Relationship between Executive Function and Persistence in 5-year-olds

Abstract

Children's persistence can predict later academic achievement. However, few studies have examined the factors related to individual differences in persistence. In this study, we investigated the relationship between executive function (EF) and persistence in 5-year-olds (N = 72). The scores of the Dimensional Change Card Sort (DCCS) task and gift delay task were positively associated with persistence. We conducted a mediation analysis to examine the cognitive mechanisms underlying the associations between EF and persistence. This analysis revealed that children with high scores on the DCCS task, used multiple strategies for the persistence task, and this contributed to their persistence. We also found that children with high scores on the gift delay task concentrated on the task without getting distracted, and this approach contributed to their persistence. Thus, our findings reveal the factors related to individual differences in persistence and cognitive mechanisms underlying these associations between EF and persistence.

Keywords: Executive function; persistence; individual differences; preschooler

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To accomplish something, we are required to make an effort, and exerting effort is regarded as one of the important factors in human life. Effort has been studied from various perspectives—namely, resilience (Yeager & Dweck, 2012), self-control (Mischel et al., 1989), and persistence (Leonard et al., 2017). *Persistence*, the ability to persist in facing challenges, is characterized by withstanding the urge to quit, maintaining effort, and repeatedly resuming effortful behavior after it has been interrupted (Brandstätter & Bernecker, 2022). Recently, persistence has gained attention from researchers, parents, and educators. This is because persistence is key to achieving success in several fields, such as school, the workplace, and personal relationships, beyond IQ (Duckworth & Quinn, 2009; Eskreis-Winkler et al., 2014). In young children, persistence predicts later academic achievement, cognitive outcomes, and learning-related behavior (Berhenke et al., 2011; Mokrova et al., 2013), as well as higher levels of social mastery with teachers and peers (Lunkenheimer & Wang, 2017).

Recently, studies have investigated the factors that can foster persistence in young children. For example, infants' persistence is influenced by adults' actions and words: When infants see an adult trying very hard to achieve a goal, they tend to tackle a task more persistently (Leonard et al., 2017; Lucca et al., 2020). Infants whose parents often use language about persistence, hard work, and effort are more persistent than infants whose parents do not (Lucca et al., 2019). Moreover, parents' use of praise rather than instruction was shown to positively affect 3-year-olds' persistence in daily life, which was measured by toothbrushing (Leonard et al., 2022). In a task that involved opening a secretly impossible-to-open box, young children's observation of the outcomes (success or failure) of adults' actions had the greatest impact on children's persistence; 4- to 5-year-olds tried harder to open the box when they saw adults succeeding rather than failing at the task (Leonard et al., 2020). In addition, 4- to 5-year-olds persisted less on a subsequent persistence task when adults took over and completed the difficult puzzle for them (Leonard et al., 2021). This means that adults taking over teaches children that tasks are difficult and that they are unlikely to succeed by themselves, or that when the tasks are hard, adults will help them. Although some studies have examined how others (e.g., parents and adults) influence children's persistence, there is insufficient research examining children's characteristics, such as Executive Function (EF), that may explain individual differences in persistence. Examining the abilities that are likely to be associated with preschoolers' persistence can inform ways to help children improve their persistence.

Children's Executive Function

EF is essential when considering children's development since it is related to several aspects of optimal life functioning, such as mental and physical health, school and job success, and public safety (Diamond, 2013). EF refers to the goal-oriented control of thoughts, actions, and emotions (Diamond, 2013; Garon et al., 2008). Definitions of EF vary among researchers; however, some propose that its components include "cool" (cognitive) and "hot" (emotional) aspects (Moriguchi, 2021; Zelazo & Carlson, 2012). Cool EF, which has long been investigated, is considered the more traditional EF construct. It consists of "working memory, inhibition, and cognitive flexibility" (Miyake et al., 2000; Wiebe et al., 2011). Although there are numerous assessments of cool EF, the Dimensional Change Card Sort (DCCS) task and Day/Night Stroop task are often used to evaluate cool EF in preschoolers (Kamza et al., 2016; Moriguchi, 2021). In contrast, hot EF is activated in more affective contexts and is typically assessed using the delay of gratification task and gift delay task (Moriguchi, 2021; O'Toole et al., 2020). Although both cool and hot EF develop dramatically in early childhood (Zelazo & Carlson, 2012), some differences exist between them. For example, using functional near-infrared spectroscopy, Moriguchi (2021) showed that prefrontal activities during a cool EF task were not correlated with those during a hot EF task. In addition, the effects of cool EF on children's academic success differ from those of hot EF. Previous studies suggest that cool EF (i.e., working memory, inhibition, and cognitive flexibility) is associated with academic skills such as numeracy, language, and reading performance (Blair & Razza, 2007; O'Toole et al., 2020; Peng & Kievit, 2020; Spiegel et al., 2021) and predicts later academic achievement (Brock et al., 2009; Pascual et al., 2019). In contrast to the findings on cool EF, those regarding the relationship between hot EF and academic achievement have been inconclusive. Some studies suggest that hot EF predicts later academic competence (Shoda et al., 1990), whereas others indicate that it is not directly associated with academic achievement (Brock et al., 2009; O'Toole et al., 2020).

Persistence and Executive Function

Some evidence implies that children's EF is related to their persistence. Although results regarding the association between hot EF and academic success are inconsistent, cool EF is likely to relate to academic achievement according to meta-analyses (Pascual et al., 2019; Spiegel et al., 2021). Likewise, persistence in children is associated with academic performance (Berhenke et al., 2011; Eskreis-Winkler et al., 2014; Mokrova et al., 2013). Cool EF and persistence are likely to have common factors related to academic skills; therefore, cool EF may be associated with persistence. However, both cool and hot EF may be required to deal with tasks persistently because persistent behavior has both cognitive and emotional aspects. For example, it is sometimes necessary to change strategies and approaches, as well as inhibit inappropriate actions, when completing a task. In other words, when faced with difficulties, children need to search for solutions and adjust their behavior in order to logically solve problems. In such cases, cool EF may function as an underlying mechanism to flexibly perform the appropriate response. In addition, children should resist the urge to give up a difficult task and repeatedly try, even if they feel that the goal is not achievable. However, an unachievable task can easily frustrate children. Giving up may be the quickest way to reduce unpleasant emotions when children know how to quit the task. That is, giving up is caused by the affective temptation of the unachievable persistence task. In this case, hot EF may function as an underlying mechanism for overcoming irresistible temptations and facing challenges, not giving up. Therefore, we hypothesized that a relationship may exist between both cool and hot EF and persistence in children.

