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ARTICLE

Balancing exploration and exploitation? The impact of cost and inhibitory control on information gathering in early childhood

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Abstract
The information-seeking behaviour of adults focuses on optimizing the gathering and utilizing information to minimize search costs. In contrast, children tend to engage in information search during decision-making with less consideration for costs. This difference in behaviour is believed to be linked to the development of executive functions. Therefore, the present study aimed to investigate the relationship between executive function and cost-related information-gathering behaviour. We assessed 56 children aged 4–6 years, involving three tasks: an information-gathering task, an inhibitory control and a working memory task. In the information-gathering task, children participated in both non-cost and cost conditions, where they were given the opportunity to freely gather information or incur a cost to acquire information. The findings revealed that children with higher inhibitory control tended to gather less information when a cost was involved. This highlights the important role of inhibitory control in shaping information-seeking behaviour in early childhood.

KEYWORDS
executive function, exploration–exploitation dilemma, information search, inhibitory control, young children

BACKGROUND

When faced with making decisions, humans have the option to gather new information or use existing knowledge acquired through previous experience to arrive at a decision. When adults encounter situations characterized by uncertainty, they engage in information searching while relying on their existing knowledge to guide their decision-making processes (Hills et al., 2015; Wilson et al., 2014, 2021). While adults strike a balance between exploring new information and exploiting existing information, considering factors such as information quality and associated costs, including time and economic costs (Busemeyer & Townsend, 1993), children engage mostly in information searching to inform their choices and gain an understanding of the world because of their limited knowledge. However, little is currently understood about how young children, who possess limited knowledge, manage the trade-off between information search and the utilization of existing information in decision-making, particularly in situations involving costs. Moreover, the relationship between cognitive development and information gathering for decision-making in early childhood remains unknown. This study aimed to address these two issues.

Information exploration–exploitation in adulthood

The exploration–exploitation dilemma is the balance between exploring new information and exploiting existing knowledge (see Hills et al., 2015 for reviews). Humans constantly strive to make optimal judgements by balancing the trade-off between exploration and exploitation to achieve their goals (Cohen et al., 2007). As exploring new information means incurring costs, including time and economic resources, utilizing prior knowledge allows adults to reduce their efforts and minimize the associated costs. Indeed, people often use heuristics in their decision-making processes (Gigerenzer & Gaissmaier, 2011). In particular, healthy adults often rely on these heuristics, which are approaches for calculating the probabilities of outcomes when assessing situations, to reduce the effort and minimize the costs associated with information searches (Behrens et al., 2007; Busemeyer & Townsend, 1993; Gigerenzer & Gaissmaier, 2011; Tversky & Kahneman, 1974). According to Berg and Gigerenzer (2010), heuristics can be a valuable procedure in decision-making, especially when information search costs are high.

Information exploration–exploitation in childhood

Children demonstrate decision-making properties that differ from those of adults (Decker et al., 2016; Dubois et al., 2022; Gopnik et al., 2017; Lucas et al., 2014; Schulz et al., 2019). Notably, children exhibit a stronger inclination towards acquiring new information over relying on existing knowledge, which sets them apart from adults (Blanco & Sloutsky, 2021). Recent findings suggest that children are highly motivated to reduce uncertainty and explore new information, whereas adults tend to prioritize maximizing rewards in their decision-making (Blanco & Sloutsky, 2021). Additionally, research indicates that 4- and 5-year-old children tend to prioritize new evidence over prior beliefs, whereas adults are more inclined to rely on existing assumptions (Lucas et al., 2014). Consequently, we may claim that adults are less sensitive to new evidence as compared with children (Gopnik, 2020; Gopnik et al., 2017). Thus, children exhibit a preference for acquiring new information compared to adults.

