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Does using multiple strategies enhance preschoolers' persistence in a challenging task?

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ABSTRACT

Persistence, characterized by continued efforts in the face of difficulties, is crucial for children's success. Many researchers have aimed to identify the factors that improve persistence. Previous research has found that children who use more strategies to solve a challenging task tend to exhibit greater persistence, suggesting that providing instructions for multiple strategies may enhance their persistence. Therefore, this study examined whether telling strategies through verbal instructions and demonstrations affected persistence in 4- and 5-year-old children using an unachievable persistence task. In preregistered Study 1 (N = 150), we instructed children to focus on multiple strategies or a single strategy in a direct or pedagogical manner during the task. No substantial effects of telling strategies through verbal instructions were found on the children's persistence and strategy use. In Study 2 (N = 54), demonstrating strategies did not affect children's persistence; however, demonstrating multiple and single strategies increased and decreased children's number of strategies, respectively. Thus, telling strategies through demonstrations, rather than verbal instructions, affected the number of strategies used by the children; however, the number of strategies used did not affect persistence. An exploratory analysis was conducted to examine why the number of strategies was not related to persistence. We found that independently devising new strategies, rather than following instructions, affected persistence. Furthermore, this relationship

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was replicated in Study 3 (N = 30). Our findings suggest that children are likely to persevere in challenging tasks by independently devising new strategies rather than following instructions.

Introduction

People should strive to persist when faced with challenges. Persistence is the ability to persevere to accomplish goals, enabling people to overcome difficulties. Studies with various participants, from elementary school children to adults, have revealed that persistence is the key to achieving success in many settings, including school and the workplace (Duckworth & Quinn, 2009; Duckworth et al., 2009; Eskreis-Winkler et al., 2014; Fernández Martín et al., 2020; Southwick et al., 2019; Sturman & Zappala-Piemme, 2017; Suzuki et al., 2015; Tang et al., 2019). This also applies to younger children, from infants to preschoolers; persistence in challenging situations has been associated with their academic achievement and cognitive abilities (Banerjee & Tamis-LeMonda, 2007; Berhenke et al., 2011; Mokrova et al., 2013) as well as higher levels of social mastery with teachers and peers (Lunkenheimer & Wang, 2017). Therefore, many developmental researchers have recently focused on environmental factors to investigate ways to facilitate persistence in children (Leonard, Duckworth, et al., 2021).

Some studies have identified factors that influence children's persistence. For instance, both infants and preschoolers worked harder on difficult tasks after observing an adult's goal-directed behavior with positive results (Leonard et al., 2017, 2020; Lucca et al., 2020). Adult modeling has a strong impact on whether children decide to persist in tasks. Previous studies found that hearing a story of a character who experienced some struggles but made an effort encouraged 4- and 5-year-old children to persist in a challenging task (Haber et al., 2022, 2024). Conversely, adults taking over in a challenging task decreased 4- and 5-year-olds' persistence (Leonard, Martinez, et al., 2021). Other studies found positive correlations between parental praise, particularly process praise, and children's persistent behaviors in both experimental and day-to-day contexts (Leonard et al., 2022; Lucca et al., 2019; Radovanovic et al., 2023).

Research on engagement in parent–child interaction may provide valuable insights into the factors that enhance persistence in children. Engagement is defined as sustained involvement in a voluntary activity or willingness to continue participation despite uncertain success (Sobel, 2023). According to Skinner et al.'s (2009) theoretical framework, engagement encompasses behavioral, emotional, and cognitive dimensions, with persistence identified as a component of behavioral engagement. This is consistent with Fredricks et al.'s (2004) conceptualization of engagement in school-aged children, which also emphasizes its multidimensional nature. Furthermore, empirical studies support its construct validity, including persistence, via observations of young children's behaviors during tasks (Wang et al., 2017). Parenting style, a vital facet of parent–child interaction, influences engagement from early to middle childhood. For example, children show fewer challenges when their parents set goals for them using imperatives or step-by-step instructions (Sobel et al., 2021). In contrast, children are more engaged in a task when their parents allow them to set goals themselves or support them in doing so by offering hints and suggestions (Callanan et al., 2020; Medina & Sobel, 2020). Previous studies have focused on behavioral engagement, including the number of challenges children chose to attempt and the amount of time spent on tasks. Therefore, verbal instructions to guide children, rather than instructions on the goals themselves, are likely to be more effective in promoting children's persistence. Considering application to daily life, relatively simple methods warrant further exploration. Verbal instructions aimed at guiding children may be one of the most straightforward yet effective methods for promoting persistence. Therefore, this study first focused on the effect of verbal instructions on children's persistence. We focused on preschool children because they are likely to experience difficulties, such as concentrating in class, competing with peers, and taking exams, when they prepare for formal education.