Although a few studies have examined the association between EF and persistence in children, there have been no conclusive findings to date. Oeri et al. (2020) reported that inhibitory control and cognitive flexibility predicted 5- to 6-year-olds' persistent behavior; these were assessed using cognitive tasks (inhibitory: an adapted version of the Fruit-Stroop task [Archibald & Kerns, 1999] and an adapted Flanker task [Eriksen & Eriksen, 1974], cognitive flexibility: a modified DCCS task [Carlson, 2005]). They also suggested that children's effortful control was not associated with their persistence. Effortful control is defined as a dimension of temperament related to self-regulation (Rothbart et al., 2007). Some researchers have proposed that EF and effortful control overlap in terms of their definition, construct, and core components

(Schmidt et al., 2022), especially when the concept of EF includes hot (affective) aspects (Zhou et al., 2012). However, as Oeri et al., (2020) examined effortful control using questionnaires, the association between hot EF, as measured by behavior, and persistence remains unknown. Indeed, Hongwanishkul et al. (2005) failed to find associations between hot EF and parent-reported effortful control among preschoolers. Thus, it is necessary to investigate whether hot EF in behavioral tasks is related to persistence. In addition, it is possible that the wooden puzzle task used by Oeri et al. (2020), in which the percentage of time spent persistently trying to complete the task was used as an indicator of persistence, was not challenging for children: During the task, children were able to accomplish the puzzle by cheating. Children may be motivated by a sense of small accomplishments; thus, persistence, which is the ability to persist in the face of challenges, may not be measured in this task. Moreover, this task may not capture pure persistence because children experienced the conflict of deciding whether to cheat or not. On the other hand, Leonard et al. (2020) used an impossible-to-complete task as a persistence task, in which the total time spent working was used as a measure of persistence. This task is probably more appropriate for measuring persistence as it is more difficult for children, and children are faced with a challenging situation. Therefore, in this study, we adopted an unachievable persistence task, similar to that of Leonard et al. (2020), which allowed us to examine the association between children's EF and persistence in a more appropriate context.

The main aim of this study was to examine the relationship between EF and persistence in children and to determine the factors that contribute to individual differences in persistence. We chose to focus on 5-year-olds for three reasons. First, there may be a variation in the performance of EF tasks, as each EF skill rapidly develops in the preschool period (Diamond, 2013; Zelazo & Carlson, 2012). Second, we wanted to create difficult situations for participants. According to previous studies (Leonard et al., 2020; Leonard et al., 2021), the persistence task is challenging for 5-year-olds because few children reach the ceiling scores of the task. Third, this is usually a time when children are starting school, and it may be important to understand individual differences in persistence during this specific transition. To reveal the relationships between EF and persistence based on the above, we conducted a correlation analysis, focusing on each component of EF (i.e., cool EF, including inhibition and cognitive flexibility, and hot EF). We hypothesized that each component of EF is positively associated with persistence in children because they may use both EF abilities to keep trying harder to complete the task (e.g., finding solutions and controlling their emotions). Thereafter, we conducted exploratory research to examine the cognitive mechanism underlying the correlational relationships.

Method

Participants

A total of 72 children (mean age = 60.48 months, *SD* = 3.44, range = 55–67) from a combined daycare center and kindergarten in [omitted for peer review], Japan, participated in this study. Written consent was obtained from their parents. An additional two children participated in this study but were excluded from the analysis as they did not meet the criteria for learning how to ring the bell (more details on the persistence task used are given below). A power analysis indicated that a minimum sample size of 72 was needed to detect significant findings at 80% power with an alpha of 0.05 using the effect sizes of correlation analysis (*r* =

0.325). The effect sizes were the average of the effect sizes of the correlation analysis between inhibition and persistence ($r = 0.34$), cognitive flexibility and persistence ($r = 0.30$), and interest and persistence ($r = 0.336$), as found in previous studies investigating the associations between persistence and children's other abilities (Oeri et al., 2020; Torgrimson et al., 2021). The experiment was approved by [omitted for peer review] University (approval number HB020-027).

Procedure

This experiment was conducted by two experimenters in a facility that combined a daycare center and kindergarten in [omitted for peer review], Japan. It was conducted individually during free play time or extended daycare time. Children participated in two sessions, each involving different tasks (i.e., one included the gift delay task and persistence task; the other included rest tasks: Red/Blue task, Bear/Dragon task, DCCS task, and delay of gratification task). The session order was counterbalanced across children, although the task order during the session was fixed. In particular, the persistence task preceded the gift delay task, so children received a gift at the end of the gift delay task as a reward for their hard work. During the other session, tasks were conducted in the following order: Red/Blue task, Bear/Dragon task, DCCS task, and delay of gratification task. All 72 children tackled all the tasks and took approximately 15–20 minutes to complete them. During all tasks, the children's behavior was recorded using a hidden video camera. Children's performance was recorded using another video camera in the Bear/Dragon and gift delay tasks.

Executive Function Tasks

Five EF tasks (three tasks for measuring cool EF, which included inhibition and cognitive flexibility, and two tasks for measuring hot EF) were used. Inhibition was measured with the Red/Blue task (Ogawa & Koyasu, 2008) and the Bear/Dragon task (Kochanska et al., 1996; Merz et al., 2017). Cognitive flexibility was assessed using the DCCS task (Moriguchi & Shinohara, 2018). The delay of gratification task (i.e., choice version [Imuta et al., 2014; Moriguchi et al., 2018]) and gift delay task (Merz et al., 2017) were used to assess hot EF.

