2022). In particular, we designed a task that young children would find simple, familiar, and engaging. We minimized verbal and computational task demands and made the task structure and assumptions as explicit and straightforward as possible—also making sure children had a clear understanding of the game rules and goals by the end of the familiarization phase.

At the same time, our task controlled for potential confounds (e.g., a preference for a particular color, shape, or icon; a particular sensitivity to one of the features over the others) by counterbalancing the stimuli sets, thereby ensuring that children based their inferences on the task structure, rather than on more superficial aspects of the task. We further confirmed analytically that children's performance did not differ depending on the particular set they were presented with. Moreover, the fact that 63% of children (54 out of 86) selected the correct information card in *both* rounds (with 37% of children selecting the correct card at the first attempt in both rounds), and therefore across different sets of boxes, suggests that children's information-search skills are robust and adaptive across contexts.

Our results also raise the question of whether the foundations of efficient information-search competence may emerge even earlier: Can infants differentiate between *relevant* and *irrelevant* information, and if so, how can we capture this ability experimentally?

To investigate this question, we are currently piloting an eye-tracking paradigm with 12 - to 20-month-old infants, using a finding-presents game similar to that described in this study. Infants will be presented with four boxes, one on each corner of a screen, presenting different patterns or different shapes. In the middle of the screen, infants will be presented with one cue card that, when flipped, will reveal the pattern or the shape of the one box containing the present. Crucially, this cue card will be informative or uninformative, depending on whether the feature differentiating among the target boxes is the shape or the pattern. We hypothesize that infants' pupil dilation and looking time will differ between informative and uninformative trials, indicating their sensitivity to the relevance of the information provided.

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