Instructions on the use of strategies

We highlighted instructions on the use of strategies as guidance for children because using multiple strategies may promote persistence in preschoolers. Ishikawa et al. (2023) investigated individual differences related to 5-year-olds' persistence using an unachievable wooden box task that was also implemented in previous studies (Leonard et al., 2020; Leonard, Martinez et al., 2021). Some studies used a challenging but achievable persistence task to assess children's persistence (Mokrova et al., 2012, 2013; Redding et al., 1988). However, compared with achievable tasks, an unachievable persistence task can assess children's persistence in more difficult situations. Ishikawa et al. (2023) found that the more strategies children used to open the box during the persistence task, the longer they worked on the task. These findings may suggest that using several methods to achieve a goal affects the time children spend working on the task; using multiple strategies is likely to increase the number of attempts to open the box after failure. Lucca and Sommerville (2018) stated that knowing when to switch strategies is a factor of adaptive persistence. Using various strategies for difficult tasks may be critical to children's persistence. Thus, if adults instruct children to focus on several methods of overcoming difficulties, they may persist longer. Conversely, if adults instruct children to focus on only one strategy, they might not work as long. Bonawitz et al. (2011) found that children became fixated on one function and explored a toy less when they were told the specific function of the toy. Exploration may be a key behavior for tackling difficult situations given that children can learn causal relationships and uncover ambiguous information in the process of exploration (Legare, 2012; Schulz & Bonawitz, 2007). This may also be necessary to solve challenging problems that require persistence. Thus, instructions that limit children's exploration are likely to weaken their persistence.

How instructions are communicated to children should also be considered. In parent–child interactions, parents use questions in addition to direct instructions. Several types of questions are used in these interactions (Leech et al., 2023) and play a significant role in supporting children's cognitive and academic development. For example, wh-questions (e.g., why did you think so?) are positively related to vocabulary development (Cristofaro et al., 2012; Rowe et al., 2017), recollection of memories related to past experiences (Benjamin et al., 2010; Jant et al., 2014), persistence in problem-solving (Willard et al., 2019), and academic outcomes (Reynolds et al., 2019) in children. Whereas many studies have investigated the effects of wh-questions, we focused on pedagogical questions that emphasized the knowledge state of the questioner.

Pedagogical questions are asked by a person who knows the answer and intends to help the questionee learn. These questions, similar to wh-questions, are commonly used by parents during daily parent–child conversations (Yu et al., 2019) and enhance learning and memory in preschoolers (Daubert et al., 2020). The main characteristic of pedagogical questions is the knowledge state of the questioner. Typically, questions are asked to obtain information (e.g., information-seeking questions, such as when a parent who works in an office and does not receive any information about the child from a teacher asks the child, "What did you do at kindergarten today?"). Pedagogical questions differ from information-seeking questions in that they are asked by a person who already knows the answer, which enables children to reason regarding the instructor's educational intent (Yu et al., 2018). For instance, when a person who knows how a toy works asks a child who is seeing it for the first time, "What happens if you push this button?", it is regarded as a pedagogical question. Yu et al. (2018) found that pedagogical questions encouraged 4- to 6-year-olds to play longer with a novel toy and to discover its non-target functions. Children are likely to reason why informants selected a pedagogical manner rather than a direct manner and to use that inference to guide their exploration (Yu et al., 2018). Thus, pedagogical questions may contribute to children's persistence when they can understand the instructor's educational intent because exploration may affect persistence.

Study 1

In Study 1, we investigated whether instructions on strategies affected children's persistence; we instructed children to focus on multiple strategies or a single strategy in a direct or pedagogical manner. First, we hypothesized that children instructed to focus on several strategies during the

persistence task (multiple strategies [MS] condition) would persist longer than those instructed to focus on a single strategy, namely, shaking (single strategy [SS] condition). Second, we hypothesized that children instructed to use several strategies in a pedagogical manner (multiple strategies–pedagogy [MSP] condition) and those instructed to use one strategy in a pedagogical manner (single strategy–pedagogy [SSP] condition) would persist longer than those instructed without pedagogical questions (MS and SS conditions). As another possibility, we hypothesized that an interaction would exist between instructions on strategy and pedagogical questions; that is, children in the MSP condition would persist the longest, owing to inferring the intent of the pedagogical method, and would use a greater variety of strategies. Thus, this study investigated the effect of the instructions on strategies, pedagogical questions, and their overall interaction. If the main effects or interaction were detected, we compared each condition (i.e., the MS, MSP, SS, and SSP conditions) with the baseline, wherein children were not provided specific instructions on strategies or instructed in a pedagogical manner.

Method

Participants

This study included 150 4- and 5-year-olds (85 boys and 65 girls; mean age = 58.53 months, *SD* = 3.47, range = 52–66) from day-care centers, nursery schools, and kindergartens in Osaka, Japan. Written informed consent was obtained from the parents. Four children were excluded from the analysis: two children who were not able to meet the criteria of learning the bell (see below), one child who refused to work on the task, and one child who cried during the task. The children were randomly assigned to one of five conditions: MS, SS, MSP, SSP, or baseline. Children's ages and sexes were balanced across conditions. Each condition involved preschoolers from different kindergartens given that the data were collected from multiple facilities. Based on previous studies, a power analysis indicated that each condition required at least 30 children to detect large differences in the planned condition contrast Wilcoxon rank-sum tests (d = .75, power = .80; Doan et al., 2020; Leonard et al., 2020). The experiment was approved by Osaka University (approval number HB022-016-03).

Procedure

The procedure and analysis plan of Study 1 were preregistered (https://osf.io/krfep). This experiment was conducted individually in a room in each facility by one female experimenter. This study comprised three phases: learning how to use the "all done playing" bell, instructions, and persistence task. The procedure of the first and third phases followed that of previous studies (Ishikawa et al., 2023; Leonard et al., 2020). During the experiment, children's performances were recorded with a hidden video camera.

Learning how to use the "all done playing" bell. We used a stuffed toy and bell in this phase. First, the experimenter showed the children how to play with the stuffed animal. Thereafter, the experimenter rang the bell while saying "I am all done playing" to communicate that they should ring the bell when they had finished playing. Second, the children were asked to play with the stuffed animal and ring the bell when they had finished playing. If the children did not ring the bell after playing, the experimenter explained the rules once again. If the children did not ring the bell after the rules were explained three times, the experiment was stopped (exclusion criteria).