The Red/Blue Task

The Red/Blue task (Ogawa & Koyasu, 2008) is similar to the Day/Night Stroop task (Carlson & Moses, 2001) but was selected for this study as children in Japan understand it better than the Day/Night Stroop task (Ogawa & Koyasu, 2008; Yanaoka, 2016). In this task, children were shown red and blue cards and were asked to identify the color of the cards. They were then instructed to point at the red card when the experimenter said “blue” and to the blue card when the experimenter said “red.” After two practice trials, 10 test trials (i.e., red: 5 trials, blue: 5 trials) were conducted. The order (e.g., red first) was counterbalanced across children. If a child failed the practice trials, the rules were repeated, and practice trials were conducted again. The scoring ranged from 0–10 points (wrong = 0, correct = 1).

The Bear/Dragon Task

In the Bear/Dragon task (Merz et al., 2017), a monkey puppet was used as a substitute for a bear puppet and a frog puppet as a substitute for a dragon puppet as Japanese children are more familiar with these animals. The children were instructed to perform the requested actions when the monkey talked but to inhibit the requested actions when the frog talked. Following two practice trials, 12 test trials (after six trials, we repeated the rules) were conducted. The order (e.g., monkey first) was counterbalanced across children. If a child failed the practice trials, the rules were repeated, and practice trials were conducted again. The scores ranged from 0–12 points (monkey: no movement = 0, partial movement = 1, full movement = 2, frog; no movement = 2, partial movement = 1, full movement = 0). Frog scores, not monkey scores, were used as an indicator of this task because children did not need to inhibit their behavior when the monkey required something. One coder—the original experimenter—coded all data. A second coder, who was blind to the purpose of this study, coded 25% of the data to test for reliability. Reliability was high for the Bear/Dragon task (interrater reliability: ICC .97, N = 18).

The DCCS Task

In the DCCS task (Moriguchi & Shinohara, 2018), we used pairs of the target and test cards, which have two dimensions (e.g., target cards of a green car or a yellow house, and test cards of a yellow car or a green house; the target cards match the test cards in only one dimension). First, the children were asked to guess the color and shape of the cards. If they could not determine the correct answer, it was revealed to them. Next, the children were instructed to sort cards that had two dimensions (i.e., color and shape). In the practice phase, the children were shown how to sort the cards twice. In the pre-switch phase, they were instructed to sort the cards in one dimension (i.e., color; “This is the color game. Put the cards where the colors are the same.”) and in another dimension (i.e., shape; “Next, this is the shape game. Put the cards where the shapes are the same.”) in the post-switch phase. Then, in the mixed phase, children were asked to sort the cards in two dimensions (i.e., color and shape; "In this game, you will use both color and shape rules."). The rule order (e.g., color first) was counterbalanced across children in the pre- and post-switch phases. However, it was fixed in the mixed phase (i.e., POST: rules in the post-switch phase; POST, PRE: rules in the pre-switch phase; POST, POST, PRE, POST, POST). In the pre-switch, post-switch, and mixed phases, children participated in eight trials. If they failed twice in sorting the cards in each phase, they did not move on to the next phase. The rules were provided before each phase. The percentage of successful switching between phases was calculated as the score of the DCCS task. For example, when children succeeded 3 out of 5 times in switching, their scores were 60 %. The scores ranged 0–100 %.

The Delay of Gratification Task

In the delay of gratification task (Imuta et al., 2014; Moriguchi et al., 2018), we used seven stickers, an orange arrow (19.5 cm), and a yellow game board (37×27 cm), which included a blue area (18×13 cm) labeled as "now" and a green area (18×13 cm) labeled as "later." First, the children were asked to choose one among seven stickers that they liked best to enhance the attractiveness of the rewards. They were then instructed to point to either the blue area or the green area using the orange arrow: The experimenter asked the children to point to the blue area if they wanted one sticker instantly, or to the green area if they wanted four stickers later. At least one of the stickers on the green area was the same as the sticker on the blue area to prevent children from choosing the blue area due to a particular sticker on the area. After checking whether the children understood the rules, they performed six test trials. When children chose the blue area, they received one sticker immediately after their choice; when they chose the green area, they received four stickers after finishing all the test trials in the delay of gratification task. The number of stickers the children were given ranged from 6 to 24. The scores ranged from 0–6 points (“now” = 0, “later” = 1).

The Gift Delay Task

In the gift delay task (Merz et al., 2017), the children were informed that the experimenter would give them a gift but that they had to wait for it to be wrapped. They were then instructed to turn their back to the experimenter and not to look at the experimenter while the gift was being wrapped. The experimenter made wrapping sounds for 60 seconds. We measured the strategy and latency scores based on a previous study (Merz et al., 2017). The strategy score (stands to peek = 1; does not stand but turns to peek = 2; peeks over shoulder = 3; does not peek = 4) was measured every 15 seconds, and the average score for 60 seconds was calculated. The latency score was defined as the time until the children peeked to see the present. The strategy and latency scores were standardized and averaged since they were highly correlated ($rs = .93$, $p < .001$). The scores ranged from -3.30–0.64 points. The original experimenter coded all data, and the second coder coded 25% of the data to test for reliability. Reliability was high for the gift delay task (strategy score; interrater reliability: ICC .96, N = 18, latency score; interrater reliability: ICC .93, N = 18).

The Persistence Task

We defined children’s persistence as the length of time spent attempting a challenging task and used a similar task as in the baseline by Leonard et al. (2020). The task involved two 15.cm × 7.5 cm × 4.5cm wooden boxes with some protrusions (one could be opened, the other could not), a stuffed toy, and a bell. Before conducting the persistence task, the children were taught how to use the "all done playing" bell in the game. First, the children were shown the experimenter playing with the stuffed toy. Second, the experimenter said, "I'm all done playing," and rang the "all done playing" bell to communicate to the children that they should ring the bell when they finished playing. The children were then instructed to play with the stuffed animal and ring the bell when they finished playing. When the children did not ring the bell after playing, the rules were explained to them once again. If the children did not ring the bell after the experimenter had explained the rules three times, the experiment was stopped.