Information exploration–exploitation in decision-making from childhood into adulthood

Previous studies have examined developmental changes in the utilization of existing knowledge in decision-making (Bowler et al., 2021; Decker et al., 2016). Bowler et al. (2021) conducted a study that examined information search behaviour during a decision-making task involving rewards. In the task used by Bowler et al. (2021), the participants had the freedom to gather as much information as they desired before deciding, without any explicit cost, such as losing scores or points, associated with obtaining information. The findings indicated that 8- to 9-year-old children engaged in a greater amount of information searching compared to 12- to 13-year-old and 16- to 17-year-old adolescents; these latter two groups do not differ significantly from each other. The results suggest that young elementary school-aged children are more motivated to acquire new information before decision-making than adolescents, who tend to rely on heuristics to minimize decision costs. Another study spanning childhood to adulthood found that the use of model-based information learning emerges during adolescence and strengthens in adulthood, whereas this decision strategy is less developed during childhood (Decker et al., 2016). Adolescents and adults use existing environmental information and their prior experiences to make decisions based on assumptions about possible outcomes. Thus, children exhibit a higher tendency to search for information before making a decision and engage in decision-making that incurs higher costs than adults and adolescents (Bowler et al., 2021; Dubois et al., 2022; Smid et al., 2022). In addition, Morsanyi and Handley (2008) reported that children's heuristic responses increase with age, from 5 to 11 years, as their cognitive capacity level increases. As children grow up, they increasingly engage in prediction and decision-making with limited information, perhaps due to their development of cognitive functions.

Exploration–exploitation and executive function

Theoretical proposals suggest that age-related differences in the dominance of information exploration–exploitation behaviour may be associated with the development of executive functions (Gopnik, 2020; Gualtieri & Finn, 2022). Executive function is a subcategory of cognitive function that regulates behaviour related to achieving specific goals (Diamond, 2013; Miyake et al., 2000). It encompasses the cognitive processes that consciously control thoughts, actions and emotions in goal-oriented behaviour (Diamond, 2013). Executive function is considered to consist of three subfunctions: inhibition, shifting and working memory (Miyake et al., 2000). The literature indicates that the development of executive function guides reward-related choices in decision-making scenarios (Moriguchi & Phillips, 2023; Zelazo & Carlson, 2012). In decision-making situations where there is a choice between information exploration and exploitation, adults and adolescents tend to choose actions that optimize outcomes, that is, actions that maximize rewards while minimizing costs (Decker et al., 2016).

During information search prior to decision-making, the dominance of exploration or exploitation reflects the ability to control exploration to decrease costs and maximize rewards. Adults can inhibit or adjust information exploration to achieve goals, such as controlling information-gathering costs, by relying on their previous beliefs and cognitive maturity (Gigerenzer & Gaissmaier, 2011; Gopnik et al., 2017; Tversky & Kahneman, 1974; Voorberg et al., 2021). Immature cognitive function has also been suggested to promote the exploration of goal-irrelevant information and learning about new environments in children (Blanco et al., 2023; Gualtieri & Finn, 2022; Liquin & Gopnik, 2022; Plebanek & Sloutsky, 2017; Schuck et al., 2022). Thus, cognitive immaturity may be related to immediate rewards, such as acquiring new information, while cognitive maturity may support behavioural control and limit resource depletion.

Exploration–exploitation and executive function development in early childhood

Research has consistently shown that cognitive control processes undergo significant developmental changes during children's preschool years and continue to develop throughout early childhood and adolescence (Davidson et al., 2006; Moriguchi & Hiraki, 2009; Pailian et al., 2016; Zelazo et al., 2014). The development of inhibitory function and working memory is particularly important during the preschool years (Diamond & Taylor, 1996). However, whether the development of executive function in early childhood is associated with information search behaviour in decision-making remains unclear.