Instructions. The experimenter provided instructions while showing a 15 × 7.5 × 4.5-cm wooden box to the children. First, the experimenter told the children that the experimenter needed to leave the room to do something. Depending on the conditions, the following instructions provided by the experimenter differed. In the baseline, while simultaneously shaking the box, the experimenter asked the children, "Do you hear these sounds? There may be something inside. You can try to take it out!" Subsequently, the experimenter handed the box to the children and left the room. In other conditions, the experimenter provided an instruction to open the box following the sentence used in the baseline condition. In the MS condition, the experimenter stated, "To take it out, you can play with the box in several ways." In the SS condition, the experimenter told the children, "To take it out, you can shake the box." These instructions were used to manipulate the number of strategies (i.e., focusing on multiple/

single strategies) to open the box during the persistence task. In the MSP and SSP conditions, children were instructed on each statement in a pedagogical manner (Yu et al., 2018). The experimenter stated, "What happens if you play with the box in several ways to take out what is inside?" (MSP) and "What happens if you shake the box to take out what is inside?" (SSP).

Persistence task. We used two wooden boxes (one that could be opened and one that could not) and a bell during the persistence task. In this task, we examined whether the children worked hard to open the box. The experiment was considered complete when 4 min passed or the children rang the bell. The time when the children were neither touching nor looking at the box was excluded from the overall duration given that they were likely to have thoughts irrelevant to the target task. Subsequently, the experimenter returned to the room and said, "Oh, I am sorry. I gave you the wrong box that does not open." Finally, to avoid ending the task with a failed experience, the experimenter and children together opened another box that could be opened.

Measured variables

We used the duration of time the children spent working on the task and excluded the time performed on off-task behaviors as an indicator of their persistence. The maximum time for persistence was 240 s. The number of strategies used to open the box during the persistence task was counted. For instance, when children used two strategies, such as shaking and pulling the box to try opening it, the number of strategies was two. Based on a previous study (Ishikawa et al., 2023), we defined strategies as all behaviors that children performed during the persistence task to attempt to open the box. This measure was used to examine children's strategies during the task and to confirm the effect of each instruction. We also measured children's detailed behaviors during the persistence task (i.e., the frequency and percentage of time spent using each strategy). Detailed information of the strategies is presented in the online Supplementary Materials-1. Coding (persistence and the number of strategies) was performed by two coders. The primary coder and secondary coder coded all the data and 25% of the data (N = 38), respectively. Reliability of all the variables was high (persistence: intraclass correlation coefficient [ICC] = .998; number of strategies: ICC = .88).

Analysis

To investigate the effect of the instructions on strategies and pedagogical questions on persistence, we conducted analyses using R Studio (Version 4.0.3). We followed the analysis approach of a previous study (Leonard et al., 2020), which was preregistered (https://osf.io/krfep). Because persistence and the number of strategies were not normally distributed (Shapiro–Wilk $p < .05$), these data were transformed using a natural log. First, a multiple regression analysis was performed to examine the effects of the instructions on strategies (i.e., multiple strategies or single strategy), pedagogical questions (i.e., direct or pedagogical manner), and their interaction on children's persistence. Thereafter, planned follow-up comparisons for specific conditions using nonparametric analysis (Wilcoxon rank-sum test) were conducted if a significant effect was observed. To investigate the significant effect of factors on persistence, each condition was compared with baseline. In addition, the number of strategies was analyzed using the same method as that for persistence to confirm whether the children used many or few strategies based on the instructions.

Results

Persistence

Table 1 presents the medians, means, and standard deviations of persistence across all the conditions. To explore whether the instructions on strategies (multiple/single) and pedagogical questions (direct/pedagogical manner) affected children's persistence, we conducted a multiple regression analysis on persistence, including instructions on strategies, pedagogical questions, and their interaction as the independent variables (model $R^2_{adj} = .01$, $f^2 = 0.04$). No significant effects were observed regarding instructions on strategies, $F(1, 116) = 3.77$, $p = .054$, $B = 0.26$, $SE = 0.30$, pedagogical questions, $F(1, 116) = 0.28$, $p = .60$, $B = -0.26$, $SE = 0.30$, and their interaction $F(1, 116) = 0.52$, $p = .47$, $B = 0.30$,

Table 1
Medians, means, and standard deviations of persistence and the number of strategies: Study 1.

	MS	MSP	SS	SSP	Baseline
Persistence (s)					
Median	81.5	75.5	50.0	60.5	80.0
Mean	111.33	110.57	86.63	78.00	104.23
SD	92.59	82.04	80.93	76.63	82.86
Number of strategies					
Median	3	4	3	3	4
Mean	3.80	4.13	3.10	2.83	3.90
SD	1.45	1.63	1.18	1.21	1.37

Note. MS, multiple strategies; MSP, multiple strategies–pedagogy; SS, single strategy; SSP, single strategy–pedagogy.

SE = 0.42. The effect of instructions on strategies on persistence was marginally significant. These result trends were observed via the Kruskal–Wallis test (see Supplementary Materials-2).

