Caregiver presence promotes judgements of exploration

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Abstract

The decision to explore a novel option or exploit a known one — referred to as the explore-exploit trade-off — has received much attention from diverse fields of research, ranging from computer science to developmental psychology. However, much of the work on this topic has focused exclusively on an individual agent acting alone, a scenario that does not fully capture the rich social dynamics of human decision-making. In particular, the presence and participation of others can theoretically influence the decision to explore or exploit. One factor which may affect how individuals navigate the explore-exploit tradeoff is the presence of caregivers, who can help buffer the downside costs of more exploratory decision making. Across two preregistered studies, we investigated whether children and adults predicted more or less exploratory behavior in the presence of a caregiver. In Study 1, we presented U.S. American children (N=87, ages 4 to 8) with vignettes of other children faced with the choice of exploring a novel option or exploiting a known one across a range of domains. In the vignettes, the characters either faced these decisions alone or in the presence of a parent. In Study 2, we presented the same vignettes to U.S. American adults (N=79). Across both studies, and as predicted, we found that both children and adults believed others would be more exploratory in the presence of caregivers. These results add important nuance to our understanding of how individuals navigate the explore-exploit tradeoff, and highlight the role of the social context in shaping these decisions. We aim to build on these results on future work centralizing the role and function of care in decision-making and exploration.

Keywords: explore-exploit tradeoff; caregiving; environmental cues; decision-making; childhood

Introduction

Many times a day, we face a recurrent dilemma: should we exploit a known option or explore an unknown one? These decisions range from the mundane to the consequential, from choices of what to have for lunch all the way to which medical treatments will be most efficacious. And indeed, this recurrent problem is so common that it transcends human decision-making altogether: navigating the explore-exploit tradeoff is an important task for non-human agents, from single-celled organisms to artificial intelligence systems (Berger-Tal et al., 2014), making this tradeoff a central challenge and topic of inquiry in cognitive science, more broadly.

Despite the decades of careful work on the explore-exploit tradeoff across diverse fields of cognitive science, open questions remain. An important one concerns the ways in which the explore-exploit tradeoff may be approached differently as a function of a decision-maker's age and life history stage. Recent work in developmental psychology has offered many examples of age-related changes in preferences for exploration. Typically, these are cases where younger learners are more exploratory than adults: younger children tend to exhibit greater exploration in reinforcement-learning tasks (Blanco & Sloutsky, 2021; Giron et al., 2023; Liquin & Gopnik, 2022; E. Sumner et al., 2019; E. S. Sumner et al., 2019) and are better equipped to learn unlikely causal hypotheses (in some cases, better than adults) (Gopnik et al., 2017; Lucas et al., 2014; Seiver et al., 2013; Wente et al., 2019). Younger children are also more willing to bear the costs of exploration than older children and adults, which sometimes makes them better learners (Liquin & Gopnik, 2022).

Another open question concerns the influence of the social context on decision-making, and the myriad ways in which the presence of another social agent — especially one who can mitigate the downside costs of exploration — may change how one navigates the explore-exploit tradeoff. This is particularly relevant when decision-makers are young and/or receiving high levels of care from others, as *care* itself — the provisioning of time, resources, and attention to benefit another — can fundamentally alter the decision-making environment by altering the costs and benefits of various decisions. Care provisioning is particularly high among the human species: children receive decades more care than other non-human primates from both parents and *alloparents* (Hrdy, 2009), and care networks also extend to the elderly, the infirm, and the disabled. Taking a broader perspective, it may also be the case that human childhood itself — a uniquely extended period of dependence — evolved as a solution to the explore-exploit tradeoff (Gopnik, 2020). That is, through the provisioning of care, children are allowed a period of broad hypothesis search and exploration, aided by behaviors such as play and neophilia, which can lead to a division of labor between children and adults, wherein children focus primarily on exploration while adults instead focus on exploitation (Gopnik, 2020).