Bowler et al. (2021) demonstrated that even school-aged children exhibited a decrease in information exploration when a cost was associated with acquiring information. Interestingly, 8- to 9-year-old children, who initially showed increased information exploration in a no-cost condition, reduced their information gathering when a cost was involved. Notably, the amount of information searched for by 8- to 9-year-olds was comparable to that of 12- to 13-year-olds and 16- to 17-year-olds in the cost condition (Bowler et al., 2021). These findings suggest that 8- to 9-year-old children can adjust their information search behaviours based on explicit costs. However, it remains unclear whether younger children exhibit similar control over their information search behaviours regarding minimizing costs. Moreover, a recent study by Meder et al. (2021) suggested that even younger children demonstrate controlled information exploration to acquire rewards despite having incomplete cognitive control compared to adults. This study found that 4- to 9-year-olds showed increased information generalization with age in their pursuit of rewards (Meder et al., 2021), indicating a potential link between the degree of controlled information exploration and the developmental level of executive function. Given these gaps in knowledge on this issue, the present study aimed to investigate differences in cost-involved information exploration among preschool-aged children, thereby contributing to our understanding of the relationship between executive function and information search behaviour in young children, particularly during early childhood.

METHODS

Participants

The participants in this study were 56 children aged 4–6 (58.93% girls). The participants' mean age was 62.6 months, ranging from 50 to 74 months ($SD = 7.06$). All participants were native Japanese speakers. We recruited participants from centres for early childhood education in small- and medium-sized cities in Japan under the jurisdiction of the Cabinet Office. The participants were recruited from similar areas with comparable annual income distributions. Children whose caregivers consented to their children's participation in the study were engaged in the experimental procedures. Before accessing the experimental room, children were asked to participate in the tasks. Only those children who said 'Yes' to engaging in the tasks entered the quiet experimental room. Two children chose not to continue participating and were excluded from analysis ($n = 2$). To analyse the effect of costs in decision-making, we aimed to have a minimum of approximately 34 participants to detect significant conditions with a medium-effect size (non-cost and cost condition, a within-condition factor) and a power of 80% (Erdfelder et al., 1996). Additionally, following the rule of thumb, a sample size of at least 50 was considered appropriate for the correlational analysis (VanVoorhis & Morgan, 2007). Ethical approval for all the procedures was obtained from the local Psychological Research Ethics Committee (3-P-30). Informed consent was obtained from the caregivers of each child before commencement of the study.

MATERIALS

Information-gathering task

We employed a modified version of the information-gathering task originally developed by Clark et al. (2006), which we made more child friendly (see Figure 1) (Clark et al., 2006). Each participant underwent a single trial. When the experimenter observed that the children had understood the rules of the task, they began the experimental trials. Children participated in two task conditions (non-cost and cost conditions) (see Figure 2). There were four games per condition. Each condition consisted of two 16-box and two 25-box trials (eight trials in total). The order of the games was the same for all participants and the cost condition was placed after the non-cost condition to eliminate the learning effects of the cost condition. To ensure sustained focus and attention, we used a reduced number of