Next, the experimenter told the children that she had to leave the room to do something and that they should play with the box. To introduce the children to the box, the experimenter said, "Do you hear these sounds [while shaking the box]? There may be something inside. You can try to take it out!" At this point, the children did not know that the box was impossible to open. After the children started playing with the box, the experimenter exited the room. We measured the time it took for the children to begin playing after the experimenter turned her back to them. The experiment was completed when the children rang the bell or if four minutes passed. The time during which the child played was used as an indicator of their persistence (the maximum time for persistence was 4 minutes). However, the time when the children were neither touching nor looking at the box (i.e., they were wandering around the room without holding the box) was excluded because they were likely to have thoughts that were irrelevant to the target task while doing so. At the end of the experiment, the experimenter always said, "Oh, I'm sorry. I gave you the wrong box, which does not open." Then, the experimenter and the children opened the right box together.

Results

To investigate the associations between EF and persistence in children, we used R 4.0.3 software and conducted a correlation analysis. All children's scores were not normally distributed (Shapiro–Wilk *ps* < .05). Therefore, Spearman correlations were conducted to examine the relationships between children's EF and persistence.

Performance on the EF Tasks

To assess children's EF, five EF tasks were conducted—the scores of which are shown in Table 1. The number of children performing at floor was as follows: Red/Blue task = 2, Bear/Dragon task = 3, DCCS task = 5, Delay of gratification task = 7, and Gift delay task = 1. The number of children performing at ceiling was as follows: Red/Blue task = 31, Bear/Dragon task = 31, DCCS task = 34, Delay of gratification task = 34, and Gift delay task = 40.

Table 1

Descriptive Statistics of the EF Tasks

	Mean	*SD*	*Median*	*Range*
Red/Blue task	8.24	2.60	9	0 - 10
Bear/Dragon task	9.28	3.40	10	0 - 12
DCCS task	71.1	33.55	80	0 - 100
Delay of gratification task	4.15	2.12	5	0 - 6
Gift delay task	0.00	0.90	0.64	-3.30 - 0.64

Performance on the Persistence Task

We measured the time children spent on the persistence task as an indicator of their persistence. Children's persistence scores ranged from 4–240 seconds (M = 111.80, SD = 87.46). Thirteen children reached the ceiling score on the task.

Relationship between EF and Persistence

To examine the relationship between cool/hot EF and persistence, based on previous studies and theories (Ming et al., 2021; Moriguchi, 2021; O'Toole et al., 2020; Sarsour et al., 2011; Zelazo & Carlson, 2012), we divided EF into its components (i.e., inhibition: Red/Blue task and Bear/Dragon task; cognitive flexibility: DCCS task; hot EF: delay of gratification task and gift delay task). However, we did not find any correlations between tasks in the same components (e.g., Red/Blue task and Bear/Dragon task). One of the reasons is that the distinction between cool and hot EF by means of the correlations between EF tasks can vary depending on which tasks are used and participants' age (Allan & Lonigan, 2011; Carlson et al., 2014; Kamza et al., 2016). Therefore, we investigated the correlations between each EF task and persistence, instead of each component of EF and persistence. The Holm method (Holm, 1979) was used to adjust the p-values in multiple testing. Table 2 shows the correlations of the measurement variables. Among the EF tasks, the DCCS and gift delay tasks were associated with persistence in children (the DCCS task; rs = .41, adjusted $p < .01$, the gift delay task; rs = .35, adjusted p = .03).

Table 2

Correlations between the Variables

	1	2	3	4	5	6
1 Red/Blue	-	0.18	0.28	0.05	0.23	0.17
2 Bear/Dragon		-	0.57**	0.08	0.22	0.24
3 DCCS			-	0.04	0.35*	0.41**
4 Delay of gratification				-	-0.12	0.13
5 Gift delay					-	0.35*
6 Persistence						-

Note. *$p < .05$, ** $p < .01$ after adjustment for multiple tests using the Holm method

Exploratory Analysis

There were relationships between the DCCS task and persistence, and the gift delay task and persistence. To investigate these associations in-depth, we conducted an exploratory analysis. All aspects of the exploratory analysis were generated subsequent to the completion of the correlational analysis. We considered the mediator that explains the relationships between EF and persistence based on extant theories, following which we ran the mediation analysis to reveal the cognitive mechanism underlying the relationships.

We assumed that the relationship between the DCCS task and persistence may be attributed to children's ability to change their strategies. This is because cognitive flexibility, as assessed by the DCCS task, is the ability to switch rules between tasks (Doebel & Zelazo, 2015). In fact, previous studies have suggested relationships between cognitive flexibility and switching strategies in children, such as constraint-seeking strategy use and arithmetic strategy selection (Legare et al., 2013; Lemaire & Lecacheur, 2011). In other words, children with high scores on the DCCS task may not stick to one useless strategy because they can switch and use different strategies when attempting to open the box. In particular, trying new strategies may be necessary to complete the task. If children can use several strategies, they may work on the persistence task longer depending on the number of strategies they have. As they are able to switch from unsuccessful strategies to untested strategies, they may have more opportunities to attempt the task again. It is possible that attempting the task again using multiple strategies is important to keep working on the task longer because the persistence task is challenging and unachievable, which sometimes leads to failed attempts. Overall, the more children use different strategies, the longer they work on a task. Thus, we utilized not only the total number of strategy switches but also the number of strategies used to open the box during the persistence task as a mediator. We hypothesized that cognitive flexibility increased the number of strategies and switches children used to open the box and that actions such as switching rules might relate to persistence in the task.