In psychology, there is a classic literature on "attachment" which examines the relationships between infants

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and caregivers and their consequences for later development (Ainsworth, 1978; Bowlby, 2008). Attachment, the long-term bond between child and caregiver, has often been measured using the "strange situation." During these observations of repeated separation from the caregiver and reunion, security is classified as secure when the infant is comforted by the reunion. Insecure subtypes (anxious, avoidant, etc.) show a different behavior. Normatively, caregivers function as a "secure base" for exploration. The extensive body of research on early attachment suggests that infants' general understanding of caregiving, often referred to as their "internal working model," may be shaped by their personal caregiving experiences. Particularly highlighted in Johnson et al. (2007), securely attached infants made different predictions regarding a character's reaction to stress compared to infants with insecure attachments. In a study by Tottenham et al. (2019), preschool-age children exhibited behavioral responses indicating attachment-related learning. In studies of animals, juveniles were more likely to approach, rather than avoid, an aversive conditioned stimulus if the caregiver was present during the conditioning period, and Tottenham et al. (2019) found the same pattern with preschool children. Their results revealed distinct reactions to aversive conditioning influenced by parental presence and cortisol levels.

Relatedly, there is evidence that knowing what kind of environment you are in influences decision-making strategies. Previous work has suggested that children's wait-times are modulated by an implicit, rational decision-making process that considers environmental reliability (Kidd et al., 2013). In line with reliability, children who experienced their lives as less predictable explored less for information because of a preference for familiarity and a tendency to repeat their previous responses, even when those choices yielded lower rewards (Xu et al., 2023). Frankenhuis and Gopnik (2023) integrates research on early adversity, computational learning models, and life-history theory, proposing that adversity may accelerate a shift from exploration to exploitation. Putting forward a hypothesis linking these domains, Frankenhuis and Gopnik (2023) suggests that childhood adversity, particularly the absence of caregiving, shapes hyperparameters balancing exploration and exploitation.

Against this backdrop — the relevance of care for human flourishing, and the nearly ubiquitous presence of caregivers in child development — it is important to examine the proximate mechanisms through which caregivers may be influencing children's decision-making and their navigation of the explore-exploit tradeoff. Here, we explore these dynamics in more detail, bringing together questions about both social context and developmental stage to better understand how humans navigate the decision to explore versus exploit. We do this by exploring children's intuitions about how caregiver presence will influence exploration. There is extensive work on children's "theory of mind" and their intuitive sociology, which offers insight into the child's psychological and social world. However, there is much less work on children's conceptions of caregiving relationships and downstream effects on behavior.

Across two pre-registered studies, we investigated whether participants' judgments of whether a child would explore or exploit were affected by the presence of a caregiver. To this end, we developed five novel vignettes of characters making a choice between exploring an unknown option versus exploiting a known option. Crucially, the characters either made these choices on their own or with a parent alongside them. In two studies, we tested whether US American children (N = 87, ages 4 to 8 years old) (Study 1) and adults (Study 2) predicted more exploratory behavior in the presence of caregivers. We also collected participants' open responses as to why they believed the character would make that choice. As pre-registered, we predicted that caregiver presence would function as a buffer, emboldening the decision-maker to take on more risk through exploration. Note that the alternative hypothesis is also intuitively plausible. Participants might predict that caregivers would react negatively to exploration, especially exploration involving risk, and so that children would be more likely to explore when they were alone and not subject to caregiver disapproval.

Study 1

Methods

Participants As pre-registered, we recruited N = 87 U.S. American children between 4 and 8 years old (mean age = 5.89 years , $\sigma = 1.37$, 47 females and 40 males) from children's museums in the Bay Area in California.

Stimuli and Procedure Our protocol and approach followed our pre-registration. Participants were tested using electronic tablets which showed stimuli, accompanied by an experimenter who read a script out loud explaining the vignettes. Participants clicked the tablet to make their choices or told experimenters what their choices were.

Participants were gender-matched to a cartoon character who needed to make a series of decisions across a number of vignettes. The experimenter first introduced participants to the character in the vignettes, and told them that the character is at a park where there are lots of different activities, and the character has to decide which of the activities they will do. The experimenter then explained that they were going to read aloud some stories about the character, and that they wanted the participant to tell them what they think the character will do. Participants were reminded that there are no right or wrong answers. The experimenter then introduced the idea that there were two social conditions: sometimes the character is on their own in these stories, and sometimes the character is with their mom in these stories.