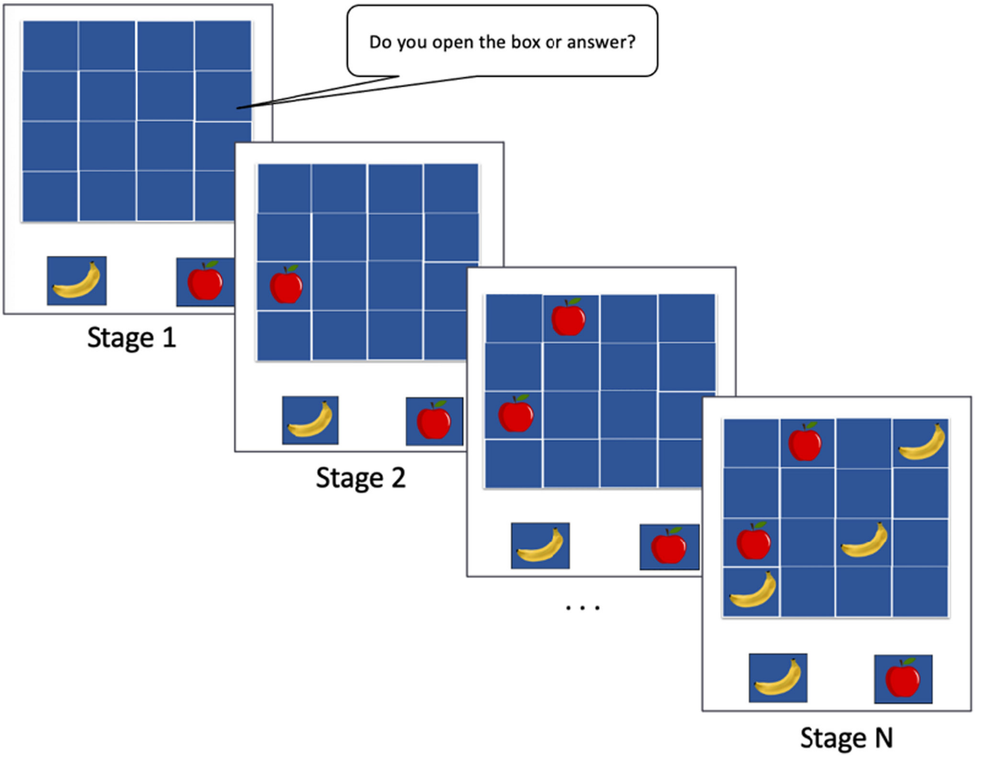

FIGURE 1 Information-gathering tasks. Task procedure: Children played an information-gathering task in which they chose to open as many boxes as needed before making a decision. Children answered whether banana or apple cards were the majority of cards in 16 or 25 covered boxes. In the reward condition, children received the same number of stickers as boxes at the beginning of each trial. For example, in the game, they received 16 stickers in a 16 boxes trial. During the game, the children had to give the experimenter a sticker when they decided to open a box.

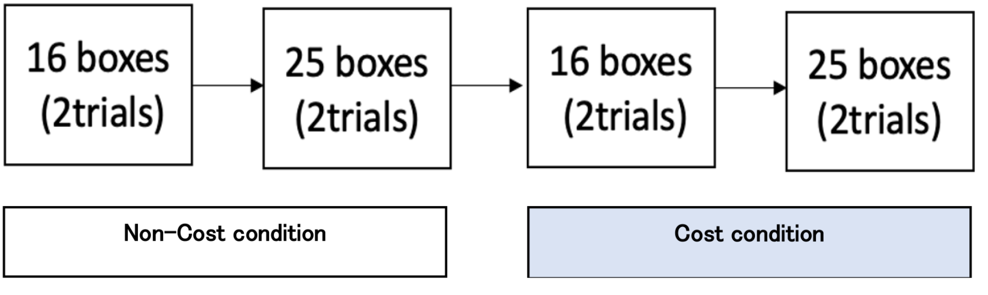

FIGURE 2 Task Procedure. To study information gathering, we used a modified information-gathering task (Bowler et al., 2021). All participants played two versions of the task in which we manipulated the reward for information gathering (four games per condition). In each condition, the children were presented with 16 covered cards for the first two trials and 25 covered cards for the third and fourth trials.

boxes (16-boxes) in addition to the original 25-box version used by Clark et al. (2006). Preliminary experiments showed that the 16-box was suitable for sustaining concentration in 4-year-old children. Additionally, because the present study was exploratory, 16-box and 25-box conditions were combined in the experimental task.

In the task, the boxes contained concealed items, and the participants were required to determine whether the majority of the fruits inside the boxes were bananas or apples. They had the freedom to open as many boxes as they desired before reaching a final decision. After the participants had decided on their answers, they were required to declare their answers (banana or apple). They observed the correct answer, which was the majority fruit in each trial. In the non-cost condition, the participants could open the boxes without incurring any associated expenses. In contrast, the cost condition required the participants to sacrifice a small sticker (approximately 1 cm in diameter) for each box they wished to open. Prior to each game under the cost condition, participants were provided with a set number of stickers corresponding to the total number of boxes in that particular game. For instance, if there were 16 boxes, the children would receive 16 stickers in that trial. No explicit rewards, such as points, stickers or praise, were provided for the participants' responses. To measure the amount of information gathered before making a decision, we recorded the number of boxes opened by each participant to determine the majority fruit category.