Number of strategies used by children

We identified 11 types of strategies. Table 1 shows the medians, means, and standard deviations of the number of strategies across all the conditions. To examine whether the number of strategies used by the children differed based on the instructions on strategies and pedagogical questions, we performed a multiple regression analysis on the number of strategies, including the instructions on strategies, pedagogical questions, and their interaction as the independent variables (model R^2_{adj} = .11, f^2 = 0.15). Regression analysis revealed a significant effect of instructions on strategies on the number of strategies used by the children, $F(1, 116) = 15.76$, $p < .001$, $B = 0.23$, $SE = 0.11$; however, no significant effect was observed for pedagogical questions, $F(1, 116) = 0.05$, $p = .83$, $B = -0.10$, $SE = 0.11$, or their interaction, $F(1, 116) = 1.18$, $p = .28$, $B = 0.17$, $SE = 0.16$). Subsequently, we performed planned comparisons between each condition and baseline. No significant differences were observed in the number of strategies used by children between MS and baseline ($w = 416$, $p = .61$, $r = .07$) or between MSP and baseline ($w = 410.5$, $p = .54$, $r = .08$). However, the children in the SS condition ($w = 313.5$, $p = .04$, $r = .27$) and SSP condition ($w = 252$, $p = .002$, $r = .40$) used fewer number of strategies than those in the baseline condition. Children instructed to focus on a single strategy were likely to follow this strategy and use fewer strategies during the persistence task.

Discussion

The results of Study 1 indicate that instructing preschoolers on strategies in a direct or pedagogical manner did not affect children's persistence. This could be because we failed to increase the number of strategies used by children in the MS and MSP conditions. This may explain why we did not observe an increase in their persistence in these conditions. Moreover, the use of strategies might not have affected children's persistence. When children were instructed to use a single strategy, they followed it; however, their persistence did not decrease. Merely telling the number of strategies through verbal instructions may be inadequate to affect children's persistence.

Furthermore, although the instructions did not increase the number of strategies, instructing on only one strategy decreased the number of strategies children used. This result was consistent with the findings of Bonawitz et al. (2011), who revealed that telling children a specific function of a toy led them to follow this function. Therefore, telling children only one strategy is likely to limit their behavior in the persistence task. However, when children were told to use multiple strategies (e.g., "you can play with the box in several ways"), they were unable to use many strategies to open the box; unlike those who were instructed on a specific strategy (i.e., shaking), they were not provided with any concrete strategies. The persistence task we used was a simple wooden box, which made it difficult to consider many strategies on their own without concrete clues. Instructions on multiple strategies may have possibly not emphasized the importance of using any strategies at all. There were no significant differences in the number of strategies used by the children in the MS and MSP conditions compared with baseline where no specific strategies were provided. Abstract instructions

in the MS and MSP conditions were inadequate for preschoolers to use multiple strategies. In contrast, instructions in the SS and SSP conditions were concrete, and children could easily use a specific strategy. Owing to the lack of detail in the instructions for the MS and MSP conditions, we observed only the effect of telling a single strategy on the number of strategies used by children during the persistence task.

Moreover, we did not identify a significant effect of pedagogical questions on children's persistence and number of strategies. This may suggest that pedagogical questions did not affect children's persistence in challenging tasks. Yu et al. (2018) used an exploratory task with several buttons and spinners and found that pedagogical questions improved exploratory behaviors in preschoolers. In their task, the children were able to obtain feedback from an exploratory task (e.g., the children pressed a button and it glowed). Consequently, they could understand the instructor's pedagogical intent (e.g., this toy has some functions, and the instructor wanted the children to find them). However, in the persistence task in the current study, the children heard sounds when shaking but did not receive any other responses. This may have hindered their understanding of the instructor's teaching methods (i.e., pedagogical questions). Differences in whether children could infer the instructor's intent, caused by the task structure, may explain why pedagogical questions did not affect children's behaviors in the persistence task. A concern with Study 1 is that the pedagogical conditions were not compared with other types of questions despite the possibility that pedagogical questions resemble wh-questions. Thus, whether the pedagogical nature of the questions failed to promote persistence in preschoolers or whether the act of asking questions itself was ineffective remained unclear.

Taken together, instructions on using a single strategy influenced children's use of strategies in the persistence task. However, the MS and MSP conditions did not increase the number of strategies used compared with baseline. Instructors should consider manipulations that increase the number of strategies to improve children's persistence. Thus, we conducted Study 2, where explicit hints were provided to help children use many strategies. We presented concrete actions rather than abstract expressions. In addition, we used demonstrations rather than verbal instructions to convey concrete examples, which has previously been shown to be effective (Sumers et al., 2023).

Study 2

In Study 2, the experimenter demonstrated how to use either multiple strategies (shaking, pulling, and spinning the box) or a single strategy (shaking, pulling, or spinning the box). This study did not use the baseline and pedagogical question conditions to focus on the effects of demonstrating the strategies. We hypothesized that children in the demonstrating multiple strategies (DMS) condition would persist at the task longer than those in the demonstrating a single strategy (DSS) condition. In addition, we hypothesized that children in the DMS condition would use more strategies than those in the DSS condition.

Method

Participants

Study 2 included 54 4- and 5-year-olds (27 boys and 27 girls; mean age = 63.30 months, *SD* = 7.18, range = 51–74) from a kindergarten in Osaka, Japan. Written informed consent was obtained from the parents. Three children were excluded from the analysis: one child who could not meet the criteria of learning the bell and two children owing to an experimental error. The children were randomly assigned to the DMS or DSS condition. Children's ages and sexes were balanced across the conditions. Although we attempted to recruit 30 children per condition as in Study 1, we were unable to do so due to the COVID-19 pandemic. Therefore, the final sample size was 27 per condition. The experiment was approved by Osaka University (approval number HB023-025).