On the other hand, scores on the gift delay task demonstrated children's ability to wait for a certain time before being rewarded by controlling their emotions (Carlson & Moses, 2001; Carlson et al., 2002). This task also required children to avoid shifting their attention to attractive distractions. When children attempt an impossible task, they feel and express negative emotions, such as "I cannot do it" (Perkins et al., 2021). As the persistence task is also difficult for children, and they are involved in an emotional context, they will be likely not to focus on the target task, be distracted by other things unrelated to it, and want to stop working on it. During the persistence task, the number of off-task behaviors children demonstrated (e.g., glancing at the door and bell, touching the bell, and walking around the room) was few. Among such off-task behaviors, the door and bell can be attractive distractions for children because they remind them of the end of the difficult task. Thus, shifting attention during the gift delay task may be associated with only glancing at the door and bell. That is, children with high scores on the gift delay task may stay focused on the task for longer without getting distracted. Moreover, non-persistence behavior such as off-task behavior has been found to be related to low persistence in preschoolers (Oeri et al., 2020). Together, sifting attention to the door and bell may have a negative effect on children's persistence.

Therefore, we hypothesized that the relationship between the scores on the gift delay task and persistence may be due to children's ability to concentrate on the task without getting distracted. In other words, the less children glance at the door and bell, the longer they may attempt to work on the task. We used the number of glances at the door and bell as a mediator. We assumed that the ability assessed by the gift delay task reduced the number of glances at the door and bell, and that children who glanced at the distractions less would direct their attention to opening the box for longer than those who glanced at the distractions more. Thus, concentrating on the task without glancing at the distractions might be related to persistence.

Coding and Scoring of Mediators

Children's behaviors (i.e., strategies used, switches, and glances at the door and bell) were used to determine the cognitive mechanism between EF and persistence. Based on a previous study investigating preschoolers' exploratory play, "strategies" were defined as the actions performed when attempting to open the box (Doan et al., 2020). For example, children could shake and pull the box as a strategy (see the list in the Supplementary Material). A "glance" was defined as a peek at the door or bell then back to the box. Each behavior was coded as follows. When children used the shaking, pulling, shaking, pulling, and clapping strategy on the persistence task, the number of strategies was 3, and the total number of strategy switches was 4 times. The range of the number of strategies was 1–7 points; the average score was 3.79. The total number of strategy switches ranged from 0 to 80 times, with an average score of 21.76 times. There was a strong association between the number of strategies and the total number of strategy switches (rs = .83, p < .0001). The number of glances at the door and bell was also counted during the persistence task. The number of glances per minute was used as the score for glances. Its range was 0–45 times/min; the average score was 5.01 times/min. The number of strategies, switches, and glances were coded from video footage by the two coders. The original experimenter coded all the data, while the second coder coded 25% of the data for reliability. Reliability was high for the number of strategies (interrater reliability: ICC .88, N = 18), the number of strategy switches (interrater reliability: ICC .96, N = 18), and the number of glances at the door and bell (interrater reliability: ICC .96, N = 18).

Mediation Analysis

We conducted mediation analysis to reveal the cognitive mechanisms underlying the associations between EF tasks (the DCCS task and gift delay task) and persistence in children. We used the number of strategies, switches, and glances during the persistence task as the mediator between EF tasks and persistence.

Relationship between DCCS Task and Persistence

To examine whether the number of strategies used to open the box accounted for the relationship between the DCCS task and persistence, we conducted mediation analysis. We used the Holm method (Holm, 1979) to adjust the p-values in multiple testing. Significant correlations were found between the DCCS task and persistence ($rs = .41$, adjusted $p < .001$), the DCCS task and the number of strategies ($rs = .38$, adjusted $p = .001$), and the number of strategies and persistence ($rs = .76$, adjusted $p < .001$). In the critical condition for mediation, the path coefficient between the predictor variable (DCCS task) and the outcome variable (persistence) was not significant when the mediator variable (number of strategies) was included in the model (Figure 1). The results of the bootstrapping analysis based on 2,000 bootstrap samples (Preacher & Hayes, 2004) revealed that the indirect effects were significant as they did not include zero (95% Confidence Interval [CI: 0.29, 1.13]). Greater DCCS predicted a higher number of strategies used during the persistence task, which in turn, predicted better persistence. Overall, the effect of the DCCS task on persistence increased by 0.68 for every additional strategy used.

Additionally, we observed a similar pattern of results when using the total number of strategy switches. It exhibited a correlation with cognitive flexibility ($rs = .36$, adjusted $p = .002$) and persistence ($rs = .94$, adjusted $p < .001$). Moreover, it helped explain the relationship between DCCS and persistence (please refer to the Supplemental Material for further details).

Relationship between the Gift Delay Task and Persistence

Next, to examine whether the number of glances at the door and bell accounted for the relationship between affective ability assessed by the gift delay task and persistence, we conducted another mediation analysis. The Holm method (Holm, 1979) was used to adjust the p-values in multiple testing. Significant correlations were found between the gift delay task and persistence (rs = .35, adjusted p = .002), the gift delay task and the number of glances at the door and bell (rs = -.38, adjusted p = .002), and the number of glances at the door and bell and persistence (rs = -.52, adjusted p < .001). The path coefficient between the predictor variable (i.e., gift delay task) and outcome variable (persistence) reduced significantly when the mediator variable (i.e., number of glances at the door and bell) was included in the model; however, the relationship was still statistically significant (Figure 2). The results of the bootstrapping analysis based on 2,000 bootstrap samples (Preacher & Hayes, 2004) revealed that the indirect effects were significant as they did not include zero (95% CI [3.62, 20.00]). Greater gift delay predicted a lower number of glances at the door and bell observed during the persistence task, which in turn, predicted better persistence. Overall, the effect of the gift delay task on persistence decreased by 0.26 for every additional glance.

