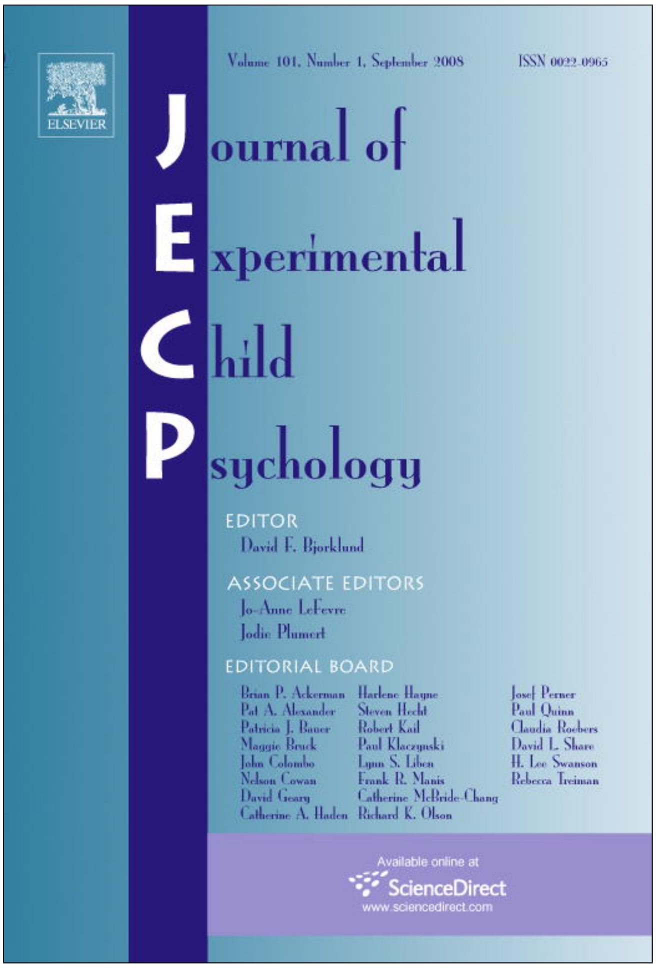
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Children's note taking as a mnemonic tool

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ABSTRACT

When given the opportunity to take notes in memory tasks, children sometimes make notes that are not useful. The current study examined the role that task constraints might play in the production of nonmnemonic notes. In Experiment 1, children played one easy and one difficult memory game twice, once with the opportunity to make notes and once without that opportunity. More children produced functional notations for the easier task than for the more difficult task, and their notations were beneficial to memory performance. Experiment 2 found that the majority of children who at first made nonmnemonic notations were able to produce functional notations with minimal training, and there was no significant difference in notation quality or memory performance between spontaneous and trained note takers. Experiment 3 revealed that the majority of children could transfer their training to a novel task. The results suggest that children's production of nonmnemonic notes may be due in part to a lack of knowledge regarding what task information is important to represent or how to represent it in their notes rather than to an inability to make functional notes in general.

Introduction

Children are surrounded by print and other external representations in their environment. In Western culture, it would be nearly impossible for a child to go through a day without encountering at least some form of external symbols such as numbers, signs, or iconic symbols. Gradually, children learn how to interpret, produce, and use many of the external representations they encounter for a variety of purposes. Although theorizing about the influence of external symbols on cognition has

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had a long history, it is only recently that researchers have begun to investigate how children's interaction with external symbols can influence cognitive processing such as in problem solving or memory tasks (for a review, see Eskritt & Lee, 2007). Currently, researchers still know very little about how children develop the ability to produce and use external symbols to aid cognition.

One common use of external symbols is as a mnemonic aide (Intons-Peterson & Fournier, 1986). Even children in kindergarten provide more examples of external memory aids than of internal memory aids for remembering information (Kreutzer, Leonard, & Flavell, 1975). However, the literature on children's use of external mnemonic aides is considerably less extensive than research on their use of internal memory strategies, and only a few studies have examined children's use of notations for aiding memory (Bialystok & Codd, 1996; Brown & Smiley, 1978; Cohen, 1985; Eskritt & Lee, 2002; Hughes, 1986; Karmiloff-Smith, 1979; Luria, 1978). Hughes (1986) reported that even preschoolers have the ability to represent small quantities on their own. Bialystok and Codd (1996) found that the 3- to 5-year-olds produced different types of notations, and there was a relationship between the quality of notations produced and memory performance. Eskritt and Lee (2002) looked at how 6- to 12-year-olds used notations in a memory game. The results from their study revealed that older children were able to produce functional notations, whereas younger children were more likely to produce notations that did not contain useful information for the task. Higher quality notations were related to superior performance on the task.

An interesting finding in each of these studies is that when given the opportunity to take notes in a memory task, some children were able to produce functional notations that were related to an improvement in performance, but others tended to make nonmnemonic notations that were unrelated to performance. Functional notations are notes produced in a memory task that contain information relevant to the memory task. They contain information that is required to be successful in the memory task. Nonmnemonic notations, on the other hand, are notes made to assist in a memory task but contain no obvious useful information, for example, drawing an unrelated picture such as a scene from a birthday party. Although it is assumed that children produce functional notations because they intend their notes to aid their performance on the task, it is not understood why children make nonmnemonic notations.

One explanation for why children make nonmnemonic notations is age-related change. Children producing more functional notations may be more cognitively advanced, perhaps having more advanced symbolic understanding. On the other hand, nonmnemonic note takers might not understand how to use notations to aid their memory and, therefore, might not understand that their nonmnemonic notations are not useful. This explanation appears to be supported by previous research that has found that functional note takers tend to be older children, whereas those who make nonmnemonic notes are more likely to be younger (Bialystok & Codd, 1996; Eskritt & Lee, 2002; Hughes, 1986). Age-related change may help to explain why some children make nonmnemonic notations, but it cannot be the sole reason. Although researchers have found a link between age and children's ability to produce and use adequate notes, there appears to be some discrepancy as to what the developmental pattern actually looks like, and this discrepancy in age for when children start to produce functional notations is quite substantial. For instance, Bialystok and Codd (1996) and Hughes (1986) found that preschoolers were able to produce adequate notes, whereas the 6-year-olds in the study by Eskritt and Lee (2002) produced nonmnemonic notations. Hughes (1986) also found that when children were asked to produce notations representing addition and subtraction, even 9-year-olds had difficulties. Thus, it appears that there is no one age range when children make a particular type of notation and that children do not follow a standard pattern of producing nonmnemonic notations at one age and functional notations at another. Although age-related change may play a role in children's notational production, clearly other factors play a fundamental role as well.

One possible cause for the dramatic variability in children's notational ability across studies could be task constraints. Triona and Klahr (2007) reviewed research conducted on children's production of notations for a variety of different types of tasks. They argued that the differences in quality of children's notational productions are related to the amount and types of information the tasks require to be represented. For example, tasks that require children to represent objects (e.g., Bialystok & Codd, 1996; Callaghan, 1999; Hughes, 1986) appear to be easier for children to notate compared with tasks that require the representation of location or sequence (e.g., Cohen, 1985; Eskritt & Lee, 2002; Karmiloff-Smith, 1979). Increasing either the types of information to represent (e.g., Lee & Karmiloff-Smith, 1996) or just the overall amount of information, regardless of type (e.g., Eskritt & Lee, 2002), also appears to affect children's production of useful notations. Therefore, it is possible that children may understand the general strategy for using notes to assist them in remembering information, but they might not be able to determine the specific information to represent or how to represent it for a more difficult memory task. Although Triona and Klahr's (2007) analysis suggests that this is a possibility, research is needed to verify this hypothesis by asking the same children to participate in several memory tasks in which they are required to take notes.

The current study tested the Triona–Klahr hypothesis. Specifically, we first examined whether task constraints have an effect on the types of notations children produce, and we then explored the effectiveness of the different types of notations on memory performance. In general, research has shown a positive relationship between producing functional notations and performance on a memory task (Bialystok & Codd, 1996; Eskritt & Lee, 2002; Hughes, 1986; Luria, 1978). However, type of notes produced is a quasi-variable in that the experimenter cannot manipulate it. Therefore, it is unknown whether differences in performance are due to the type of notes produced or to a characteristic of the children who produce that type of notation. For example, children producing functional notations may also be more cognitively advanced or better at memory tasks in general. However, if children produce different types of notations for different tasks and their performance is different depending on the type of notation produced, then it is more likely that it is the type of notation that influences performance. In the current study, it is expected that when children produce functional notations, it will be beneficial to their performance on that task regardless of whether or not they make nonmnemonic notations for the alternative task.

Children in the first experiment were presented with two different memory tasks to determine whether task constraints would affect the types of notes children produce. Based on Triona and Klahr's (2007) analysis, one of these tasks should be easier to notate and the other one should be more difficult. Children also performed each of these types of tasks twice, once with the opportunity to make notes to aid memory (write condition) and once without that opportunity (no write condition) to examine whether the quality of their notations affects performance on the task.

Experiment 1

Method

Participants

To control for level of education, children were recruited from Grade 1 classrooms in schools across Nova Scotia, Canada. Participants were 69 5- to 7-year-olds (mean age = 6.5 years, *SD* = 0.58). Of these children, 13 were 5-year-olds, 45 were 6-year-olds, and 11 were 7-year-olds. In addition, there were 25 boys and 44 girls. Children were given a small gift at the end of the procedure to thank them for their participation. Children were treated ethically according to American Psychological Association. (1992) guidelines.