Procedure

Study 2 was not preregistered because we designed the experimental procedures based on the results of Study 1. The experiment followed the same procedures as Study 1 except for the following points. After the children learned the "all done playing" bell, the experimenter showed them how to

use multiple strategies or a single strategy using the wooden box. In the DMS condition, the experimenter demonstrated three strategies: shaking, pulling, and spinning the box. At this point, the experimenter asked the children "What am I doing?" to help them understand how to use the strategies demonstrated. If the children did not respond, the experimenter explained the strategies (e.g., "this is shaking"). The order of the three strategies was counterbalanced. After demonstrating the strategies, the experimenter emphasized the importance of using multiple strategies and asked the children what they should do to open the box to help them fully understand the instructions. If the children did not answer this question, the experimenter stressed the importance of using multiple strategies again. Subsequently, the children were instructed to use the same procedure as in the MS condition in Study 1 and were handed the box. In the DSS condition, children were shown how to use one strategy (shaking, pulling, or spinning the box) three times. After the experimenter emphasized the importance of using a specific strategy and asked a confirming question, the experimenter instructed the children to use the same procedure as in the SS condition in Study 1. Subsequently, the experimenter asked the children what they should do during the persistence task to confirm whether they remembered the instructions. Most children passed this question in Study 2, which indicated that they understood the instructions. We excluded three children who failed this question, which did not change the results of Study 2 (see Supplementary Materials-3).

Coding and analysis

Measured variables were coded using the same methods as in Study 1. Reliability of all the variables was high ($N = 14$; persistence: ICC = .99; number of strategies: ICC = .88). The measured variables (persistence and number of strategies) were not normally distributed (Shapiro–Wilk $p < .05$); therefore, we performed a Wilcoxon rank-sum test to examine whether demonstrating the use of multiple or single strategies affected children's persistence.

Results

Persistence and the number of strategies used by the children

We identified 13 types of strategies (see Supplementary Materials-4). Table 2 presents the medians, means, and standard deviations of persistence and the number of strategies in the DMS and DSS conditions. We did not identify significant differences in children's persistence between the conditions ($w = 272$, $p = .11$, $r = .22$). However, children in the DMS condition used more strategies than those in the DSS condition ($w = 68.5$, $p < .001$, $r = .78$), which suggested that demonstrations of multiple strategies increased the number of strategies used but did not affect persistence.

Exploratory analysis

Although Ishikawa et al. (2023) found a relationship between the number of strategies and persistence in preschoolers, they did not provide any instructions to the children regarding the specific strategies. This study differed from Ishikawa et al.'s study regarding whether the children followed the experimenter in using strategies or independently devised strategies. Following instructions may decrease children's sense of autonomy, a key factor in engagement (Sobel, 2023). Leonard, Martinez, et al. (2021) found that when adults took over a difficult puzzle, children gave up quickly on subsequent challenging tasks. This finding suggested that the loss of autonomy owing to adult interactions reduced children's persistence, a component of engagement. In this study, unlike in

Table 2
Medians, means, and standard deviations of persistence and the number of strategies: Study 2.

	Persistence (s)		Number of strategies	
	DMS	DSS	DMS	DSS
Median	99	73	5	3
Mean	127.07	99.07	5.59	3.04
SD	83.21	83.75	1.67	1.13

Note. DMS, demonstrating multiple strategies; DSS, demonstrating a single strategy.

Ishikawa et al. (2023), children were instructed to use single or multiple strategies, and the use of these instructed strategies may have diminished their sense of autonomy. Therefore, we used an exploratory analysis to explore the effect of self-generated strategies, which were likely to reflect a higher sense of autonomy, rather than those taught by the experimenter. We counted the number of self-generated strategies used by the children. For example, if the children in the DMS condition used four strategies (e.g., shaking, spinning, pulling, and clapping the box), they received 1 point for the self-generated strategy (i.e., clapping). If the children in the DSS condition were instructed to shake the box and they used three strategies (e.g., shaking, spinning, and pulling the box), they received 2 points for the self-generated strategies (i.e., spinning and pulling).

The number of self-generated strategies in the DMS condition ranged from 1 to 6 ($median_{DMS}$ = 3.0, $mean_{DMS}$ = 3.19, SD_{DMS} = 1.36), and that in the DSS condition ranged from 0 to 4 ($median_{DSS}$ = 2.0, $mean_{DSS}$ = 2.04, SD_{DSS} = 1.13). To examine the importance of the number of self-generated strategies, we conducted a multiple regression analysis on persistence, including the number of self-generated strategies, condition (DMS or DSS), and their interaction as the independent variables. Persistence was transformed using a natural log, and the number of self-generated strategies was standardized (model R^2_{adj} = .40, f^2 = 0.78). We identified significant effects of the number of self-generated strategies, $F(1, 50) = 28.21$, $p < .001$, $B = 0.38$, $SE = 0.15$, and an interaction between the number of self-generated strategies and condition, $F(1, 50) = 6.07$, $p = .02$; $B = 0.58$, $SE = 0.24$; however, no significant effect of condition was detected, $F(1, 50) = 0.10$, $p = .75$, $B = 0.12$, $SE = 0.23$ (Fig. 1). To further examine the interaction, we conducted simple slope analyses for the regression of the number of self-generated strategies on persistence. Regarding the contrast between the mean number of self-generated strategies ± 1 *SD,* children who used four self-generated strategies (+1 *SD*) showed greater persistence than those who used one self-generated strategy (−1 *SD*) in both the DMS condition (*estimate* = 0.76, *SE* = 0.30, $p = .04$) and the DSS condition (*estimate* = 1.92, *SE* = 0.36, $p < .001$). We did not observe significant differences between the conditions at four or one self-generated strategies, although children in the DSS condition demonstrated marginally longer persistence than those in the DMS condition with four self-generated strategies (*estimate* = 0.70, *SE* = 0.34, $p = .09$). These result trends were observed using nonparametric analyses (see Supplementary Materials-5). Thus, the exploratory analyses revealed that children who used more self-generated strategies were more likely to persist in the task regardless of the conditions.