Black-and-white inhibitory task

To assess inhibitory control, we administered a black-and-white inhibitory task based on a modified version of the task (Moriguchi, 2012; Simpson & Riggs, 2005). The task involved two cards, one white and one black, measuring 89 × 127 mm, which were placed on a table. The participants were seated facing the experimenter, and the white-and-black cards were positioned approximately 15 cm away from the participant's side. Initially, participants were instructed to touch the white card with one hand when the experimenter said ‘white’ and to touch the black card with one hand when the experimenter said ‘black’. Once their accuracy was confirmed, the rules were reversed. Participants were then instructed to touch the black card when the experimenter said ‘white’ and to touch the white card when the experimenter said ‘black’. Two practice trials were conducted, and participants who responded correctly to two consecutive practice trials proceeded to the main experiment. If participants answered incorrectly, the instructions were reviewed and repeated until two consecutive correct responses were achieved.

During the main experiment, the experimenter randomly uttered ‘white’ or ‘black’ at a rate of once per second, resulting in a total of 16 trials. The instructions were not reiterated once the experiment began and no feedback was provided. The number of correct trials completed by each participant, which ranged from 0 to 16, was recorded as a variable in the analysis.

Backward word span task

After completing the black-and-white inhibitory task, the children participated in a backword ward span task to measure working memory. The task was adapted from a previous study conducted by Carlson et al. (2002) (see Table A1 for further details). During the task, the participants were presented with a list of words and instructed to recite them in reverse order. A practice trial was conducted to ensure task comprehension. During both the practice and main trials, a set of blank papers matching the number of words in the word list was provided on the desk. The experimenter presented the words orally while pointing to the paper. The participants were instructed to recite words in the reverse order of their presentation. To aid understanding, participants were shown a demonstration of reciting words in reverse order using a Cookie Monster hand puppet. If a participant made an error or did not respond correctly during the practice trial, the demonstration was repeated until a correct response was provided. Once the participant provided the correct response during the practice trial, the main trial commenced. The length of the word list increased incrementally, starting from two words and progressing to five. Two trials were conducted for each word length, and if the participant responded correctly in at least one of the two trials, the word list was expanded. The variable used for analysis was the number of correct trials completed by each participant. For example, if a student answered correctly in both trials of the two-word list and correctly in one trial of the three-word list, and did not respond accurately to the fourth word, the total number of correct trials was recorded as three.

Procedure

The experimental tasks were conducted in a quiet room at the participants' educational institutions. Prior to commencing with the main tasks, a preliminary activity was conducted to assess participants' familiarity with the target words, such as 'apple', 'dog' and 'ball', used in the Backward word span task. During this activity, the children were presented with picture cards and instructed to touch them as directed by the experimenter. All participants responded correctly, indicating their knowledge of the target words for the subsequent backward word task. Following the preliminary activity, the participants proceeded to complete the following tasks in a predetermined sequence: black-and-white inhibitory task, backward word task and information-gathering task. The total duration of the experiment was approximately 30 min, encompassing the completion of all tasks.

Data analysis

Our study aimed to investigate the potential relationship between developmental levels of executive function and the extent of information exploration prior to judgment. To test this relationship, we employed Pearson's correlation coefficients to assess the associations between various variables, including age in months, quantity of information gathered per condition, accuracy, inhibitory control and working memory. Furthermore, we conducted a *t*-test for interval-scaled variables to explore the potential differences in the amount of information gathered between the two experimental conditions (non-cost and cost). All statistical analyses were performed using SPSS version 26.