Materials

Children participated in two separate tasks. One of the tasks was a Concentration game (Eskritt & Lee, 2002) for which two different decks of cards were used: a practice deck and an experimental deck. The practice deck was a set of 6 cards consisting of 3 pairs with pictures of safari animals on them. The experimental deck contained 12 pairs for 24 cards in total. Half of the cards had pictures of objects (e.g., a moon, a snowman), whereas the other half had abstract designs. The other task was a variation of the Store task used by Eskritt and Olson (2001). In this task, children sold cards that came in different colors and shapes. The cards were rectangles, triangles, and circles that were blue, red, or green in color.

Procedure

Children were seen individually at their school and participated in two tasks: the Concentration task and the Store task. Previous research has found that children vary in the types of notations they produce across these two different tasks. Eskritt and Lee (2002) found that 5- to 7-year-olds produced nonmnemonic or no notes for their Concentration task. On the other hand, Eskritt and Olson (2001) found that 5- to 7-year-olds produced both functional and nonmnemonic notations for their Store task. For each task, the children participated in a *write* condition in which they were given paper and different colored markers to take notes. In this condition, children were asked to "mark down anything you want to help you remember the cards better." Children also participated in a *no write* condition in which they were not given any writing implements and, therefore, did not have the opportunity to take notes. The design was within-participant, so children participated in all four conditions during one session. The order of the two tasks and of the write and no write conditions was counterbalanced.

Concentration task. For the Concentration task, the rules of the game were first explained. The instructions were to turn over one card and then turn over a second card to look for a match. If a match was found, the cards were removed and the procedure was repeated. If the cards did not match, they were turned over and the turn ended. The objective was to match all of the cards in as few turns as possible. Although the game can be played with more than one player, for the current experiment participants played without an opponent. Children were first given an opportunity to practice the task with the practice deck. They were then shown the cards from the experimental deck, and the cards were laid out randomly in a 6×4 array face down. Children played the game twice, once with the opportunity to make notes and once without that opportunity.

Store task. In the Store task, children were told that a customer (i.e., a puppet) would be coming in to buy cards for his friends and that later they would need to put the cards in gift bags and deliver them to the customer. There were a total of 38 cards scattered in front of the children. They participated in a practice trial and two experimental trials. During the practice trial, a puppet made two card orders containing 1 card each for a total of 2 cards. For each order, the puppet chose 1 card that was set apart from the others while the children studied it. When the children were ready, the card was placed back with the others and the children were then asked to place the two card orders in gift bags.

For the experimental trials, a different puppet chose cards from the same 38 cards; however, in these trials, the puppet chose three orders of 3 cards each, requiring children to remember 9 cards in total. Each time the puppet placed an order, the group of 3 cards was set apart from the others. Children were given as much time as they wanted to study the cards or complete their notes, and when they were finished the cards were mixed back in with the others. After all three card orders were placed and returned to the pile, the children were asked to place the card orders in gift bags. The children needed to place the correct 3 cards together for each order; however, they were not asked to recall which group of cards came first, second, or third. The children received credit so long as the correct 3 cards were placed together. The practice cards and two semirandom sets of 9 cards were chosen ahead of time with the stipulation that not all cards could be the same shape or the same color (e.g., cards could not be all blue or all circles). Children participated in two experimental trials: one with the opportunity to make notes and one without that opportunity.

Each session took approximately 30 min and was videotaped for later coding.

Scoring

For each task, the notations children produced during the write condition were evaluated and placed in one of three different notation categories based on the types of information children included in their notes. Both tasks required the children to remember two types of information to be successful on the task. Therefore, full notations included both types of relevant information for a task. In the Concentration task, children needed to provide information in their notes that could differentiate the identity of the cards and show their location. In the Store task, the information needed was the shape and color of the cards. Partial notations included only one type of the relevant information. For example, in the Store task, partial notes included either color or shape information. Nonmnemonic notations contained no useful information to assist in performing the tasks, such as drawing an unrelated picture (e.g., a rainbow), or contained relevant information that was drawn at an inappropriate time and therefore not useful. For example, in the Concentration task, children sometimes drew the identity of the cards either before the game started or after they obtained a pair. Children who did not produce notations for a task were also classified as nonmnemonic.

Full notations produced for the Concentration task were also evaluated using the quality of notations scale developed by Eskritt and Lee (2002) to evaluate notes produced for the Concentration task. The scale consisted of three subscales. The figural subscale assessed the degree to which the identities of the cards were distinguished from each other in the children's notes, with participants receiving a score of 0 for no differentiation between cards, 1 for some ambiguity among several cards, and 2 for complete differentiation. The relational information subscale assessed the degree to which the locations of the cards were represented in relation to one another in notations and ranged from 0 (no relational information) to 3 (perfect relational information). Notations that had some relational information that was very inadequate received a score of 1 on the relational scale, and they received a 2 if they had relational information but part was problematic (e.g., having too many rows). The completeness subscale assessed the number of cards that were notated with scores of 0 (representing no cards), 1 (representing 1–5 cards), 2 (representing 6–9 cards), and 3 (representing 10 cards or more). A total score could also be obtained by adding the scores from the subscales together, with the highest score attainable for a notation being 8. Interrater agreement for children's scores on the quality of notations scale was 93%.

Results

Preliminary chi-square analyses indicated that there was no relationship between order of task or age and the type of notations produced by the children. Additional preliminary analyses of covariance (ANCOVAs) found no significant difference when comparing children's memory performance for different orders of the presentation of tasks or orders of presentation of the write and no write conditions within each task for different notational types; therefore, data were collapsed across these variables.

Types of notations

Fig. 1 provides an example of children's productions of each notational type for each task, whereas Fig. 2 displays the number of children producing each of the different notational types in the write condition for each task. It is important to note that in the Store task, only 1 child actually made nonmnemonic notations, whereas the others in the nonmnemonic category chose not to make notes. For the Concentration task, 10 children made nonmnemonic notations, whereas the other 34 made no notes. As seen in Fig. 2, children were much more likely to be placed in the nonmnemonic category than to produce partial or full notations for the Concentration task. On the other hand, in the Store task roughly equal numbers of children fell into each category. Of the 69 children who participated, 40 (58%) produced different types of notations. A McNemar chi-square analysis was conducted to compare the numbers of children producing different types of notations across tasks. The partial and nonmnemonic categories were collapsed into one category, and the number of children in this category was compared with the number of children producing full notations. The comparison across tasks was significant, χ^2 (N = 69) = 13.89, $p < .001$. The different pattern in the types of notations produced by children for each task suggests that many of the children were producing different types of notations for the two tasks.

Performance on the Store task

The mean number of correct cards recalled within the orders by children producing each notational type can be seen in Fig. 3. A 2 (Condition: write or no write) × 3 (Notational Type: full, nonmnemonic, or partial) ANCOVA, covarying out the effect of age, was performed on the number of correct cards children recalled in the Store task. Results indicated that there was a significant main effect for notational type, $F(2, 63) = 24.00$, $p < .001$, $\eta^2 = .43$, and the covariate of age was significant, $F(1, 63) = 8.80$, $p < .01$, $\eta^2 = .12$. Pearson correlations were conducted to examine the relationship between age and memory performance. In general, older children performed significantly better in the write condition, $r(66) = .28$, $p < .05$, but there was no relationship between age and performance in the no write condition. There was also a significant interaction between condition and notational type, $F(2, 63) = 43.72$, $p < .001$, $\eta^2 = .54$. An analysis of simple effects ($p < .05$) revealed no significant differences

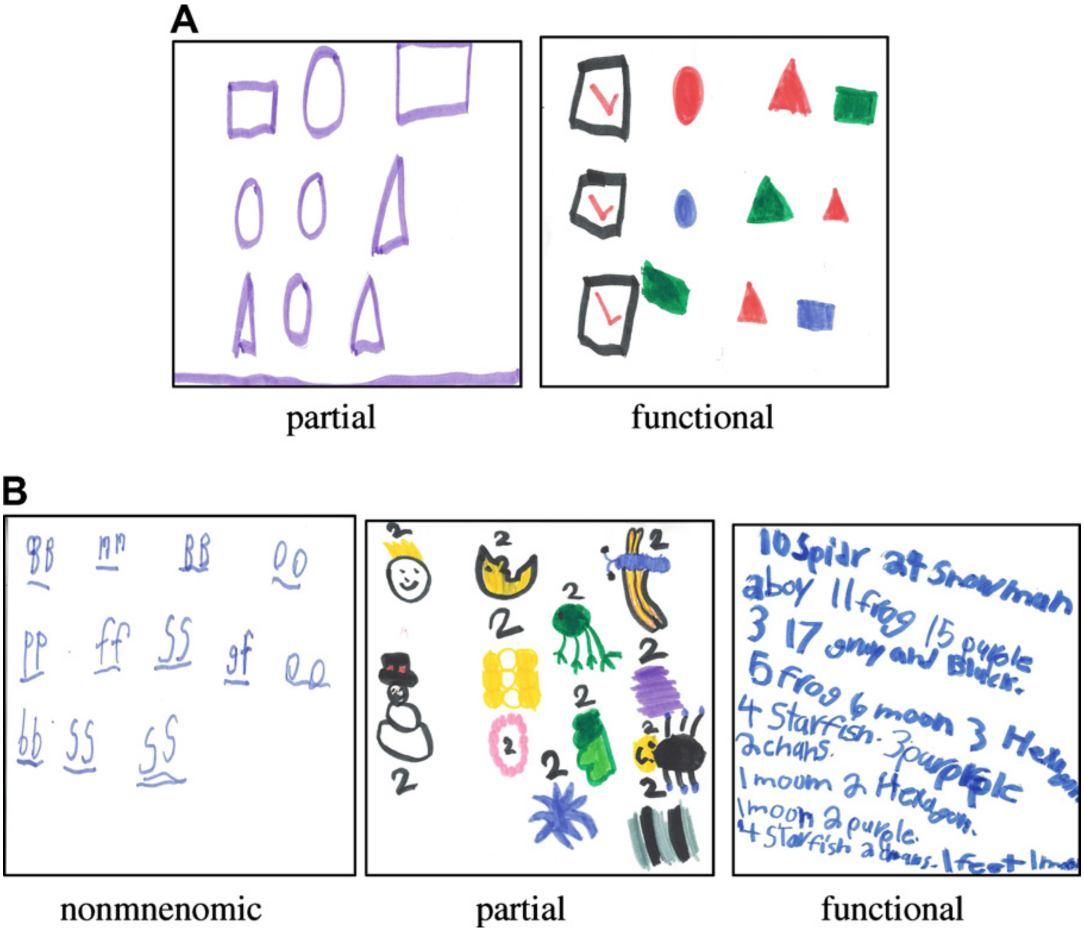

Fig. 1. Examples of different types of notations produced by children from the Store task (A) and the Concentration task (B).