To confirm the robustness of this exploratory analysis, we examined associations between self-generated strategies and children's persistence in the SS condition in Study 1 using a setting relatively similar to Study 2. The number of self-generated strategies in the SS condition ranged from 0 to 5 (median = 2.00, mean = 2.10, *SD* = 1.18). We conducted a regression analysis on persistence, including the number of self-generated strategies as the independent variable (model R^2_{adj} = .46, f^2 = 0.93). The results revealed a significant effect of the number of self-generated strategies, $F(1, 28) = 26.06$, $p < .001$, $B = 0.73$, $SE = 0.14$. This finding indicated that the number of self-generated strategies predicted children's persistence.

Discussion

The findings of Study 2 indicated that demonstrating various strategies did not increase the time spent on the task; however, the number of strategies used during the persistence task increased. The demonstration was effective in telling children how to try the task. Exploratory analysis showed that the more self-generated strategies they used, the longer the children worked on the task regardless of the conditions. This suggested that independently generating strategies, rather than the number of strategies, affected children's persistence. This trend was also observed in the SS condition in Study 1. Thus, devising new strategies affected children's persistence; however, this result was based on the exploratory analysis. Study 3 evaluated the robustness of this trend.

Study 3

In Study 3, we conducted the same experiment as the DSS condition to investigate whether the results of Study 2 could be replicated. We selected the DSS condition for two reasons. First, the

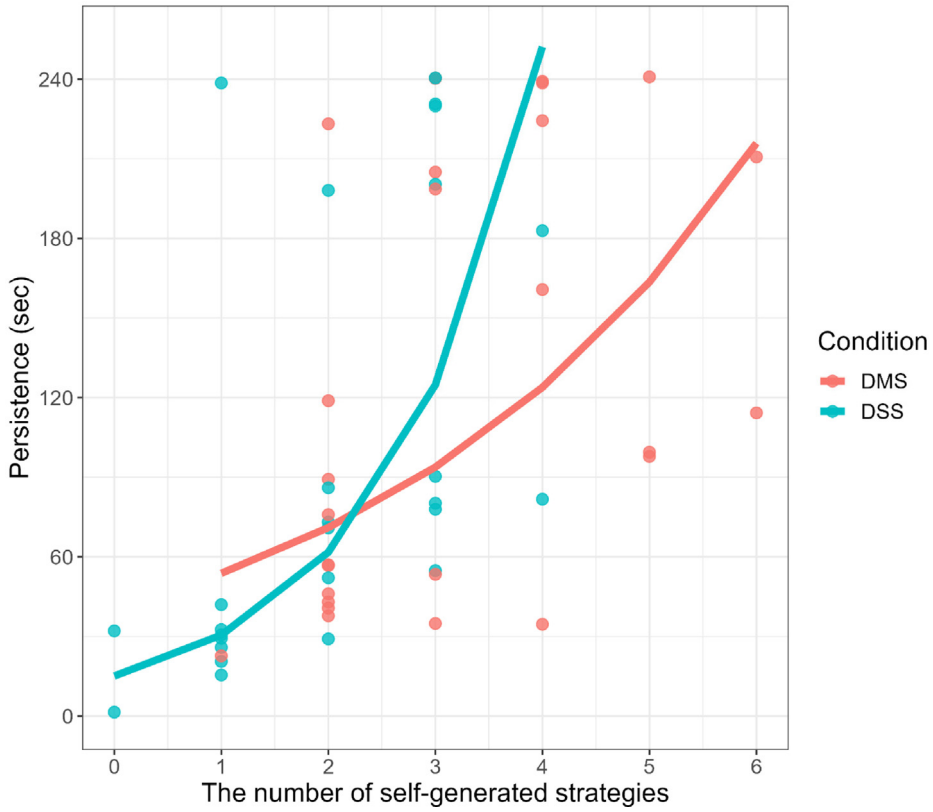

Fig. 1. The effect of the number of self-generated strategies and conditions on persistence. The high (or low) value of the standardized number of self-generated strategies was defined as + 1 *SD* (or − 1 *SD*) about the mean. The lines indicate predicted values from the model fitting. The dots indicate raw data. DMS, demonstrating multiple strategies; DSS, demonstrating a single strategy.

DMS condition provided less room to generate new strategies than the DSS condition given that the former (i.e., instructions on using three strategies) presented two more strategies than the latter (i.e., instructions on using one strategy). Second, the manipulation of the DSS condition may have been more effective for children's persistence than the DMS condition, in which children independently devised new strategies, given that we detected marginal significance in the pairwise comparison.

Method

Participants and procedure

This study included 30 4- and 5-year-olds (15 boys and 15 girls; mean age = 59.60 months, *SD* = 6.30, range = 50–71) from a kindergarten in Osaka, Japan. Written informed consent was obtained from the parents. We excluded one child who did not attempt the task without the teacher. The experiment was approved by Osaka University (approval number HB024-006). Study 3 was not preregistered, and the procedure was identical to the DSS condition in Study 2. All children passed the manipulation check on the instructions to use a single strategy.