RESULTS

Descriptive and correlational analysis

Table 1 illustrates the Pearson's correlation coefficients used to examine the relationships between the variables. We calculated participants' accuracy for the information-gathering task. Their accuracy indicates their ratio of correct responses over eight trials. The results indicated that inhibitory control was positively correlated with accuracy in the non-cost condition ($r(56) = .273$, $p = .042$), indicating that higher inhibitory control was associated with a higher accuracy in this condition. Additionally, inhibitory control demonstrated a negative correlation with the amount of information gathered in the cost condition ($r(56) = -.335$, $p = .012$), suggesting that higher inhibitory control was related to less information gathering in this condition. Partial correlations were computed to further examine these relationships while controlling for age in months. The results of the partial correlations revealed a similar pattern, indicating that inhibitory control remained positively correlated with accuracy in the non-cost condition ($r(51) = .347$, $p = .011$) and negatively correlated with the amount of information gathered in the cost condition ($r(51) = -.331$, $p = .015$). However, no significant relationships were found between working memory and accuracy in the non-cost condition ($r(56) = -.147$, $p = .279$) or the amount of information gathered in the cost condition ($r(56) = -.060$, $p = .661$).

Younger children control information gathering in cost condition

To investigate whether the amount of information gathered differed between conditions (non-cost and cost), a paired *t*-test was conducted. Condition was treated as a within-subject variable.

The results revealed a significant main effect of condition ($t(55) = 6.07$, $p < .001$, $d = 0.7$), indicating that participants gathered more information in the non-cost condition compared to the cost condition.

TABLE 1 Pearson zero-order correlations between variables in this study.

	1	2	3	4	5	6	7	8
1. Sex	–							
2. Age (months)	.050	–						
3. No of opened boxes (non-cost)	.010	−.299*	–					
4. Choice Accuracy (non-cost)	−.158	−.155	.278*	–				
5. No of boxes (cost)	.050	−.063	.627**	−.076	–			
6. Choice Accuracy (cost)	.237	−.160	.349**	.255	.412**	–		
7. Inhibitory tasks (correct answer)	−.207	.368**	−.211	.273*	−.335*	−.208	–	
8. WM tasks	.090	.276*	.011	−.147	−.060	−.257	.163	–

Note: No of opened boxes (non-cost): The number of boxes participants opened before deciding non-reward condition (no stickers condition).
No of boxes (cost): The number of boxes participants opened before deciding the reward condition (no sticker condition).
Inhibitory task: The number of correct answers in the black−white inhibitory condition task.
WM tasks (backward word span): Children repeat a list of words in reverse order. The number of correct trials completed.
$^*p < .05$. $^{**}p < .01$.

Overall, these findings indicate that the participants tended to gather more information in the non-cost condition.

DISCUSSION

The present study aimed to explore the relationship between explicit costs and information gathering in young children, as well as the influence of executive function development on this behaviour. To accomplish this goal, we conducted an information-gathering task in which we manipulated the presence of explicit costs. Additionally, we employed two well-established measures to assess specific aspects of executive function: the black-and-white inhibitory task to measure inhibitory control, and the backward word span task to evaluate working memory. Interestingly, our findings demonstrate that preschoolers reduce their information gathering when faced with explicit costs. The findings of this study align with previous research indicating that even in early childhood, school-aged children tend to engage in less information seeking when explicit resources are at stake (Bowler et al., 2021). This implies that the presence of explicit costs leads to a decrease in information-gathering behaviours, similar to what has been observed in older children and adults. Our data further indicate that preschool-age children engage not only in exploring new information for decision-making but also in behavioural control to strike a balance between minimizing costs and exploring information. This behaviour is associated with the development of inhibitory control.

Our findings demonstrate that, among preschool-aged children, the amount of information searching they engage in during decision-making varies depending on the presence or absence of explicit costs associated with acquiring information. Specifically, when there is no explicit cost, children tend to engage in increased information search. However, when an explicit cost is involved, preschool-aged children show a decrease in the amount of information they search for. These findings suggest that, unlike adults, children may lack the motivation to regulate their information-seeking behaviour when it does not involve any resource costs. Instead, young children's information-seeking tendencies are primarily driven by the desire to clarify uncertain information without necessarily considering the minimum information required to achieve the task goal. This strong motivation to seek information may be fuelled by curiosity (Blanco & Sloutsky, 2021; Lamnina & Chase, 2019; van Lieshout et al., 2021).