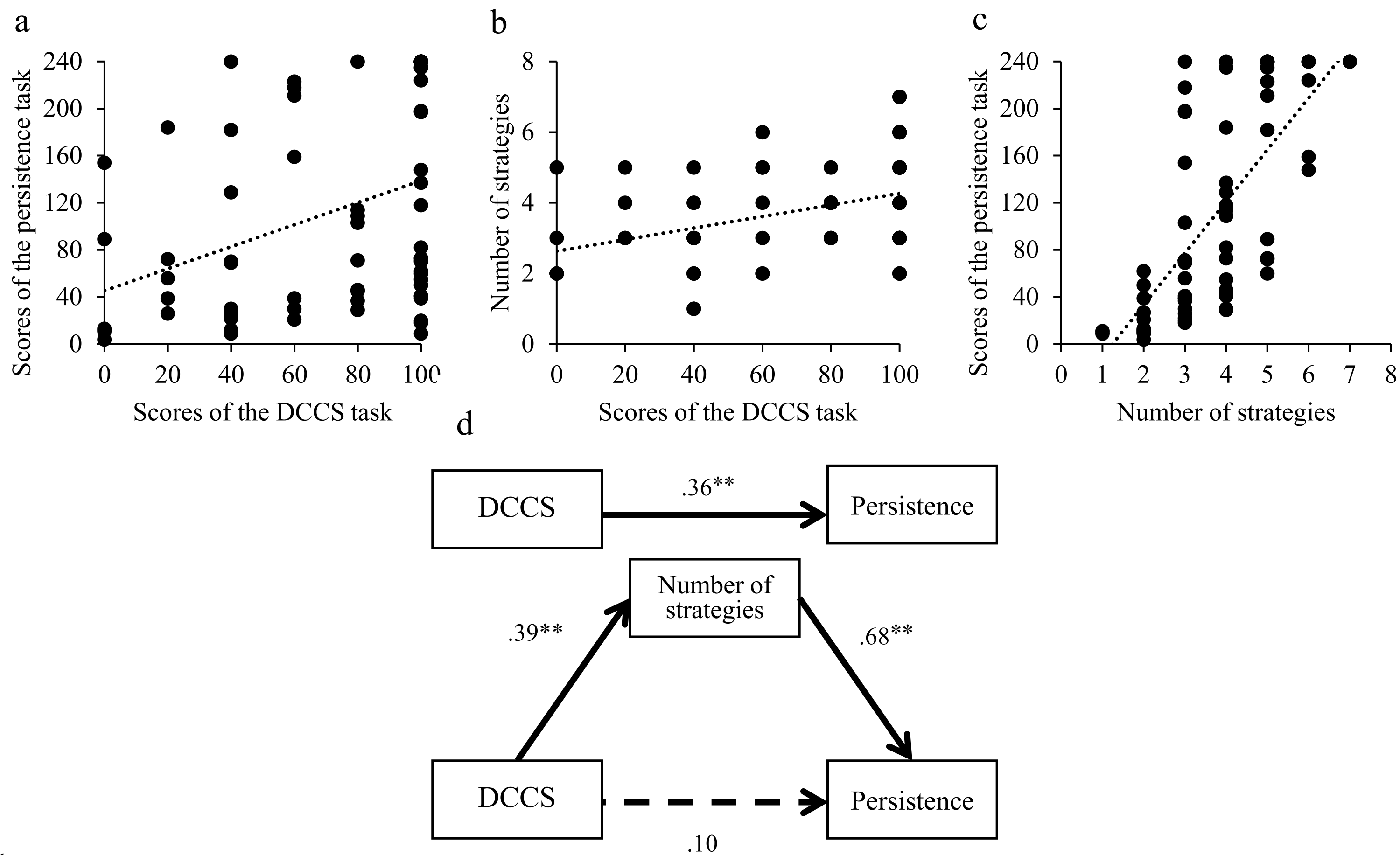

Figure 1

(a) Relationship between scores of the DCCS task and persistence task; (b) Relationship between scores of the DCCS task and the number of strategies; (c) Relationship between the number of strategies and scores of the persistence task; (d) Mediation model shows that the number of strategies mediates the relationship between the DCCS task and persistence.

Note. Asterisks indicate significant paths (**p* < .05, ***p* < .01).