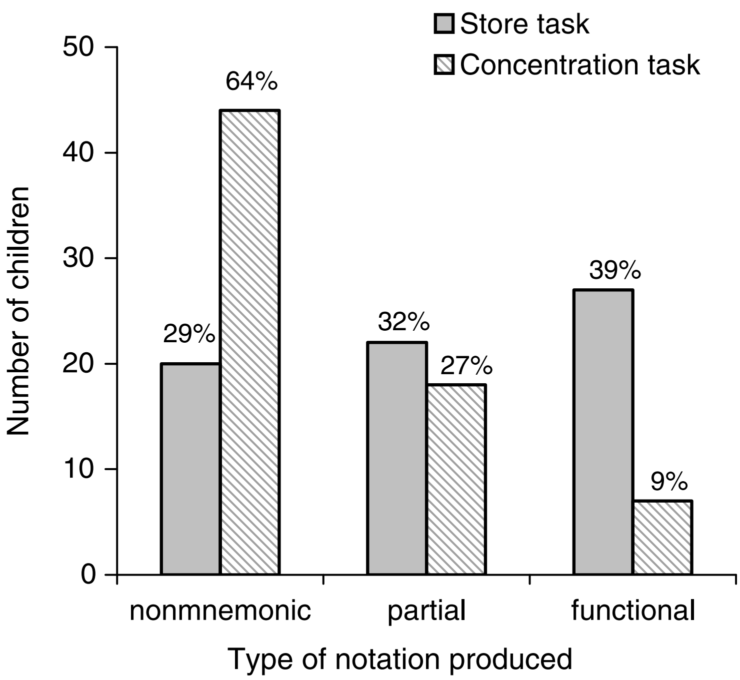

Fig. 2. Number of children producing each of the different notational types for the Store and Concentration tasks in Experiment 1.

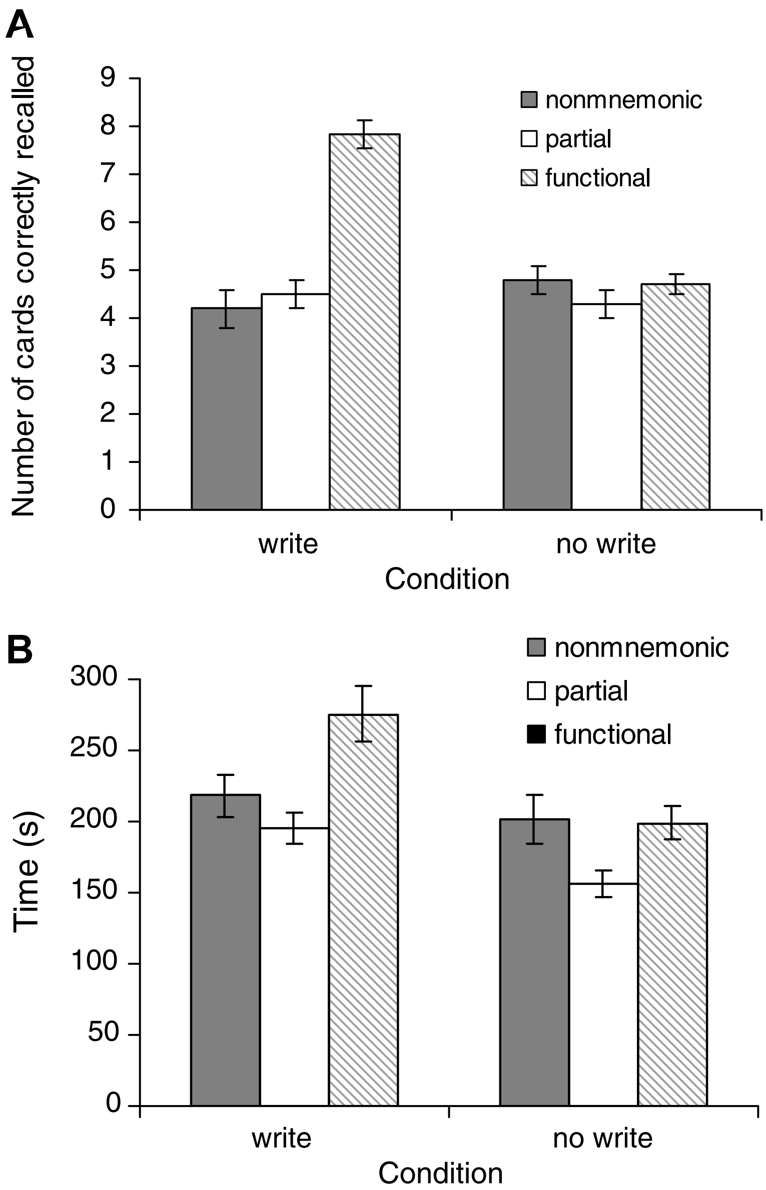

Fig. 3. Children's performance in Experiment 1 on the Store task measured in terms of the mean number of correct cards recalled within the orders (A) and the length of time needed to complete the task (B).

between the write and no write conditions for children who produced nonmnemonic or partial notations. This is not surprising for children in the nonmnemonic category given that nearly all of them did not produce notations and, therefore, their write condition was very similar to the no write condition. Producing partial notations, however, was also unrelated to performance. On the other hand, there was a significant difference between the write and no write conditions when children produced full notations. In addition, children who produced full notations performed significantly better than children in the nonmnemonic and partial categories in the write condition but not in the no write condition. These findings indicate that children who made full notes performed better on the Store task when they were given the opportunity to make notes than when they were not. These results also indicate that these children performed better than children who made less useful notes (i.e., partial) for the task.

The length of time needed for children to complete the Store task was also explored (see Fig. 3). A 2 (Condition: write or no write) $\times$ 3 (Notational Type: full, nonmnemonic, or partial) ANCOVA, covarying out the effect of age, was performed. A significant main effect was found for notational type, $F(2, 54) = 8.82$, $p < .001$, $\eta^2 = .25$. Post hoc analyses indicated that children who produced full notations took significantly longer in general on the task compared with children who produced partial notations ($p < .05$). The covariate of age was also significant, $F(1, 54) = 7.41$, $p < .01$, $\eta^2 = .12$. There was a significant negative correlation between time to complete the task and age in the no write condition, $r(59) = -.29$, $p < .05$. No other significant differences were found (condition: $F(1, 54) = 0.53$, *ns*), although the interaction between notational type and condition did approach significance, $F(1, 54) = 3.11$, $p = .06$.

Performance on the Concentration task

A 2 (Condition: write or no write) × 3 (Concentration Task Notational Type: full, nonmnemonic, or partial) ANCOVA, covarying out the influence of age, was conducted on the number of turns it took children to complete the Concentration task. No significant differences were found except age as a covariate, $F(1, 62) = 6.55$, $p < .05$, $\eta^2 = .10$. The same results were found when children in the nonmnemonic category were separated into those who made nonmnemonic notes and those who produced no notes at all. As can be seen in Fig. 4, the type of notations children produced did not appear to be related to task performance, $F(3, 62) = 1.38$, *ns*. Children's performance also did not differ significantly when they had the opportunity to make notes compared with when they did not have that opportunity, $F(1, 62) = .02$, *ns*. However, there was a significant positive correlation between children's memory performance and age for both the write condition, $r(66) = .31$, $p < .05$, and the no write condition, $r(66) = .29$, $p < .05$.

It should be noted that although children producing full notations for Concentration included information on both identity and location of the cards, the quality of the children's notations was not as informative as notations typically created by adults or older children for this task (Eskritt & Lee, 2002; Eskritt, Lee, & Donald, 2001). In particular, children had difficulty in representing the location of the cards. Specifically, when children attempted to use a coordinate system, they miscounted and mixed up the columns and rows when trying to represent this information in their notations. This is evident in the scores children received on the quality of notations scale. Although children scored high on differentiating the different cards ($M = 1.8$ [of 2], $SD = 0.41$) and on the completeness of their notations ($M = 2.7$ [of 3], $SD = 0.82$), they received the minimum score required on the relational scale to still be considered a full notation ($M = 1.0$ [of 3], $SD = 0.0$).