Previous research has emphasized the challenges that young children face in controlling their behaviours to achieve their goals (Davidson et al., 2006). It has been observed that young children are more easily distracted by goal-irrelevant information compared to adults (Merrill & Conners, 2013). This exploration of goal-irrelevant information has been proposed as a developmental aspect of cognitive inhibitory control (Gopnik, 2020). Consistent with these findings, Yanaoka et al. (2020) conducted a study that revealed a correlation between the level of inhibitory control and goal neglect behaviour (difficulty in maintaining goal representations) in young children. This study revealed a correlation, indicating that children with higher inhibitory control were more successful in maintaining their goal representations (Yanaoka et al., 2020). These findings suggest that inhibitory control plays a crucial role in facilitating goal-directed behaviour and reducing goal neglect in young children. Consistent with previous research, our study provides initial evidence of preschoolers' reduced information exploration in the presence of explicit costs; this decrease is linked to the maturity of their inhibitory control. These findings highlight the role of inhibitory control in regulating information-seeking behaviours, even in young children, particularly when there are associated costs. These results imply that young children are capable of considering explicit costs as a significant factor in their decision-making processes. Moreover, our study suggests that the recognition of costs associated with information seeking leads to an increase in the inhibition of search behaviour in young children.

Additionally, even preschool-aged children may consider the costs of information acquisition. As mentioned above, cognitive control processes undergo significant developmental changes during the preschool years (Davidson et al., 2006; Moriguchi & Hiraki, 2009; Pailian et al., 2016; Zelazo et al., 2014). This developmental process may be linked to control of information-seeking behaviours. The maturity of inhibitory control in young children plays a crucial role not only in reducing costs but also in regulating the expenses associated with information gathering. In our study, we specifically focused on 4- to 6-year-old children and observed that those with higher inhibitory control exhibited less information exploration when explicit costs were introduced. Overall, our study provides evidence of preschool-aged children's ability to adapt their information-seeking behaviours, which is linked to the maturity of their inhibitory control.

Our results revealed no significant relationship between working memory and information gathering. These findings align with previous research indicating that inhibitory function and working memory are distinct cognitive processes, even during early childhood (Davidson et al., 2006; Diamond, 2002; Hasher et al., 1991; Miyake et al., 2000). Executive function is a composite construct that encompasses both inhibitory control and working memory (Hughes et al., 1998). Working memory involves the maintenance and manipulation of acquired information in the mind (Baddeley, 2010; Diamond, 2013) as well as cognitive and action planning (Osaka et al., 2007).

In the current study, the significant association between information-seeking and inhibitory function suggests that information seeking is more closely related to behavioural regulation than to the immediate retention and utilization of acquired information. That is, during decision-making, information seeking in young children may be driven by a desire to satisfy their curiosity and increase their desire for knowledge when there are no associated costs involved. However, when costs are involved, other motivating goals may exert control over information seeking. Doebel (2020) proposed that the development of executive functions reflects the ability to use inhibitory control to guide behaviour in response to mental contexts, such as knowledge and beliefs (Doebel, 2020). In this study, inhibitory control may represent the ability to regulate costs in the pursuit of information. Furthermore, we observed that even among participants with more developed inhibitory functions, some children sought extensive information in both the non-cost and cost conditions. In these cases, regulating the cost of information exploration may not have been the primary goal.

Previous research has primarily focused on comparing the characteristics of information seeking between children and adults or adolescents. In contrast, our study represents the first attempt to examine the relationship between information seeking and the development of executive function, which undergoes significant changes even in early childhood. Our findings suggest that executive function may be associated with the strategies employed during information seeking, even in early childhood.