Participants saw a total of five vignettes: *food, height, distance, play,* and the *Tissue Box Task* (TBT) (Figure 1). These vignettes were intended to capture naturalistic cases of the explore-exploit dilemma in children's lives. In the *food* vignette, the character could either choose a food that they had already eaten and know they like, or they could try a food they never had before. In the *height* vignette, the character could

either choose a slide that was short that they had already gone down before and know they like, or they could try a tall slide they had never gone down before. In the *distance* vignette, the character could either choose a slide that was nearby that they had already gone down before and know they like, or they could try a slide that was far away where no one could see them and they had never gone down before. In the *play* vignette, the character could either play on a structure alone which they had done before and know they like, or they could play on a structure with another child they don't know and they had never played with before. The vignette relating to the *Tissue Box Task* incorporated a scenario from a novel explore-exploit paradigm that seeks to understand the factors that influence children's decisions to explore or exploit. The basic paradigm involves involves hiding stickers inside of wooden boxes and tracking which boxes children choose to open. In this task, participants are presented with four boxes. One of the boxes has no stickers in it, another box definitely has a sticker in it (the *exploit* choice), and there is one sticker in either the third or fourth box, but the character doesn't know which one it's in (and they can choose to *explore*). Participants are then asked which box they think the character will pick.

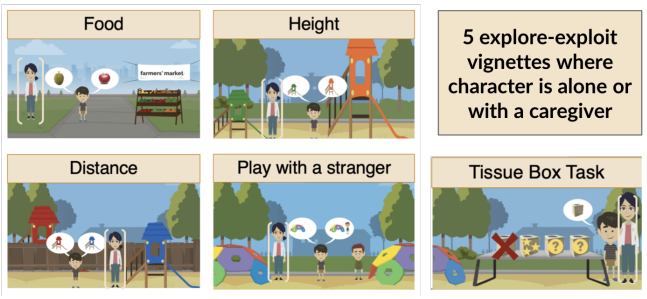

Figure 1: **Explore-exploit vignettes.** Five different exploration vignettes were presented to participants. Participants were asked which option the character will choose to pick, an "explore" option or an "exploit" option. Participants gave their predictions of what the character will do while the character was in the presence of a parent and when the character was on their own.

The script was styled similarly across all the vignette types (with some slight difference in the Tissue Box Task vignette). The exploit prompt was presented as the safe option that the character has tried before and knows they like. The explore prompt was presented as the new option that the character does not know if they'll like. The experimenter suggested that the explore option is unknown, and the character could really like it, like it, not like it, or really not like it, the character won't know if they like it until they have tried it, and that the character is a little nervous but curious to try it.

Importantly, in these explore-exploit vignettes the character was either alone or with a parent. In both social conditions, the experimenter asked the participants which choice they thought the character would make: would the character choose the explore or exploit option as described in the vignette (see Table 1). These choices were coded as the following – for the *food* vignette: dax (explore) or apple (exploit), for the *height* vignette: tall slide (explore) or short slide (exploit), for the *distance* vignette: far slide (explore) or nearby slide (exploit), for the *play* vignette: stranger (explore) or alone (exploit), for the *Tissue Box Task* vignette: unknown sticker boxes (explore) or certain sticker box (exploit).

After participants either clicked the screen or verbally told the experimenter their choice, participants were asked why they thought the character would choose that option. Experimenters recorded the participants' responses. After participants responded, experimenters continued with the next vignette and this process repeated until the participant saw all five vignettes and the experiment concluded.

Table 1: **Explore-exploit vignette choices.** For all the explore choices, participants were told that the character had never had tried the option before, and didn't know if they'll like the option. Participants were told the character could really like it, like it, not like it, or really not like it, and they won't know until they've tried it, and that the character was a little nervous but curious to try it. For the exploit option, participants were told that the character had tried that option before and they know they like that option. In the Tissue Box Task (TBT) vignette, the explore choice involved choosing a box with an uncertain number of stickers in it as opposed to an exploit choice where the box has a certain number in it. Social context varied within subjects so that participants saw each vignette type both with the character on their own and with a parent.