Once again, the length of time that children took to play each game of Concentration was examined. Due to problems with the videotapes, the time measurements could not be made for 4 children. A 2 (Condition: write or no write) × 3 (Concentration Task Notational Type: full, nonmnemonic, or partial) ANCOVA, with age as a covariate, was performed. A significant main effect was found for condition, $F(1, 59) = 3.97$, $p < .05$, $\eta^2 = .06$, and notational type, $F(2, 59) = 10.09$, $p < .001$, $\eta^2 = .25$, which were qualified by a significant interaction between condition and notational type, $F(2, 59) = 26.58$, $p < .001$, $\eta^2 = .47$. Analysis of simple effects revealed that in the write condition, children producing full notes took significantly longer to play the game than did children producing partial notes, who also took significantly longer than children producing nonmnemonic or no notes. The covariate of age was not significant. The same pattern of results was found when children in the nonmnemonic category were divided into those who made nonmnemonic notations and those who did not produce any notes at all.

Comparison of tasks

Table 1 compares the type of notation produced by children for both the Store and Concentration tasks. Only 1 child placed in the nonmnemonic group in the Store task produced notes containing any relevant task information in the Concentration task. However, it should be noted that this child actually did not make notes in the Store task; therefore, it is unknown whether the child did not know what information to notate in the Store task or whether she simply chose to not make notes. In addition, all other children producing useful notations in the Concentration task also made these types of notes in the Store task. Therefore, the types of notations produced by children follow the predicted pattern, with children tending to use more sophisticated notational strategies on the Store task than on the Concentration task.

To gain a fuller picture of how performance on one task may be related to performance on the other task, children were divided into groups depending on the types of notations they made in the Store

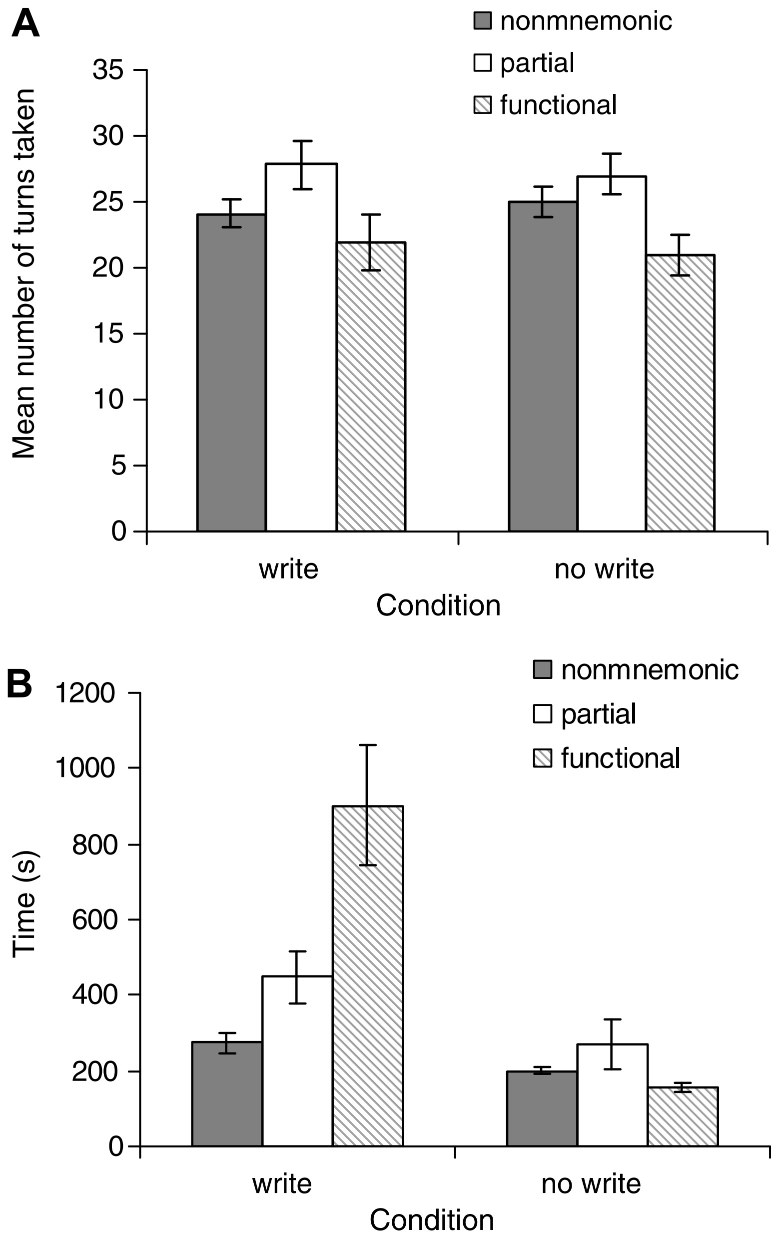

Fig. 4. Children's performance in Experiment 1 on the Concentration task measured in terms of the mean number of turns needed to win the Concentration game (A) and the length of time needed to complete the games (B).

Table 1
Types of notations produced by children in the Store and Concentration tasks for Experiment 1

Store task notational type	Concentration task notational type			
	No notes	Nonmnemonic	Partial	Functional
No notes	16	0	0	1
Nonmnemonic	0	1	0	0
Partial	9	4	8	1
Functional	9	6	10	4

task. Their performance on the Concentration task was examined to determine whether type of notes produced in the Store task was indicative of performance on the Concentration task. Once again, a 2 (Condition: write or no write) $\times$ 3 (Store Task Notational Type: full, nonmnemonic, or partial) ANCOVA, with age as a covariate, was conducted, and only the covariate of age was significant, F(1,

63) = 7.39, $p < .01$, $\eta^2 = .11$. Fig. 5 illustrates how notational type produced for the Store task was unrelated to performance on the Concentration task. Children producing full notations in the Store task did not appear to perform any better on the Concentration task than those producing partial or nonmnemonic notations in the Store task (condition: $F(1, 63) = 0.02$, *ns;* store task notational type: $F(2, 63) = 0.73$, *ns;* Condition × Store Task Notational Type: $F(2, 63) = 0.28$, *ns*).

Discussion

Experiment 1 presented children with two memory tasks of differing task constraints to determine whether the type of notations produced would vary with the type and quantity of information required to successfully complete the tasks. Although most children did not produce full notations in the difficult task, 39% (27 of 69) were successful note takers in the easier task. Thus, the inability to produce adequate notations in one task was not an indication that the children could not make useful notations for a memory task in general. Furthermore, the different types of notations that children produced fell into the predicted pattern, with 97% of children producing notations that were either the same type across tasks or producing more sophisticated notational strategies in the Store task than in the Concentration task. These findings support Triona and Klahr's (2007) hypothesis that task constraints are related to the quality of notations produced by children.

Experiment 1 also revealed that the production of full notations was related to improved performance on the Store task. Previous research has found that the quality of notations is related to performance (Bialystok & Codd, 1996; Eskritt & Lee, 2002; Hughes, 1986). However, it has been unclear whether the superior performance is due to the use of better quality notes or to the possibility that children who produce higher quality notes are also simply better at the memory task. The results of the current experiment suggest that the superior performance is influenced by the quality of notes. Children's performance on the Concentration task was unrelated to whether children were placed in the full, partial, or nonmnemonic category in the Store task. Therefore, it is likely that children's superior performance on a memory task is due to use of full notations and not simply to more advanced skills in performing memory tasks.

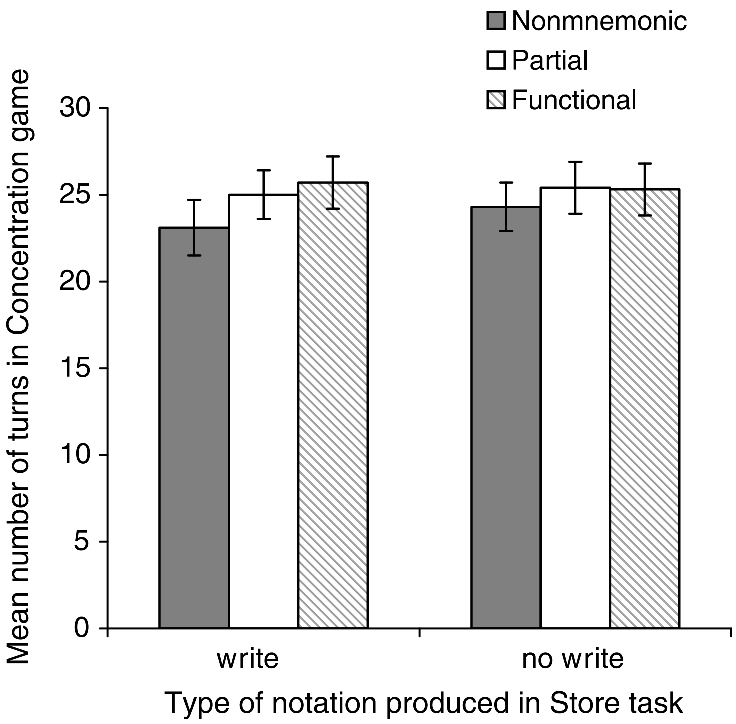

Fig. 5. Mean number of turns needed to win the Concentration game by children producing different notational types for the Store task in the write and no write conditions of Experiment 1.

This conclusion is bolstered by the unusual finding that children who produced full notes for the Concentration task did not perform better in the write condition than in the no write condition. This finding is contrary to research by Eskritt and Lee (2002), who found that full notes did aid memory performance on the Concentration task for children. However, the age range of children in Eskritt and Lee's study was much broader, and those who produced full notations in that study did not have difficulty in representing location information as did the children in the current experiment. When the quality of full notations was examined for children in the current experiment, their scores for relational information were quite low. Therefore, the notations were probably of limited use for aiding them in the memory task. Although children's ability to produce full notations for the Concentration task at this age is quite exceptional (Eskritt and Lee did not find any children in this age group who could), their memory performance did not differ from children who produced partial or nonmnemonic notations.