Coding and analysis

Coding of measured variables was conducted using the same procedure as in Studies 1 and 2. Reliability of all the variables was high (*N* = 8; persistence: ICC = 1.00; number of strategies: ICC = .81).

Study 3 had only one condition, and we performed a regression analysis on persistence, including the number of self-generated strategies as the independent variable. Persistence was transformed using a natural log, and the number of self-generated strategies was standardized.

Results and discussion

Persistence (median = 48.47, mean = 78.59, *SD* = 64.44) and the number of self-generated strategies (median = 2.0, mean = 2.07, *SD* = 1.51) exhibited similar trends as in the DSS condition of Study 2. We identified 12 types of strategies (see Supplementary Materials-6). We performed a regression analysis on persistence, including the number of self-generated strategies as the independent variable (model $R^2_{adj} = .56, f^2 = 1.33$). We detected a significant main effect of the number of self-generated strategies, $F(1, 28) = 37.28$, $p < .001$, $B = 0.66$, $SE = 0.11$ (Fig. 2). This result replicated that of the exploratory analysis in Study 2, which indicated that children who devised new strategies persisted longer in the task.

General discussion

Across three studies, we investigated the effect of providing verbal instructions (direct and pedagogical manner) and demonstrations on preschoolers' persistence. In Study 1, instructions on strategies did not contribute to children's persistence. When children were told to use one strategy, they followed it; however, when they were told to use multiple strategies, the number of strategies used was baseline. Moreover, pedagogical questions did not affect children's persistence and the

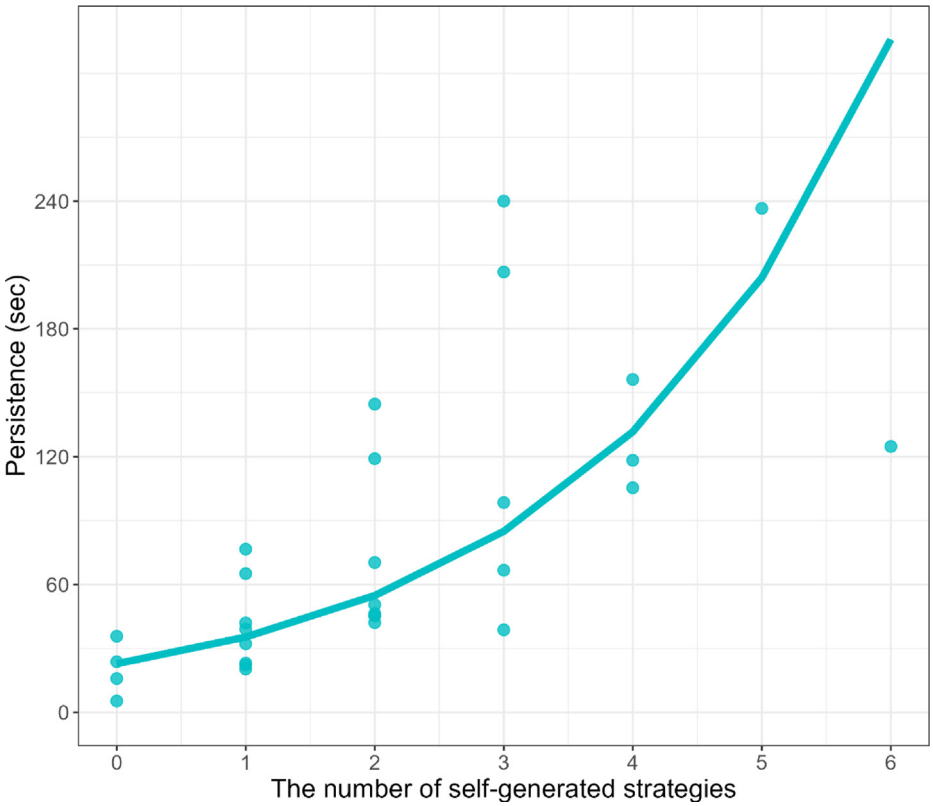

Fig. 2. The effect of the number of self-generated strategies on persistence. The line indicates predicted values from the model fitting. The dots indicate raw data.

number of strategies. These findings may indicate that verbal instructions were not powerful enough to enable children to focus on multiple strategies and increase persistence despite acknowledging the limitations that the instructions aimed at focusing on multiple strategies did not include any examples of strategies. To effectively influence strategy use (multiple or single) as a prerequisite to increasing persistence, we presented concrete strategies in Study 2. Furthermore, we used demonstrations rather than verbal instructions to provide examples. This affected the number of strategies the children used but did not affect their persistence. The exploratory analysis demonstrated that independently devising new strategies affected persistence. This trend was replicated in Study 3; children who independently devised more new strategies worked on the task longer when instructed of only one strategy. This suggested that children persevered at the task if they did not follow instructions that limited their behaviors.