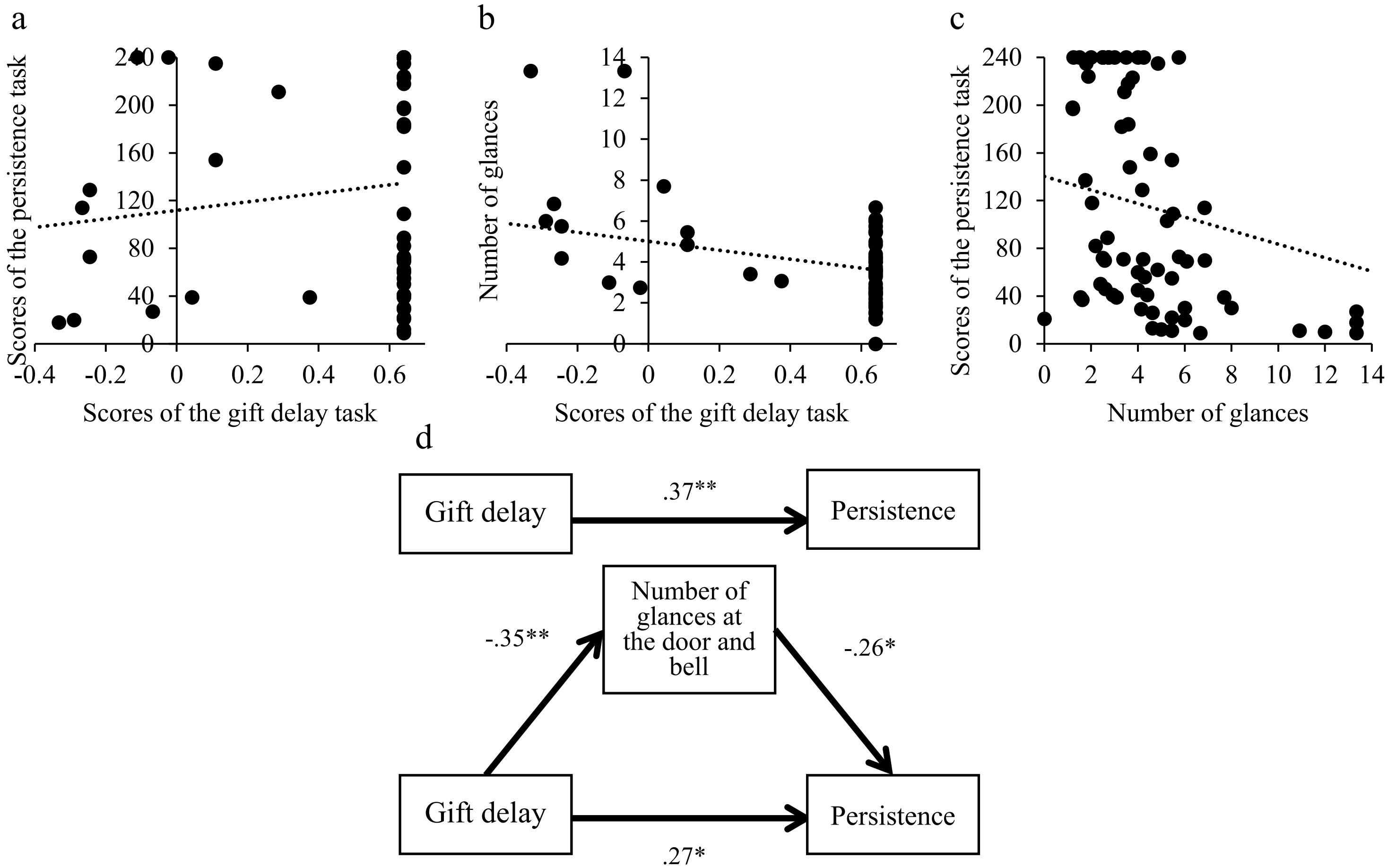

Figure 2

(a) Relationship between scores of the gift delay task and persistence task; (b) Relationship between scores of the gift delay task and the number of glances at the door and bell; (c) Relationship between the number of glances at the door and bell and scores of the persistence task; (d) Mediation model shows that the number of glances at the door and bell mediate the relationship between the gift delay task and persistence. Note. Asterisks indicate significant paths (**p* < .05, ***p* < .01).

Discussion

To investigate the relationships between EF and persistence in young children and the cognitive mechanisms underlying the relationships, we conducted the planned correlation analysis and, mediation analysis as an exploratory analysis. Accordingly, we found that EF skills assessed by the DCCS task and gift delay task were related to persistence in 5-year-olds. The results of the mediation analysis suggest that it was important for children to use several strategies to open the box and concentrate on the persistence task without glancing at distractions for them to work on the task longer.

Correlations between EF and Persistence in Children

First, we investigated the correlations between EF and persistence and found that two EF tasks were associated with their persistence. In this study, cognitive flexibility assessed by the DCCS task was positively correlated with persistence. This result is partially consistent with a previous study (Oeri et al., 2020) that reported positive relationships between inhibition/cognitive flexibility and persistence. Cognitive flexibility enables children to switch rules; therefore, children with high cognitive flexibility can switch their actions related to the task, such as the strategies used to open the box. To work on the persistence task, it may be important for children to switch their actions, rather than stick to one strategy. Hence, we found a relationship between the DCCS task and persistence.

In contrast, the result for inhibition was not consistent with the previous study. Inhibition assessed by the Red/Blue task and Bear/Dragon task enables children to suppress inappropriate behaviors. In the persistence task we used, inhibition may indeed be necessary to work harder on the task without off-task behaviors. However, in Oeri et al.'s (2020) study, the children could cheat to complete the task by looking at the hidden puzzle. In this case, children may have been required to inhibit their inappropriate behaviors more to work on the puzzle box task than on the persistence task we used. Thus, the differences in the persistence tasks between the two studies may be one of the reasons why inhibition was not associated with persistence in the current study. Further, Oeri and Roebers (2021) reported that age had a greater influence on children's persistence than inhibition. Similarly, Torgrimson et al. (2021) did not find a direct association between inhibition and persistence in early elementary school children. Inhibition is necessary when attempting a persistence task, but it may not be the most important component associated with persistence. However, we cannot conclude that there is no relationship between inhibition and persistence. Further studies should consider the differences in the characteristics of both EF and persistence tasks.

Only the gift delay task, not the delay of gratification task, was correlated with persistence. One explanation for this result is that the children were required to judge whether they would acquire one reward sooner or four rewards later because the choice version of the delay of gratification task was used. In this task, children must suppress their impulses to obtain a reward sooner for a relatively short time to achieve a high score. In the gift delay task, children were required to wait for a relatively long time to obtain a reward. Thus, they needed to suppress their desire for a longer time before receiving the reward in the gift delay task than in the delay of gratification task. Similarly, in the persistence task, children were required to suppress their desire for a relatively long time. Therefore, only the gift delay task was associated with persistence, and not the delay of gratification task.

In addition, our study's and previous findings (Oeri et al., 2020) on the relationships between children's persistence and emotional skills are mixed. In Oeri et al. (2020), effortful control measured by questionnaires appears to be more ecologically valid and can capture children's temperament across multiple contexts. However, it is possible that questionnaires and performance in specific tasks (e.g., the gift delay task) provide different information about aspects of children's abilities because of biased parental reporting (Samyn et al., 2015) and the contexts in which they were assessed. Therefore, these differences may explain the inconsistency. However, few studies have investigated the relationships between children's affective aspects based on behavioral tasks and persistence, as in this study. In that sense, our finding provides new insights to contribute to the research on persistence in young children although further research is needed.

Cognitive Mechanisms Underlying the Relationships between EF and Persistence

In the exploratory analysis, we investigated the cognitive mechanisms underlying the associations between EF and persistence. We revealed that children with high scores on the DCCS task used multiple strategies to open the box; the use of many strategies related to their persistence. Children experienced some failures when working on the persistence task because it is challenging and unachievable; therefore, they needed to attempt the task repeatedly to be more persistent with it. Children with high cognitive flexibility were able to change strategies, which could have produced new and useful information that could be used to challenge the task. This is why they were likely to work on the persistence task for longer. In addition, we revealed that children with high scores on the gift delay task concentrated on the task without glancing at the door and bell; this approach related to persistence. The persistence task sometimes frustrated children because they could not complete it. They also knew how to finish the task by themselves; thus, they may have felt an impulse to give up on it. Children with high scores on the gift delay task were likely able to try on the task longer as they were able to suppress such negative emotions and persist in working on the task. In sum, the cognitive mechanisms that explain the relationships between EF and persistence were revealed by the mediating behaviors (i.e., using several strategies to open the box and focusing on the task without glancing at distractions).