Another possible explanation for why children may demonstrate better memory performance when producing full notations is that taking notes forces them to study the cards for a longer period of time. Therefore, the benefits of note taking are indirect and related to time on task rather than to the use of notes in the task. The results suggest that, at least for this experiment, the superior performance in the write condition for children producing full notations in the Store task was not due to spending extra time on the task. They did take a significantly longer time to complete the task, but they did so across both the write and no write conditions, and their memory performance differed from the other groups only in the write condition. Furthermore, children in the full notation group for the Concentration task took a significantly longer time in the write condition compared with the other groups and their own performance in the no write condition, but their performance was not significantly better. Eskritt and Lee (2002) also found that when they controlled for study time, participants still did better when they were permitted to make notes. Thus, although length of time taken on a task may have the potential to sometimes influence the beneficial effects of note taking on memory, this would be only a partial explanation for the beneficial role of note taking.

Experiment 2

Experiment 1 found that children's ability to make adequate notes to aid memory is influenced by the nature of the memory task. Therefore, children may know how to use notes to aid memory but may lack knowledge about the type of information that would be useful to include or how to represent that information for more demanding tasks. Based on this line of reasoning, children may be able to produce functional notes for more difficult memory tasks if they are shown what task information would be helpful to include in their notations and how to represent it.

There is some evidence to suggest that it might be possible to teach children how to make functional notes. A few studies have examined the ability of children to judge the value of notations produced by someone else (Bialystok & Codd, 1996; Eskritt & Olson, 2001; Lee, Karmiloff-Smith, Cameron, & Dodsworth, 1998). For example, Lee and colleagues (1998) found that 8- to 10-year-olds were better able to choose functional notes from a group of ready-made notations than to produce them on their own, and even children who produced nonfunctional notations often chose functional ready-made notations to use when given the opportunity. These findings suggest that it may be possible for children who produce nonmnemonic notations to recognize the relevant information when shown. They then may be able to incorporate that information into their notes if it is actively brought to their attention. Thus, Experiment 2 explored whether children could produce functional notations if relevant information was highlighted for them.

Experiment 2 had several goals. The first was to examine whether children who did not spontaneously produce useful notes for a memory task could be taught to make these kinds of notations. Eskritt and Lee (2002) found that children around 10 years of age made a range of different notational types for the Concentration task, from adult-like functional notations to nonmnemonic notations. Therefore, we decided to look at this older group of children for Experiment 2. Not only are they more likely to produce a range of different notational types, but also their full notations are more likely to resemble the types of notations made by adults. Furthermore, Eskritt and Lee found that older children who produce functional notations for the Concentration task do perform better on the task, allowing us to examine whether children with training in note taking could benefit in terms of memory performance.

We first determined the type of notes produced by children at this age in our sample on the Concentration task. Those who produced nonmnemonic notations or no notes were given brief training in how to make functional notations for the task. To examine the possible impact of this notational training on memory performance, children played two games of Concentration: one with the opportunity to make notes and one without that opportunity. Finally, the performance of children who were taught to make functional notes was compared with the performance of children who spontaneously produced functional notes to see whether they differed.

Method

Participants

To control for education level, children were recruited from Grade 5 classrooms in schools throughout Nova Scotia. Participants were 60 9- to 11-year-olds (mean age = 10.7 years, *SD* = 0.49). Of these children, 2 were 9-year-olds, 38 were 10-year-olds, and 20 were 11-year-olds. In addition, 31 of the participants were girls and 29 were boys. None of the children who participated in Experiment 2 participated in either Experiment 1 or 3.

Materials

The practice and experimental decks for the Concentration task used in the first experiment were used in the current experiment.

Procedure

Children were tested individually in a quiet corner at their school. The rules of the game were explained, and children played a practice game to ensure that they understood the rules. Children then played another three games of Concentration: one more practice game and then two games with the experimental deck. During the second practice game, children were given a piece of paper and markers and asked to "write down or draw anything you think will help you win the game in as few turns as possible." The paper and markers were left beside the children so that they could use them to make notes during the second practice game.

Children who produced notes containing information helpful for aiding memory performance during the second practice game were assigned to the spontaneous note-taking group and did not receive any instruction on a functional note-taking method. Children who did not produce notations or who produced nonmnemonic notes during the second practice game were assigned to the trained note-taking group and were shown how to make functional notes by the experimenter before proceeding to the experimental trials. The experimenter used the practice deck to show the children that the cards were laid out in grid formation and that this grid could be used when they were making notes. The experimenter drew a 4 × 2 grid on the paper to represent the practice cards and turned over 2 random cards in the array. The experimenter then showed the child that the identity and location of the 2 cards in the array could be represented using the grid drawn on the paper. This notation strategy was chosen as the strategy to teach the children in the nonmnemonic note-taking group for two reasons. First, the strategy involves representing information about the identity and location of cards in the array within one's notes, which is necessary information for aiding task performance. Second, this strategy is the one most frequently used by children who produce functional notes spontaneously (Eskritt & Lee, 2002). The training phase took approximately 1 min. After training, the notes the experimenter made to teach the strategy were placed out of the children's sight, and children were not directly instructed to use this note-taking strategy.

Following the two practice games, children in both groups were shown the experimental deck of cards and then the cards were placed face down in a 6 × 4 array. Children played two games of Concentration with the experimental deck: one with the opportunity to make notes (i.e., write condition) and one without that opportunity (i.e., no write condition). The order of the two conditions was counterbalanced. Each session was videotaped and took approximately 25 to 30 min.

Scoring

In addition to children's notations being categorized as functional or nonmnemonic, the quality of children's functional notations was again evaluated using the scale developed by Eskritt and Lee (2002). Interrater agreement for children's scores on the quality of notations scale was 92%.

Results

Quality of notations

Of the 60 children who participated, 27 made functional notes in the practice game and were assigned to the spontaneous note-taking group. The remaining 33 children made nonmnemonic notes in the practice game and were assigned to the trained note-taking group. Following training, 73% (24 of 33) of the trained note takers produced functional notes in the write condition of the experimental game. The scores on the quality of notations scale were high for both the spontaneous and trained note-taking groups. The mean total score for the spontaneous note-taking group was 7.7 ($SD = 0.5$), and the mean total score for the training group was 7.3 ($SD = 1.4$), out of a possible score of 8. An independent samples t test was conducted to compare the total mean scores on the quality of notations scale for the trained and spontaneous note takers. Only children who made functional notes in the write condition were included in this analysis. No significant difference was found, suggesting that spontaneous and trained note takers did not differ in the quality of functional notations produced in the write condition of the experimental game.

Of the children in the trained note-taking group, 9 did not produce functional notes for the task after training. Of these 9 children, 5 did not produce any notes and 4 made nonmnemonic notes. However, note that not all of the children in the spontaneous note-taking group produced notes in the write condition of the experimental game either; of 27 children, 3 chose not to produce notes.

The content of nonmnemonic notes produced by the trained children for both their practice and experimental games was also examined. In the practice games, 3 of the children wrote instructions to themselves about how to play the game (e.g., "When I flip a card up, I remember where the card is"), and 1 child could not think of anything to write. In contrast, for the experimental game after they received training, 1 child drew a grid before the game started but chose not to fill it in during the game, and 2 children's notes at least contained information relevant to the task but not useful to aid their memory (e.g., drawing the cards as the child found the pairs). In addition, 1 child still made notes that did not reference the relevant information for the task after training (i.e., she wrote "trust your heart").

Performance on task

To examine the effects of functional note taking on memory performance, further analyses include only children who produced functional notes in the write condition of the experimental game. A preliminary ANCOVA established that order of presentation for the write and no write conditions did not influence performance across different notational types; therefore, data were collapsed across this variable. The mean number of turns taken to win the game by spontaneous and trained note takers in the two conditions can be seen in Fig. 6. A 2 (Condition: write or no write) $\times$ 2 (Group: spontaneous or trained) ANCOVA, with age as a covariate, was performed to examine the number of turns taken to win the game by spontaneous and trained note takers in the write and no write conditions. The analysis indicated a significant main effect for condition, $F(1, 45) = 21.40$, $p = .001$, $\eta^2 = .32$. Children generally took significantly fewer turns in the write condition than in the no write condition. Therefore, taking notes assisted in task performance for both the spontaneous and trained note takers. The main effect for the note-taking group, $F(1, 45) = 3.70$, *ns,* the covariate of age, $F(1, 45) = 1.10$, *ns,* and the interaction between group and condition, $F(1, 45) = 2.38$, *ns,* were not significant. Trained note takers did not differ in the number of turns taken to win the game compared with spontaneous note takers in either condition.