Vignette type	Explore option	Exploit option
Food	Dax	Apple
Height	Tall slide	Short slide
Distance	Far slide	Nearby slide
Play	With stranger	Alone
TBT	Uncertain sticker box	Certain sticker box

Counterbalancing and attention checks We counterbalanced both the order in which the explore/exploit choices were presented in the script (e.g. explore first or exploit first), and the order of the social condition (e.g. participants either saw a character alone first or with a parent first).

As pre-registered, four of the vignettes (*food, height, distance, and play*) were presented randomly across participants with the Tissue Box Task always being the last vignette participants saw. Participants were gender matched to the character: female participants saw the vignettes with a female character called Molly, and male participants saw the vignettes with a male character called Max.

Training and attention checks: To make sure children were accurately clicking the correct pictures and options throughout the experiment, we first presented participants with pictures of the character either alone or with a parent. We asked participants to click the picture where the character was

alone. We also asked participants to click the picture where the character was with a parent.

Correct social condition checks: To compare to a baseline of where there is an objectively correct answer, we also included a prompt where a character was either alone or with a parent and had to decide which table and chair combination to eat at. One of the tables had one chair and the other option was a table that had two chairs. The experimenter asked the participant to choose which table the character should sit at when they are alone (ideally, the table with one chair) as opposed to when they are with their parent (ideally, the table with two chairs).

Results and Discussion

To assess the effect of caregiver presence on children's judgments, we built a linear mixed-effect model predicting children's judgments (explore or exploit, binary) as a function of condition (alone or with parent, categorical) and age (continuous). As predicted, we found that participants predicted the character would choose the explore option more when they are in the presence of a caregiver as compared to cases where the character was on their own (Figure 2) ($\beta = 0.22$, SE = 0.03, $p < 0.01$). Further, we found a significant effect of age such that, on average, older participants were more inclined to predict the character would choose the explore option, independent of social context ($\beta = 0.03$, SE = 0.01, $p = 0.04$). As an exploratory analysis, we looked at the interaction between age and condition. We found that in the "own" condition, there is no significant effect of age ($\beta = -.01$, SE = 0.02, $p = 0.7$). However, in the "caregiver" condition, we find that with increasing age, children are more likely to select "explore" ($\beta = 0.06$, SE = 0.02, $p < 0.01$). With increasing age, children are increasingly sensitive to caregiver presence, and predict more exploration in parental presence.

We found no significant differences between the vignette types (Figure 3), nor evidence for demographic differences between participants in terms of their gender ($\beta = -0.05$, SE = 0.03, $p = 0.14$). Further, we found no order effects for either the order of the explore/exploit option ($\beta = 0.06$, SE = 0.05, $p = 0.22$) nor the parental presence/absence option ($\beta = 0.06$, SE = 0.05, $p = 0.24$).

We found high rates of comprehension and attention among our participants. All children passed the attention checks correctly: they distinguished which picture showed the character with a parent and which picture showed the character on their own. The vast majority of participants (with the exception of *N*=5 children), also chose the correct chair and table configuration, choosing the table with two chairs when the character was with their parent, and the table with one chair when alone. Data was not excluded from the five participants that failed the comprehension checks.

We are currently in the process of analyzing the transcriptions of the participants' explanations for their decisions. We plan to code responses for language about care, help, protection, exploration, and exploitation. We will report the transcription results once they have been completed. A first-pass, qualitative assessment, however, suggests that children invoke the caregiver's ability to help when forming their judgments. For example, one participant said the character will choose the closer slide when on their own because "it's closer and he's on his own so if he goes farther he might get kidnapped" whereas they may choose the further slide when with their parent because: "He's with his mom and it's safe with his mom."

Taken together, these results strongly suggest that American children take caregiver presence into account when evaluating whether one will explore or exploit, predicting more exploratory behavior in their presence as opposed to their absence.