Prospects for Future Research

Although this study focused on the children's EF as one of the abilities related to persistence, there may be another individual difference in children's persistence, namely, the motivation for the task. In the persistence task, some children may not have been motivated as they were unaware what was inside the box. It is possible that their motivation, instead of EF ability, had an effect on their persistence and mediating behaviors. Thus, a future study considering the motivation for the persistence task could reveal another individual difference in children's persistence.

Moreover, this study's findings may lead to interventions for developing children's persistence. One of the reasons that children did not work on the persistence task longer is that they did not know how to. If children have only one strategy, they may quickly give up working on such tasks. In contrast, if children can use multiple strategies, they may work on such tasks longer because they can switch between several strategies and have more opportunities to challenge the tasks. Therefore, teaching children more strategies to approach a task may improve their persistence. In addition, when children face difficulties in a distracting environment, they are likely to direct their attention away from such difficulties. If adults can manage distractions and set up an environment with minimal distractions, children may be able to concentrate on the difficulties and persist in working on tasks for longer. These interventions may enhance children's persistence. Of course, enhancing children's EF may enable them to work on difficulties with persistence because children's EF is related to persistence. However, while training EF improves skills on similar tasks, this improvement is not generalized (Diamond & Ling, 2016; Harrison et al., 2013). Thus, rather than training children's EF, it may be more effective to provide them with concrete strategies for solving problems and to create environments without distractions.

Limitations

While our findings may be important for providing a methodology for interventions that can enhance children's persistence, the study has some limitations. First, the question of causality between children's EF and persistence in this study remains. It is possible that persistence causes EF, although we assumed that EF causes persistence in the exploratory analysis. When children have to work on certain EF tasks continuously, they sometimes make mistakes. In this case, children with low persistence may give up on achieving the goals of a task. In contrast, children with high persistence are unlikely to give up on accomplishing the goals of an EF task even if they fail a few times; therefore, they may demonstrate their complete ability during EF tasks. In addition, there is another limitation regarding the causality between persistence (total time) and the number of strategies in the persistence task. Although we assumed the direction of the path (from the number of strategies to persistence) based on several extant theories, it is possible that children who persisted longer on the task had more time to try various strategies. Future studies must reveal these causal associations.

Second, there are problems with task selection and measurement methods for both EF and persistence. To investigate children's EF, particular types of tasks are used. For example, researchers have used two paradigms to assess children's delay of gratification: the choice and maintenance paradigm, but we assessed children's delay of gratification using the only choice paradigm task. Additionally, we found a large number of ceiling effects on some EF tasks (e.g., Read/Blue task), which may make it more difficult to interpret the findings. Together, the results in this study may be caused by the specific EF tasks that were employed, rather than broader EF abilities. Future studies should use multiple and more appropriate EF tasks to better capture children's abilities. Further, as we defined children's persistence as the time, they took to attempt a challenging task, we chose to conduct an unachievable task, similar to Leonard et al. (2020). However, there are other kinds of persistence tasks, such as the achievable task, in which participants can complete the task during the experiment (Chang & Olson, 2016; Lucca et al., 2019; Mokrova et al., 2013; Oeri et al., 2020). In addition, the indices of persistence differ depending on the study. For example, Leonard et al. (2020) used the total time spent on a task as their measurement for persistence, while Chang and Olson (2016) focused on on-task (i.e., physically working on the task) and off-task (i.e., playing with other toys) behaviors for every 30-second interval. It is unclear which tasks and measurements of persistence precisely capture children's persistence; therefore, future studies should verify the definition and measurement of children's persistence.

Conclusion

In sum, we found that cognitive flexibility, as assessed by the DCCS task, and children's ability to control their feelings, as assessed by the gift delay task, were associated with persistence. We also revealed that the relationships between EF and persistence were explained by the number of strategies the children used and the number of times they glanced at the door and bell. Thus, our findings emphasize the factors related to individual differences in children's persistence. Factors such as strategies used, and task focus may provide insights into interventions for developing children's persistence.

Acknowledgments

We thank all the children and parents who participated in this study. This research was supported by JST grants to [omitted for peer review].

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Supplementary Material

List of All Possible Strategies

1) Pulled the box

2) Clapped the box

3) Shook the box

4) Observed the box without touching it

5) Touched the box while looking at it

6) Touched the box without looking at it

7) Spun or slid the box on the desk

8) Touched the box while moving around

9) Hit the box against other surfaces, such as the floor or desk

10) Blew on the box

11) Pressed the box

12) Used their teeth to open the box

13) Searched for tools to open the box

Exploratory mediation analysis of the total number of strategy switches

The mediation analysis revealed that the total number of strategy switches explained the relationship between them (Figure 3; 95% Confidence Interval [CI: 0.28, 1.13]). That is, greater DCCS predicted a higher number of strategy switches during the persistence task, which in turn, predicted better persistence.

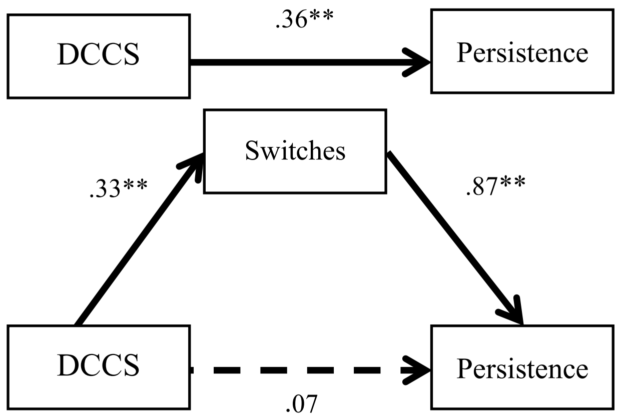

Figure 3

*The mediation model illustrates that the total number of strategy switches mediate the relationship between the DCCS task and persistence. Note. Asterisks indicate significant paths (**p < .01).*