A 2 (Condition: write or no write) $\times$ 2 (Group: spontaneous or trained) ANCOVA, with age as a covariate, was also performed to compare the length of time needed to complete the games under the write and no write conditions (see Fig. 6). Although the Condition $\times$ Group interaction approached significance, $F(1, 37) = 3.78$, $p = .06$, no significant effects were found (condition: $F(1, 37) = 0.16$, *ns;*

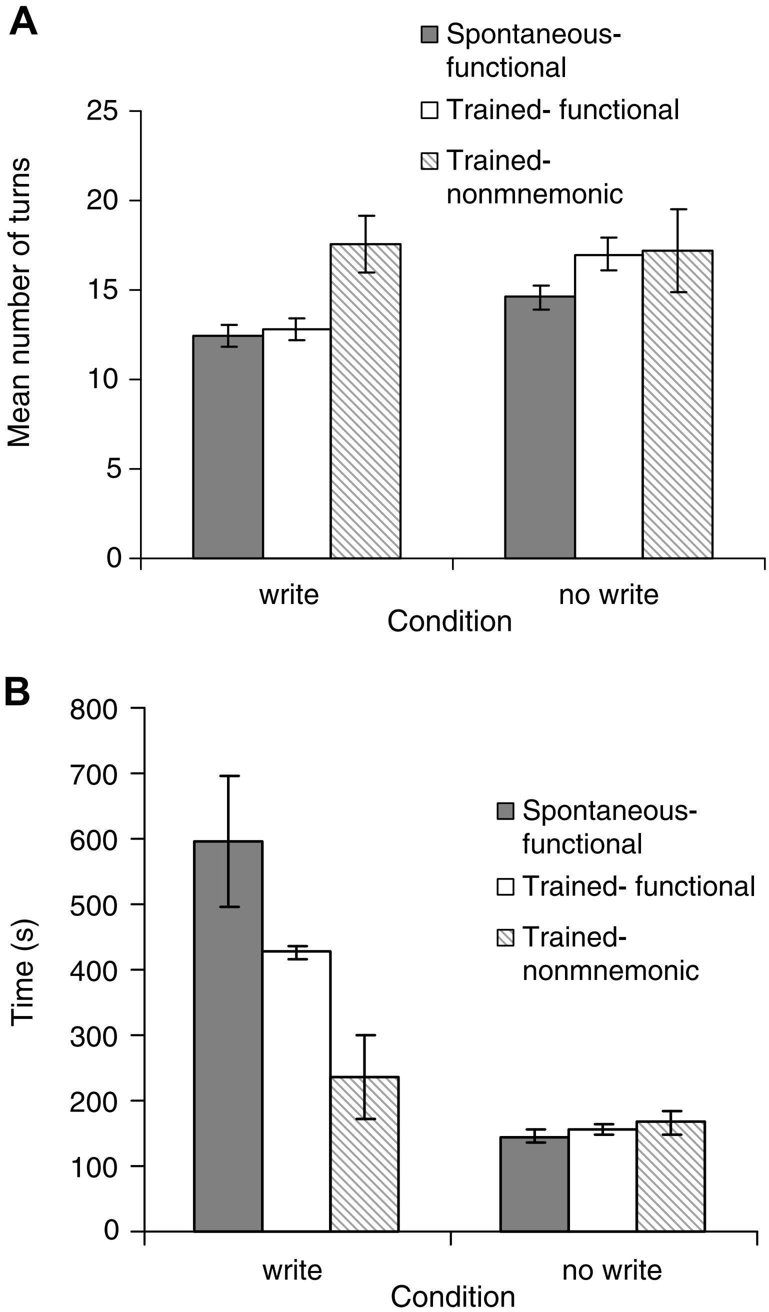

Fig. 6. Children's performance in Experiment 2 measured in terms of the mean number of turns needed to win the Concentration game (A) and the length of time needed to complete the games (B). The time for the spontaneous group includes the data from the two potential outliers. Children are also divided by whether they produced functional or nonmnemonic notes (including no notes) in the write condition.

group: $F(1, 37) = 2.55$, *ns*). Two children in the spontaneous group took particularly long in the write condition (23 and 30 min each) and might be considered as outliers. The removal of their times from data analysis did not change the pattern of results.

Discussion

Experiment 2 examined whether children who do not produce useful notations for a memory task (i.e., Concentration) could be taught to make notes and, if so, whether the quality of those notes differed from notes produced by children who spontaneously made useful notes. As expected, most of the children (i.e., nearly three-quarters) in the trained note-taking group produced functional notes after training. In addition, despite the training being very brief, there was no significant difference in the quality of notations produced by children who were taught how to make useful notes compared with children who spontaneously produced these kinds of notes. These findings support the suggestion that children who do not produce functional notes for Concentration may be aware of how to use notes as part of a memory strategy but might not know what information would be useful to include in their notes or how to represent that information using notes for a specific task. Once the children in the current experiment were shown the notation strategy, most were able to produce the strategy for the task and the quality of those notes was high, as indicated by the children's scores on the quality of notation scale. Furthermore, trained note takers benefited from producing notations by performing significantly better in the write condition than in the no write condition.

Trained and spontaneous strategy producers benefited from the use of notations, and both benefited to a similar degree in the Concentration task. This contrasts with the literature examining training in internal memory strategies. Many of these studies have found that children will exhibit a utilization deficiency during the initial stages of acquiring a memory strategy (Bjorklund, Miller, Coyle, & Slawinski, 1997). Some researchers have suggested that strategy implementation requires a great deal of mental effort, and this may hinder the ability of children to benefit from the strategy if they are not familiar with it, resulting in a utilization deficiency (Bjorklund et al., 1997; De Marie-Dreblow & Miller, 1988; Fletcher & Bray, 1997; Miller, Woody-Ramsey, & Aloise, 1991). Research does suggest that when this mental effort is reduced or eliminated, utilization deficiencies are not found (Bjorklund et al., 1997; De Marie-Dreblow & Miller, 1988; Fletcher & Bray, 1997; Miller et al., 1991). A study by Fletcher and Bray (1997) examined children trained on the use of external aids to help in problem solving and also found no evidence of a utilization deficiency. These authors suggested that strategies employing external aids allow information important for task performance to be represented externally, which lessens the demand on children's internal cognitive resources. This in turn reduces the likelihood of a utilization deficiency occurring in trained children because they are able to devote more cognitive resources to performing the task than would be the case if they needed to represent all the task information internally.

In the current experiment, the demands made on children's mental capacity for producing functional notations were independent of the capacity demands for remembering. Once children used mental resources to make functional notations, they would need fewer resources for remembering. Furthermore, children had unlimited time to perform the task. With internal memory strategies, capacity for study and capacity for remembering come from the same pool of cognitive resources. Thus, using more of one's limited capacity to perform a study strategy would take away from one's capacity to remember. However, utilization deficiencies could still occur with external memory strategies if the cognitive demands are too high. For example, children producing full notations in the Concentration task for Experiment 1 could be argued to have shown a utilization deficiency because their performance was not aided by their notes. Therefore, one would expect utilization deficiencies to occur more frequently with internal memory strategies and to be less likely when using notation as a memory strategy.[1]

Another possible explanation for why trained children in the current experiment showed no evidence for a utilization deficiency is because they were not learning a new strategy but rather being shown how to adapt a strategy with which they were already familiar (i.e., note taking) to a novel situation. If indeed children in the trained group understood how note taking can benefit memory performance but were only unsure of how to represent the relevant information, then they would not necessarily show a utilization deficiency. It is also possible that both the reduction in mental resources created by notational use and the benefits of using a familiar strategy may have contributed to the trained group's impressive performance. Which of these alternatives is correct is a question for future research.

If it is the case that children are aware of the mnemonic potential of note taking and it is the knowledge of relevant task information that prevents them from producing useful notes, then when shown this information children should be able to make useful notes not only for the specific task on which

[1] We thank an anonymous reviewer for suggesting this possibility.

they were trained but also for different tasks so long as the types of task information to be represented remain the same. The ability of children to generalize their note-taking training to a different task was examined in Experiment 3.

Experiment 3

The results of Experiment 2 indicate that children who were trained to make functional notations did not differ in the quality of notes produced compared with children who spontaneously produced functional notes. Furthermore, children in the trained group had significantly better memory performance when they produced functional notations than when they were not permitted the opportunity, and their memory performance was comparable to that of children in the spontaneous group. The purpose of the third experiment was to determine the robustness of the knowledge and understanding the children acquired from training by examining whether they could transfer what they learned to a different version of the game.

Children were again divided into either the spontaneous note-taking group or the trained group. They then played two games of Concentration. However, rather than place the cards in a grid formation, for one of the games the cards were placed in a circular formation. Thus, the groups' ability to make notes for each array type could then be compared.

Method

Participants

A total of 111 9- to 11-year-olds were recruited from Grade 5 classrooms in schools throughout Nova Scotia. Due to problems with video equipment, 7 children were not included in the data analysis. An additional 2 children chose to withdraw from the experiment (1 child cited fatigue and the other child cited anxiety). Therefore, 102 children (with an equal number of girls and boys) were included in data analysis (mean age = 10.4 years, *SD* = 0.55). Of these children, 18 were 9-year-olds, 73 were 10-year-olds, and 11 were 11-year-olds.

Materials

The deck of cards for the Concentration game used in the current experiment was similar to that used in the previous two experiments except that this deck consisted of 20 cards with 10 matching pairs. The number of cards was reduced slightly in the current experiment because children were asked to make notes for three different games.

Procedure

As in the previous experiments, children were tested individually at their school. First, the rules of the Concentration game were explained, and children played a practice game to ensure that the rules were understood. The children then played three more games of Concentration: a second practice game and two experimental games. Children were provided with markers and paper for all three of these games and were instructed to "write down or draw anything you think will help you win the game in as few turns as possible."

The purpose of the second practice game was again to determine what kind of notations children produced when given the opportunity to make notes for the Concentration task. Children making functional notes were assigned to the spontaneous note-taking group, whereas those producing non-mnemonic notes were assigned to the trained note-taking group or a control group. Children in the trained note-taking group received instruction on how to produce useful notes for Concentration similar to that of the second experiment. Children in the control group were not given any instruction to see how many would spontaneously produce functional notations in the experimental games.