With these findings in mind, we were curious to see if the intuitions children and adults have would result in convergent predictions. Children and adults may have competing motivations and incentives, and so in Study 2 we ask whether these child-specific intuitions are a result of being cared for as a child or is there something more general about caregiving that caregivers and non-caregivers also acknowledge.

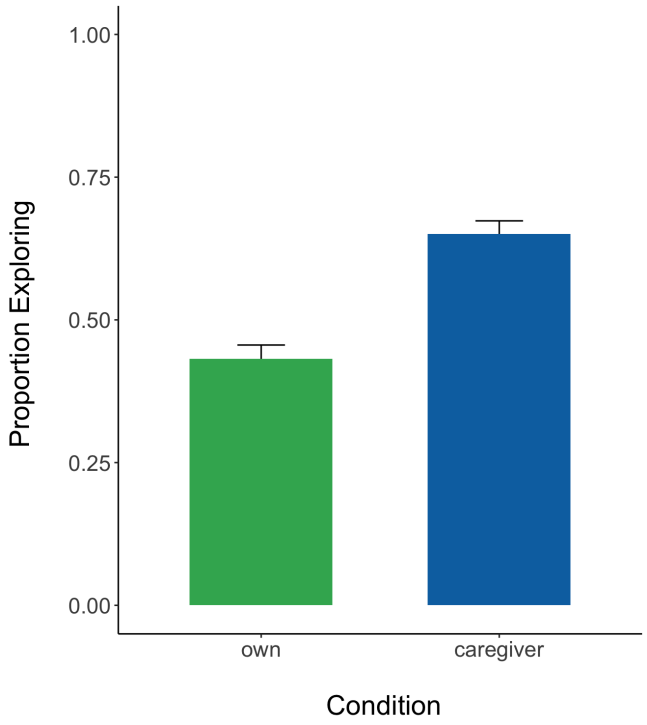

Figure 2: **Results of explore predictions made by children.** Children significantly say that other children will choose the explore option more when they are in the presence of a caregiver compared to when they are alone.

Study 2

Methods

Participants We recruited a total of N= 79 US American adults (mean age = 47.75, $\sigma = 13.97$; 37 females, 41 males, and 1 other) on Prolific to complete the same task as the

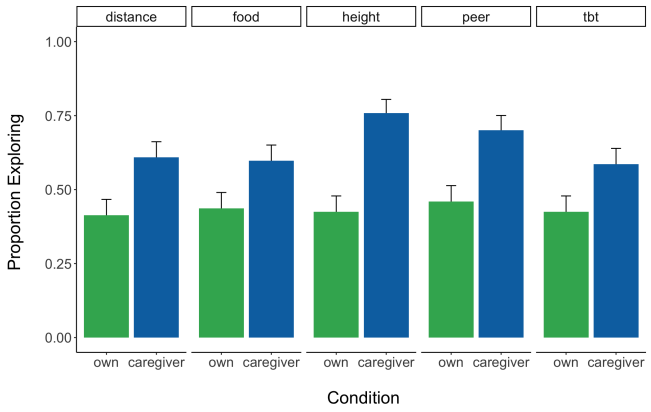

Figure 3: **Results of predictions made by children for each type of explore-exploit vignette.** There was no statistical difference between vignette choices. Across all vignette types, child participants said the character would choose the explore option more when they were with a parent compared to when they were on their own.