The persistence task was challenging, and the children did not know how to solve it. Thus, some children could not generate new strategies and chose to follow the experimenter's instructions. This may have led to boredom and demotivation given that they were not willingly attempting the task. Some children generated new strategies themselves and used various strategies to open the box. These children may have enjoyed working on the task given that this challenging process involved deciding actions toward a goal. Hence, children's perceived sense of autonomy adjusted their motivation, which may have affected their persistence. This mechanism is supported by the self-determination theory, which identifies the need for autonomy as a psychological requirement (Ryan & Deci, 2000, 2020). Sobel (2023) proposed that a sense of autonomy is one of the key factors for children's engagement, which encompasses persistence as a behavioral component. Adult involvement that undermines this sense of autonomy, such as adults troubleshooting or taking over tasks instead of allowing children to do them, decreases children's persistence in challenging tasks (Leonard, Martinez, et al., 2021; Willard et al., 2019). Children who used many self-generated strategies may have been motivated to attempt the task because the sense of autonomy increased their intrinsic motivation, which affected their persistence (Fishbach & Woolley, 2022). Although we cannot exclude the possibility that the number of self-generated strategies may simply relate to children's knowledge, it is unlikely that their knowledge alone influences strategy generation and persistence, especially considering that the task is novel to them and no strategies lead to successfully opening the box. Instead, the sense of autonomy during the task is likely to explain our results that the number of self-generated strategies predicts persistence in children.

Why was children's autonomy enhanced during the persistence task in this study? In cases where children generated multiple new strategies, those who observed a single strategy persisted longer than those who observed multiple strategies; however, this result was marginal. This finding suggests that providing too many hints may have limited the children's ability to independently devise strategies (i.e., autonomy), thereby decreasing their persistence. Consistent with this result, previous studies found that a parenting approach that affected children's autonomy, such as minimizing the use of parental control and offering choices, was associated with children's increased persistence (Froiland, 2015; Su-Russell & Russell, 2021; Viljaranta et al., 2018) and behavioral aspects of engagement in children (Callanan et al., 2020; Medina & Sobel, 2020; Sobel et al., 2021). Autonomy-supportive parenting includes providing help when children need it (Grolnick et al., 2002; Whipple et al., 2011) and differs from merely promoting independence without support (Joussemet et al., 2008). These findings underscore the necessity of adult support in fostering children's persistence as long as it is moderate and does not undermine their sense of autonomy. In the persistence task, children were instructed on either a single strategy or multiple strategies as hints to open the box. However, they were unable to open it due to a hidden lock and realized that the provided strategies were ineffective. Thus, they were required to generate new strategies to persist in the task. When children were shown three strategies, they found it difficult to generate new ones given that the easily generated strategies (i.e., shaking, pulling, and spinning the box) had already been presented. Due to the difficulties in generating additional new strategies, they may have felt incapable of doing so independently. In contrast, when children were shown only one strategy, there was more room for them to think of more strategies. They found it easy to use self-generated strategies and believed that they could do more independently, which may have facilitated a greater sense of autonomy. In sum, providing

relatively fewer hints fosters children's autonomy, which in turn may enhance their persistence in challenging tasks, even though the task structure may affect this mechanism.

This study has three limitations. First, our results may have been affected by the task structure, which was impossible to complete. We used a wooden box task (Leonard et al., 2020) to measure children's persistence because it was more challenging than achievable persistence tasks (Chang & Olson, 2016; Mokrova et al., 2013; Torgrimson et al., 2021). We were likely able to capture children's persistence in appropriate situations. However, some children persisted less after trying several strategies when they realized that their causal nature was irrelevant to opening the box. Instead of demonstrating less persistence, these children may have been acting rationally. This may explain the result in Study 2, where children shown three strategies and who used more strategies did not work on the task longer than those shown only one strategy. Other children persisted by primarily using the instructed strategies because they believed they should continue following the instructions until the box opened. This may reflect compliance rather than persistence, with only a limited number of children exhibiting this behavior. The persistence task used here cannot definitively determine the possibilities that were applicable. However, our results significantly indicated that children who generated new strategies, rather than acting rationally or following instructions, exhibited greater persistence.

Second, whether children's abilities affected their strategy development in the persistence task remains unclear. Cognitive flexibility—an executive function—enables children to switch rules between tasks (Doebel & Zelazo, 2015). Ishikawa et al. (2023) revealed that children with high cognitive flexibility used multiple strategies, which contributed to greater persistence. Previous studies reported that cognitive flexibility was related to creativity in children (Arán Filippetti & Krumm, 2020; Krumm et al., 2018). Creativity can lead to idea generation (Alves-Oliveira et al., 2022); thus, cognitive flexibility may be required to switch from strategies presented by the experimenter to new strategies. Furthermore, creativity may be required to devise new strategies. Further studies should investigate individual differences in children's ability to deviate from instructions and generate new strategies.

Third, the experimental design may pose a limitation. We chose a between-participants design to account for the potential distress children might experience from attempting the task twice as well as to align with previous studies that investigated children's persistence in challenging tasks (e.g., Jeon & Park, 2024; Leonard et al., 2020). However, given the significant individual differences in persistence, a within-participants design might have been more suitable to measure persistence across the various conditions.

Our findings suggest that children must independently generate new strategies for challenging situations rather than relying on adults to provide instructions and demonstrations. Adults often provide children with instructions in daily life, such as how to play with toys, draw pictures, and play musical instruments. Although this is well-intentioned, excessive guidance may limit children's autonomy and harm their persistence. Future studies should examine the importance of spontaneous strategies in children's persistence; however, our findings provide new insights into factors associated with children's persistence in challenging tasks.

CRediT authorship contribution statement

Moeko Ishikawa: Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yasuhiro Kanakogi:** Writing – review & editing, Methodology, Funding acquisition, Supervision, Conceptualization.

Data availability

All data are available on the Open Science Framework (https://osf.io/2pa7s/). Data were analyzed using R Studio (Version 4.3.0). The design and analysis of Study 1 were preregistered (https://osf.io/krfep). The design and analysis of Studies 2 and 3 were not preregistered.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2024.106170.

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