After completing the practice games, children were shown the experimental deck of cards and played two more games of Concentration with this deck. All children played one experimental game with the cards laid out to form a 5×4 grid and one experimental game with the cards in a circular formation. The order of the two conditions was counterbalanced. Children assigned to the grid-first condition played both practice games and the first experimental game with cards forming a grid. Those assigned to the circle-first condition played the practice games and the first experimental game with cards forming a circle. Children in the trained note-taking group who played the grid first were trained with cards forming a grid, whereas trained note takers who played the circle first were trained with cards forming a circle. Unlike the first two experiments, children in the current experiment were permitted to make notes in both experimental games. Each session was videotaped and took approximately 30 min.

Scoring

In addition to children's notations being rated as functional or nonmnemonic, the quality of children's functional notations was evaluated using the same scale as in the previous two experiments. Interrater agreement for children's scores on the quality of notations scale was 92%.

Results

Quality of notations

Of the 102 children, 45 spontaneously made functional notes, whereas 57 did not make functional notes. Of these 57 children, 33 were trained and the other 24 served as controls. Table 2 displays the numbers of children producing the different types of notations. Among the trained note takers, 61% (20 of 33) of the children made functional notations in their first experimental game where they made notes on the array type in which they had been trained. Despite training, 13 children in the trained group produced nonmnemonic notes in their first game, and 7 of these children produced no notes at all. Of the children who produced nonmnemonic notations, 3 wrote instructions to themselves and 3 drew the array but then did not fill it in. In contrast, for the practice game, 4 children wrote instructions to themselves, 1 child drew two rectangles that might have represented the cards, and 1 child could not think of anything to write. For spontaneous note takers, 7 children also did not make any notes in their first experimental game and 3 children drew the array (e.g., made a grid) but did not fill in the location of cards.

Of those 20 trained children who produced functional notations for the first experimental game, the majority continued to make functional notations for the array on which they had not been trained. Fifty-eight percent (19 of 33) of children produced functional notations in their second game. It might appear that only 1 child did not generalize the training, but in fact 3 children did not and 2 children produced functional notations in their second game, although they did not produce them in the practice game or first experimental game. Both of these children experienced the circle array during the two practice games and first experimental game and then produced functional notations in the final grid condition. Of the 24 children in the control group, 4 spontaneously made notes, 1 in the first experimental game and the other 3 in the second experimental game. Of these children, 3 produced

Table 2
Numbers of children (and percentages) producing different types of notations across games and groups

Group	Game 1	Game 2
Trained (n = 33)		
Functional notations	20 (61)	19 (58)
Nonmnemonic notations	6 (18)	7 (21)
No notes	7 (21)	7 (21)
Spontaneous (n = 45)		
Functional notations	35 (78)	31(69)
Nonmnemonic notations	3 (7)	0
No notes	7 (16)	14 (31)
Control group (n = 24)		
Functional notations	1 (4.2)	3 (12.5)
Nonmnemonic notations	8 (33.3)	7 (29.2)
No notes	15 (62.5)	14 (58.3)

Note. Percentages are in parentheses.

functional notes for the grid array and 1 child did so for the circular array. The rest of the children either continued to produce nonmnemonic notes or made no notes at all.

A 2 (Group: spontaneous or trained note takers) × 2 (Order: grid first or circle first) × 2 (Array: circle or grid) ANCOVA, with age as a covariate, was performed on the quality of notations scores of children who made functional notes for both array types. A significant main effect for array was found, $F(1, 41) = 17.21$, $p = .001$, $\eta^2 = .30$, with children (regardless of whether they were trained or not) receiving higher scores on their notations for the grid array ($M = 7.5$, $SD = 1.1$) than for the circular array ($M = 6.8$, $SD = 1.2$). There was also a significant interaction between group and order, $F(1, 41) = 10.26$, $p = .03$, $\eta^2 = .10$. Analysis of simple effects revealed that children trained with a circular array ($M = 6.7$, $SD = 1.4$) made notations that were significantly poorer than did children who spontaneously produced functional notations for the circular array first ($M = 7.6$, $SD = 0.7$). In general, it appears that children had more difficulty in notating the circle array than in notating the grid array. The covariate of age was not significant.

Performance on task

Preliminary ANCOVAs indicated that order of array presentation did not make a significant difference in performance; therefore, data were collapsed across this variable. The mean number of turns

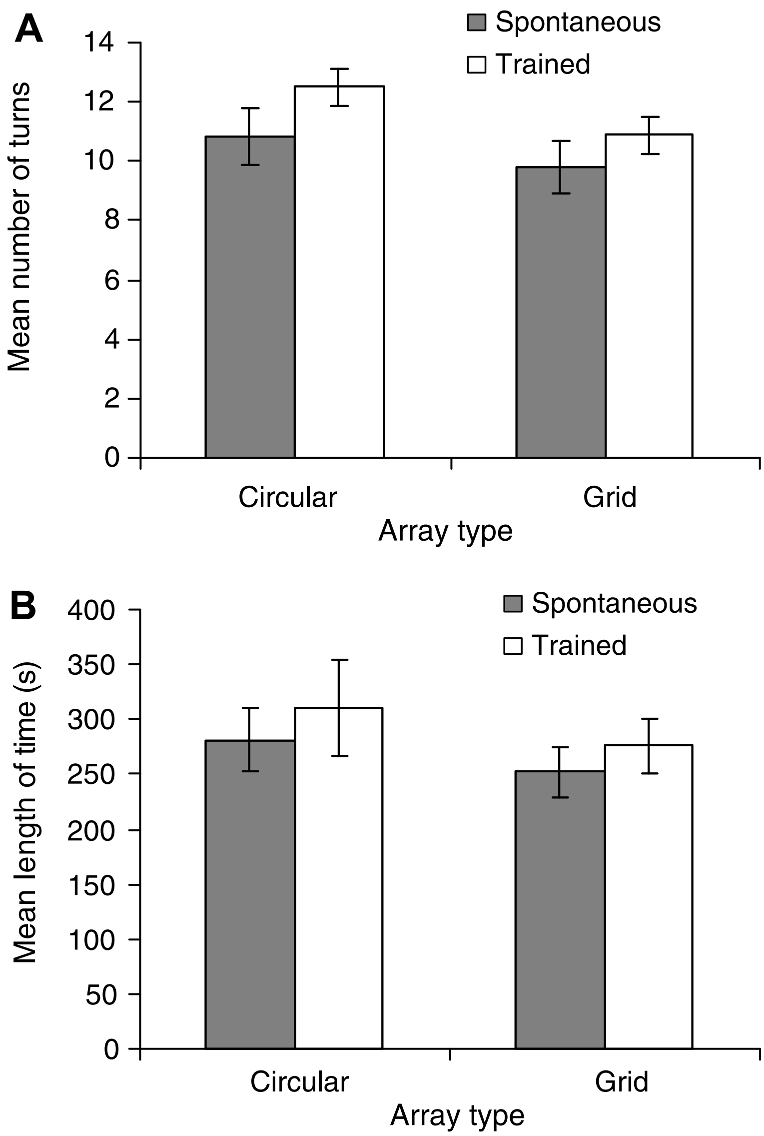

Fig. 7. Children's performance in Experiment 3 measured in terms of the number of turns needed to win the Concentration game (A) and the length of time needed to complete the games (B).

taken to win the game by spontaneous and trained note takers in the two conditions can be seen in Fig. 7. The figure and further analyses include only children who produced functional notes across the two games. A 2 (Group: spontaneous or trained note takers) $\times$ 2 (Order: circle first or grid first) $\times$ 2 (Array: circle or grid) ANCOVA, with age as a covariate, was conducted on the number of turns taken to win the game. No significant main effects (group: $F(1, 42) = 2.79$, *ns;* array: $F(1, 42) = 0.73$, *ns*) or interaction, $F(1, 42) = 0.05$, *ns,* were found.

Fig. 7 also displays the mean length of time children in each group took to play the different experimental games. Due to problems with the videotapes, data from 9 children could not be obtained; therefore, the analysis was conducted on only 54 children. A 2 (Group: spontaneous or trained note takers) $\times$ 2 (Array: circle or grid) ANCOVA, with age as a covariate, was conducted on the mean length of time. Again no significant main effects (group: $F(1, 49) = 0.22$, *ns;* array: $F(1, 49) = 1.00$, *ns*) or interaction, $F(1, 49) = 0.05$, p = *ns,* were found.

Discussion

The purpose of the third experiment was to determine whether children could generalize their training to a novel array type. Once again, the majority of children trained on the notational strategy produced functional notations during the first experimental game, lending confidence to the reliability of the findings in Experiment 2. To determine whether children who produced nonmnemonic notations during the practice game but received no training might spontaneously produce functional notations in the experimental games, a control group was also included in the third experiment. Only 4 of these children spontaneously produced functional notations in one of the experimental games, suggesting that it was the instruction that aided children in the trained group. Of those children in the trained group who produced functional notations in the first experimental game, 85% generalized their training and also produced functional notations in the second game. Furthermore, the quality of the notations was still high even though children trained on the circular array did not score quite as high on their notations as did the spontaneous group. Nevertheless, children trained on how to produce notations were able to generalize their understanding and did not differ significantly from children in the spontaneous note-taking group, suggesting some cognitive flexibility in the trained groups' understanding of what they were shown.

General discussion

The purpose of the current study was to examine the effect of task constraints on children's ability to produce and use notations as a memory aid. The findings of Experiment 1 revealed that although young children may produce nonmnemonic notations for one task, this does not imply that they cannot make functional notations for another memory task. Children who made functional notations in the Store task also performed better on that memory task regardless of the types of notations produced for another task. In addition, the production of functional notations for one task did not predict performance on another memory task. Therefore, age-related change alone cannot account for the production of nonmnemonic notations or the relationship between quality of notational production and memory performance. In fact, although the covariate of age was significant for some analyses, it was not for all of them, especially in Experiments 2 and 3.