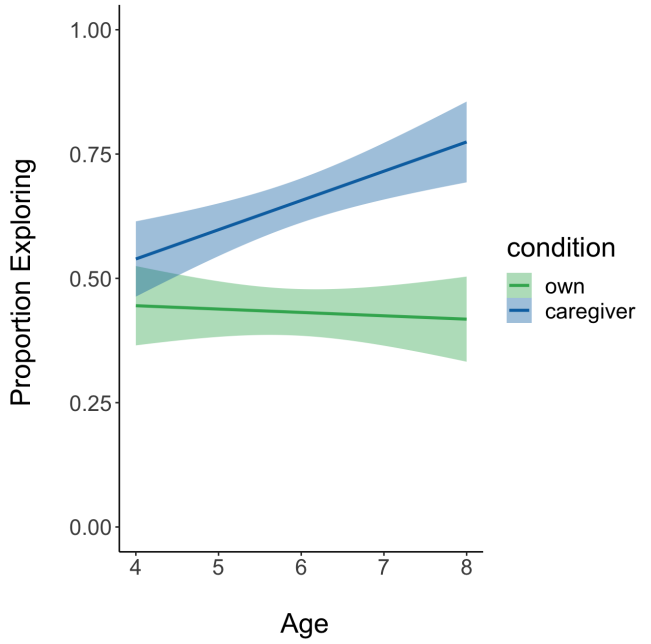

Figure 4: **Results of predictions made by children across age groups.** Children significantly say that other children will choose the explore option more when they are in the presence of a caregiver compared to when they are alone across all age groups.

child participants in Study 1. Our selection criteria targeted participants who were from the United States, between the ages of 18-99, fluent in English, had an approval rating of 95-100, and had completed at least 50 previous Prolific studies.

Stimuli and Procedure As pre-registered, Study 2's procedure was similar to that of Study 1. In addition to the vignettes, we also collected demographic information from participants regarding their parental status and their favorite activity to do with their child.

Results and Discussion

We followed the same analysis technique as in Study 1. Our results suggest that, much like the children in Study 1, adult participants predicted the character would choose the explore option more when with a parent than when alone ($\beta = 0.25$, SE = 0.03, $p < 0.01$). There were no significant gender differences ($\beta < 0.01$, SE = 0.04, $p = 0.87$), nor differences between parents and non-parents ($\beta = -0.06$, SE = 0.04, $p = 0.12$). We further did not find evidence of significant order effects. Unlike the child participants, however, we did find that adults differed in their judgments across vignettes. Namely, we found that adults did not predict more exploration when caregivers are present in the Tissue Box Task, as opposed to the other vignettes ($\beta = 0.14$, SE = 0.05, $p < 0.01$) (Figure 6).

As in Study 1, we also collected participants' explanations for their decisions. We are currently analyzing the responses and will report results once they are coded.

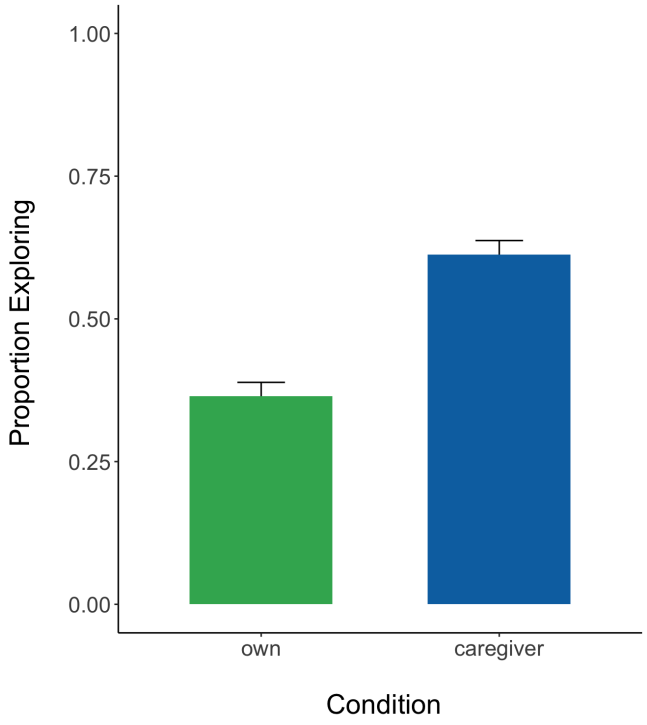

Figure 5: **Results of predictions made by adults.** Adults believed the character would choose the explore option more in the presence of a caregiver as compared to when they are alone.