Studying the impact of explicit and time costs on information-gathering behaviour from infancy to adolescence offers valuable insights into the cognitive and behavioural aspects of decision-making across different developmental stages. Even preschool-aged children may consider the costs of information acquisition. Additionally, investigating the potential association between information exploration in decision-making and individual differences in trait curiosity, a stable inclination towards seeking new information, enhances our understanding of the factors influencing information-seeking behaviour in decision-making contexts (Kashdan et al., 2004; Litman & Spielberger, 2003).

A previous study reported that children prefer to explore new information rather than rely on existing knowledge (Blanco & Sloutsky, 2021). However, our study suggests that preschool children reduce the amount of information they search for when they perceive a reduction in resources. Children may adopt heuristics to make decisions and avoid losing resources when faced with information costs. Although it is unclear why children inhibited their information-seeking behaviour, their information searching was reduced in the cost condition of this study. Our results imply that children may stop actively seeking more information when facing a reduction in resources. Curiosity and the desire to know seem to be more dominant in young children. However, as in the present study, it is also suggested that when children recognize restrictions, such as a decrease in resources and time, the suppression of behaviour may be prioritized over their desire to know.

Parents and educators should create an environment in which children can actively explore information in situations where they can, rather than imposing restrictions on time and resources. The current study showed that even preschool children limit their information-seeking behaviour when it leads to a reduction in resources. As such, our findings suggest that early childhood educators and parents can promote information seeking in real-life settings by encouraging young children to explore the environment and access information without rigid time constraints.

A previous study suggested that even 3-year-olds believe in and predict outcomes by considering real external information (Wellman & Bartsch, 1988). In the current study, it was not clear whether participants relied on knowledge or belief in their decision-making because we did not ask the children why they stopped searching for more information in either condition (non-reward condition/reward condition). Future studies should investigate why young children stop acquiring information.

In summary, our study highlights the significant role of explicit costs in shaping young children's information search behaviours. The presence of costs acts as a deterrent influencing children's decisions to explore or acquire new knowledge. When promoting information-searching behaviour in early childhood, it is important to consider the factors that regulate children's desire to acquire knowledge, such as the explicit costs associated with information seeking. By recognizing the influence of explicit costs on information search behaviour, educators and parents can effectively support children in developing a balanced approach to information acquisition. Furthermore, it is important to acknowledge individual differences, as some children may be more motivated to inhibit information exploration because of the perceived costs involved. By incorporating this understanding into educational strategies, we can empower children to navigate the complex world of information from a balanced perspective, promoting curiosity and informed decision-making.

AUTHOR CONTRIBUTIONS

Shoko Iwasaki: Conceptualization; methodology; investigation; writing – original draft. **Yusuke Moriguchi:** Conceptualization; writing – review and editing; writing – original draft. **Kaoru Sekiyama:** Writing – review and editing; writing – original draft; conceptualization.

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CONFLICT OF INTEREST STATEMENT

No potential conflict of interest was reported by the authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at https://osf.io/9v7kg/?view_only=9e183527c2de49f09b513b7e2e446927.

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APPENDIX

TABLE A1 Word list for word backward task for the current study.

Practice trial	Apple — dog
Two words	pants — balloon
	pig — book
Three words	spoon — cat — clock
	ant — table — banana
Four words	pencil — bear — train — toy
	tiger — shoes — cup — star
Five words	hand — TV — lion — bicycle — tree
	car — fish — pen — insects — ball

Note: The word lists used in this study were adapted from the article titled 'The Relation between Components of Executive Function and Theory of Mind in Young Children' by A. Ogawa and M. Koyasu, 2008, *The Japanese Journal of Developmental Psychology*, 19(2), 171–182. The word lists in this study were modified to ensure their alignment with everyday language. The selection of alternative words was referred to in '*Tables of vocabulary obtained from Japanese children by association method*' by The National Language Research Institute, 1981, Tokyo, Japan: TOKYO SHOSEKI CO., LTD.