This conclusion is further supported by the results of Experiment 2 indicating that most 9- to- 11-year-olds who do not initially produce functional notes for a memory task will produce useful notes and use them once the task information that is important to represent is made evident. In addition, when children in this age group who failed to produce functional notes were shown a method for representing the information in their notations, their ability to do so was comparable to that of children who spontaneously produced mnemonic notations for Concentration. The extent of their understanding after very brief training was further illustrated in Experiment 3 when children generalized their training to a novel variation of the same task.

Triona and Klahr (2007) argued that the influence of task constraints needs to be considered when examining children's notational ability. The notion that task demands influence performance is not new and is found across the developmental literature, from conservation to false belief tasks. However, understanding the specific types and nature of task features that influence performance can aid in comprehending a phenomenon better (Clément & Richard, 1997; Kotovsky, Hayes, & Simon, 1985; Wason & Shapiro, 1971; Zhang, 1997), and the influence of task constraints appears to be particularly relevant for understanding children's ability to produce functional notations for a task. There is large variability in ages found across studies regarding the quality of children's notational production, and this variability does not appear to be necessarily related to general task complexity. Instead, notational quality appears to be related to the type and quantity of information specifically required for producing useful notations. Perhaps it should not be surprising that task constraints are so important for notational production considering the results of research examining the effect of task constraints on problem solving in adults. Kotovsky and colleagues (1985) and Zhang (1997) both discussed the importance of the nature of external representations on problem-solving ability. Ideally, external representations should help to reduce the demands on working memory; however, the type of notations used can affect how helpful or unhelpful notations may be for a task. For example, some external representations of a task can help to reduce the load on memory and cognitive processing by highlighting rules or constraining some of the possible choices that could be made. It should be noted, however, that the studies by Kotovsky and colleagues (1985) and Zhang (1997) examined the effects of representations provided by the experimenter rather than produced by participants themselves.

The results of the current study support Triona and Klahr's (2007) conclusions. For example, although quantity of information is related to notational quality, it is the quantity of information that is required to be represented in functional notations that is important, not the overall quantity of available information present within the task. Thus, in Experiment 1, the overall number of cards in the Store task (i.e., 38 cards) was greater than the number of cards for the Concentration task (i.e., 24 cards), yet children found it easier to make notations for the Store task. The difference is that children needed to notate only 9 of the 38 cards for the Store task to produce functional notations. The quality of the information to be represented is also important. Across experiments, some types of information were easier to notate than were others. Although both the Store and Concentration tasks required two characteristics of the relevant stimuli to be represented, children still found the Store task easier to notate because their representations required focusing only on object information (i.e., color and shape), whereas for the Concentration task they needed to distinguish between cards as well as represent location and relational information. This is apparent in the finding that children who identified relevant information in their notations for the Concentration task also did so in their notations for the Store task, but producing functional notations in the Store task did not mean that children also produced functional notations in the Concentration task. These findings support Triona and Klahr's conclusion that location information appears to be more difficult for children to identify as relevant and determine how to represent in their notations.

Although Triona and Klahr (2007) started to lay out a framework for a better understanding of the influence of certain task features, more research is necessary to gain a more comprehensive understanding of the full effects of task constraints on children's notational production. As these authors pointed out, there are some types of information that research on notational production has not yet explored, including duration. However, the results of the current study suggest that even within a particular category of information, there is a need for further delineation. For example, the quality of children's notations in Experiment 3 varied across the grid and circle arrays; however, the types and quantity of information involved did not vary. One likely explanation for the difference is that the grid array had more reference points that children could use to help in locating cards. Using the sides of the grid, in particular, can help children to pinpoint the location of cards more easily, and this could aid in both the production and use of the notations. The circle array lacked easily identifiable reference points to use in a similar manner. Thus, an aspect of information that needs to be considered is how easy it is to extract the relevant information that is to be notated. The saliency of relevant information can certainly help to explain why certain categories of information are easier to notate (e.g., object information) than are others (e.g., location information); however, saliency of relevant information also needs to be considered within a particular category of information as well.

One possible explanation for why task constraints have such a large effect involves the demands they place on cognitive processing. It takes effort to extract the relevant task information and determine how to represent that information in notational form. Even the act of notational production itself would be expected to be more difficult for younger children than for older children given that note taking would not be as automatized for the former group. One of the benefits of using the types of memory tasks in the current study was that children did not need to rely on writing words for their notes and instead could use pictorial representations that could help to reduce the amount of effort in producing notations for younger children. Furthermore, because children were given unlimited time to perform the tasks, cognitive load would also be less of an issue. However, adding note taking to a memory task could be considered increasing the task demands because children now have two tasks to complete: the memory task and notational production. For nonmnemonic note takers, this would be particularly true because the notes they produce are unrelated to the task at hand. However, the issue of cognitive load is not straightforward. Despite the fact that nonmnemonic note takers are producing nonfunctional notes, the impact on performance is minimal at best. In the first experiment, no significant differences were found when comparing nonmnemonic note takers' memory performance in the write and no write conditions. Eskritt and Lee (2002) found similar results.

For functional note takers, the issue of cognitive load is also unclear. Various theorists have suggested that notations are more than a simple memory aid and become an intrinsic part of the task (Donald, 1991; Hutchins, 1996; Zhang, 1997), making the distinction between performing one task and performing two tasks more difficult to make. The strategy of note taking, according to these theorists, is that notations are produced and used to reduce cognitive load. However, in the first experiment, children who produced functional notations in the Concentration task did not perform better in the memory task. Although the quality of their notes was low in comparison with older children and adults in previous research (e.g., Eskritt & Lee, 2002), an additional issue may be cognitive load. It was exceptional that these children could produce functional notations, and the effort may very well have interfered with memory performance. Regardless, even if fully functional notations are produced with little difficulty, cognitive load can still play a role in terms of the way information is represented in the notes. As mentioned earlier, research examining the role of external representations in problem solving (Kotovsky et al., 1985; Zhang, 1997) has found that the types of external representations used in a task can structure and constrain the nature of the task, making it more or less difficult to complete.

Although the current study found that with remarkably brief training most children were able to produce functional notations, there were still a few children in Experiments 2 and 3 who made nonmnemonic notations during the experimental games. An interesting question is why these children did not benefit from training. Too few children produced nonmnemonic notations after training to explore this issue fully; however, a closer examination of their notes can hint at some possibilities. Of the 10 trained children across Experiments 2 and 3 who produced nonmnemonic notes immediately after training, 5 produced notes that showed evidence of knowing the relevant task information to put in their notes (i.e., location information) and in fact might have understood the strategy but not followed through with it (e.g., drawing the array but not filling in the cards). This is in contrast to notes produced in the practice game, where these same children either wrote instructions to themselves or could not think of anything to notate. Thus, training did appear to help somewhat.

On the other hand, 5 of the children did not appear to benefit from training at all. They continued to produce notes that did not contain any task-relevant information (e.g., wrote instructions to themselves on how to play the game, drew a picture). They might not have understood the strategy behind the notations produced by the experimenter. Alternatively, they may have had problems understanding how to represent the relevant information even though it was demonstrated in training. Such an explanation is further supported by the finding that children in Experiment 3 who made functional notations still found the circular array more difficult to notate even though the underlying principle was the same. Although children may have some understanding of using notations as a memory aid, they might not yet be able to comprehend how to represent the relevant information for certain tasks. These findings suggest how task constraints might interact with age-related change to influence the types of notations children produce. Researchers have typically examined the adequacy of functional notations and the types of information that are missing or represented in a problematic manner. Future research is needed to examine more closely the different forms that nonmnemonic notations can take and what they reveal about children's understanding of notation as a memory strategy.

Not all of the children in the current study produced notations when given the opportunity. In Experiment 1, only 1 child placed in the nonmnemonic category actually made nonmnemonic notes. The rest chose to make no notes at all. In Experiments 2 and 3, both the trained and the spontaneous note-taking groups contained children who chose to make no notes during the experimental games. As mentioned above, some children started to produce what appeared to be functional notations by drawing the array but then did not fill in the cards while playing the game. Therefore, knowing what information to incorporate and knowing how to represent it in note form are not the only variables affecting whether children will produce functional notes. Metamemory can play a role in notational production as well. These children may have overestimated their own memory capabilities and chose not to make notes as a result (Eskritt & Lee, 2002), and future research should use some form of metamemory assessment to examine this possibility further. Research with adults has shown that as the cost and effort of making notes increases, the likelihood of individuals producing and using notes in a memory task decreases (Cary & Carlson, 2001). Notes are meant to reduce cognitive load, but if they do not serve this function and require too much effort, they will usually not be used (Cary & Carlson, 2001). Like adults, children who did not make notes in the current study may have viewed the effort of making notes too great and the gains too little, and as a result they did not bother producing the strategy for the task.

The current study found that age-related change alone cannot account for children's production on nonmnemonic notations. Although age-related change inevitably plays a role, the results of the current study suggest that certain aspects of tasks, including the type of information important for performance, the saliency of this information, and the difficulty with which this information can be extracted, influence children's success in notational production. Children need to learn how to identify relevant information for their notations as well as how to incorporate them into the task (Liben, 1999). The challenge for future research is to further examine how these variables and variables not examined in the current study, such as metamemory and cognitive load, affect and relate to children's note taking.

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