General Discussion

This investigation is among the first to investigate the role of the social context in children and adults' evaluations of exploratory behavior. Across two studies and five unique

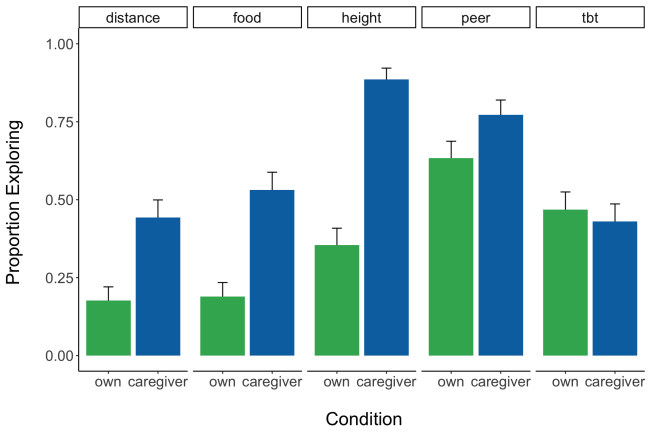

Figure 6: **Results of predictions made by adults for each type of explore-exploit vignette.** Adults predicted more exploratory behavior in the presence of a caregiver for all vignettes, except the Tissue Box Task where adults did not differentiate between social conditions.

vignettes, we found that US American children and adults consistently believe that children are more likely to explore when they are in the presence of a caregiver than when they are on their own.

These findings offer novel insights into the development and flexibility of exploratory decision-making, and the role that caregivers may play in these dynamics. Both children and adults appear to intuitively endorse a picture in which caregivers embolden exploratory behavior, perhaps by offering a safety net or social buffer that can mitigate the downside costs of exploration. These intuitions may also be linked to a more nuanced understanding of childhood, more generally, as a protected period of exploration, and an evolutionary solution to the explore-exploit tradeoff (Gopnik, 2020).

There are some limitations in our study design and future work can address these points. In our studies, we tested just the presence and absence of caregiving on behavior. However, the large literature on attachment suggests that the quality and type of attachment matters (Ainsworth, 1978). In follow-up work we will manipulate the type of relationship.

Furthermore, there is an element of risk in these vignettes, where some vignettes may be considered more riskier than others (for example, going down a tall slide versus choosing a box with uncertainty amount of stickers). However, in the findings from the child study, we found no difference across vignette types (where some may be considered more riskier than others). Contrary, in the findings from the adult study, there did appear to be a difference between vignette type. Our goal in this first pass was to use vignettes of ecological validity, where children would be making choices they would in daily life. Further work can disentangle risk preference per se versus exploration.

This investigation is an early step toward a more integrative and complex understanding of caregiving in human social life and development. To build on these results, we have a number of future studies planned. First, to explore whether participants' intuitions are shaped by caregivers, *per se*, or whether they are shaped by the mere presence of other social agents, we are conducting follow-up studies using the same paradigm, but varying whether the other agent is a caregiver, a peer, or a stranger. If the result is truly about caregiver presence, we predict that participants will continue to make more exploratory decisions when the character is with a parent compared to when the character is alone, with a peer, or with an adult they do not know. We are also interested in how caregivers' *ability* and *willingness* may shape these decisions. That is, if a caregiver is unable to provide care (e.g. due to physical constraints) or unwilling to provide care (e.g. due to preferences or desires), will those factors effect predictions about exploratory behavior? Further, as these studies primarily focused on the caregiver as a mother, we know less about how social roles and relationships may shape judgments (e.g. if judgments vary when the caregiver is a father). Lastly, and importantly, our results are currently limited to children and adults in the United States. How much of these perceptions and judgments are unique to American culture, and how much can generalize to other settings? To explore these questions, we are in the process of collecting data from participants outside of the United States (namely, in Peru) with plans to extend beyond to new cultures to better understand the ways in which cultural norms, values, and parenting styles may affect judgments about exploration.

Taken together, our results are the first steps toward a more nuanced, scientific understanding of how humans conceive of care and caregiving, and the functions that care and caregiving play in our decision-making. We believe this approach not only deepens our understanding of human psychology, but also opens further avenues of research into a the environmental cues and factors that may promote or hinder exploration and learning across both human and artificial agents.

Preregistration

Links to our pre-registered studies can be found here: https://aspredicted.org/pt7w5.pdf (Study 1) and https://aspredicted.org/vk9zy.pdf (Study 2)

Acknowledgments

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