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Effortful Control as a Mediator of Long-Term Declarative Recall in Toddlers

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Abstract

This study investigated the relationship between effortful control and long-term memory (LTM) in toddlers. It was hypothesized that children high in effortful control would demonstrate better long-term recall. Participants were 43 children who visited the lab at 18 and 21 months. A word-learning task and an elicited imitation task were administered to assess children's LTM. Effortful control was assessed using the Early Childhood Behavior Questionnaire (ECBQ). The results of this study showed that children high in effortful control did not demonstrate significantly better LTM than children low in effortful control on either the word-learning or the elicited imitation task.

Effortful Control as a Mediator of Long-Term Declarative Recall in Toddlers

Effortful control is defined as the ability to inhibit a dominant response in order to perform a subdominant response (Rothbart & Rueda, 2005). Elements of effortful control include attentional shifting and attentional focusing, and the important ability of sustaining attention. Effortful control is a form of self-regulation, which, more generally, refers to a child’s ability to manage stress and maintain focused attention. Effortful control allows a child to manage a fearful situation, as well as inhibit an automatic response (Rothbart & Bates, 2006). In two longitudinal studies, Kochanska and colleagues (Kochanska & Knaack, 2003; Kochanska, Murray, & Harlan, 2000) described five different varieties of effortful control, all related to the suppression of a dominant response in order to perform a subdominant one. These varieties include 1) the ability to delay gratification, 2) the ability to slow down motor activity, 3) the ability to volitionally suppress or initiate activity in response to a signal, 4) the ability to volitionally allocate attention, and 5) the ability to lower the voice. The ability to inhibit a dominant response in favor of a less salient one is a necessary skill for overcoming day-to-day challenges, such as controlling negative emotion in response to a novel situation (Rothbart & Rueda, 2005). Rothbart and Rueda (2005) argued that modern efforts toward incorporating effortful control into a model of temperament “means that unlike early theoretical models of temperament that emphasized how people are moved by the positive and negative emotions or level of arousal, people are not always at the mercy of affect” (p. 3).

Effortful control is typically viewed as one of several components of executive function, which includes other elements such as planning, cognitive flexibility, inhibitory control, and working memory (Friedman, Miyake, Robinson, & Hewitt, 2011; Morasch & Bell, 2011). Blair and Razza (2007) argued that effortful control is an especially important component of executive function because although executive function allows for the use of self-regulatory processes under mostly neutral conditions, effortful control allows a child to use these processes under conditions that may be stressful or cause fear.

Although believed to emerge in infants as early as 6 months of age, (Rothbart & Bates, 2006) effortful control continues to develop throughout childhood. For example, Kochanska et al. (2000) showed, both through parental rating and laboratory measures, that effortful control significantly improved between 22 and 33 months. Effortful control has also been shown to be stable during early childhood. Putnam, Rothbart, and Gartstein (2008) found that infant orienting and regulatory capacity at 18 months was predictive of toddler effortful control at 37 months. Additionally, Kochanska and Knaack (2003) found that effortful control was highly stable across tasks by 45 months.

Effortful control in early childhood has been linked to numerous cognitive outcomes. In elementary school children, effortful control has been associated with greater skills in mathematics (Bull & Scerif, 2001), reading, and linguistic ability (Fabes, Martin, Hanish, Anders, & Madden-Derdich, 2003). In preschool children, effortful control is positively predictive of mathematical ability (Blair & Razza, 2007), vocabulary (McClelland et al., 2007), and adolescent SAT performance (Shoda, Mischel & Peake, 1990). Finally, attentional ability, one component of effortful control, in 6-12 month old infants has been linked to higher adult IQ and more completed years of education (Fagan, Holland, & Wheeler, 2007).

Although numerous studies have demonstrated a link between effortful control and cognitive outcomes, the exact role of effortful control in children's academic success is unclear. At least two possible mechanisms underlying the link between effortful control and children's cognitive outcomes have been suggested. First, Eisenberg and colleagues (e.g. Eisenberg et al., 2010) postulated that effortful control facilitates interactions with teachers and peers and promotes the inhibition of undesirable behavior. According to these authors, children with better abilities to regulate their emotions, attention, and actions will consequently develop more positive social relationships with teachers and peers. These positive social relationships, in turn, will enhance children's learning potential, thus resulting in better cognitive outcomes. Berger (2011) similarly argued that "children who are better able to inhibit inappropriate behaviors, delay gratification, and use cognitive methods of controlling their emotion and behavior tend to be socially competent overall, liked by their peers, and well-adjusted" (p. 97). In a longitudinal study, Valiente et al. (2011) found that social functioning did in fact mediate the relationship between effortful control and academic success. They explained that because many learning activities involve working with others, "students who experience difficulty in the peer domain are relatively unlikely to benefit from peer collaboration or cooperative learning groups" (p. 426).

A second possibility, as argued by Zhou et al. (2007), is that attentional elements of effortful control make direct contributions to academic achievement. They claimed that attentional elements are important to academic success because many tasks that children must perform in school require managing and sustaining attention. Additionally, children must be able to shift their attention between tasks, as well as employ the subdominant response of sitting still and paying attention rather than focusing on other distracting stimuli. The authors also theorized that children high in effortful control perform better in goal-oriented tasks, which is also linked to higher academic achievement. Consistent with this position, Fabes et al. (2003) argued that "young children who can more readily regulate their attention and control their emotions and impulses appear to be more likely to thrive in the learning-related environments of preschool and kindergarten" (p. 856).

But even though effortful control may impact cognitive outcomes directly, mechanisms underlying the relationship are still not clearly identified. At least one mechanism which may underlie the link between early effortful control and later cognitive outcomes is memory (Dixon et al., 2011; Wolfe & Bell 2004, 2007). Because memory is an important cognitive ability, greater mnemonic skills should result in positive cognitive outcomes. Thus, if effortful control facilitates memory, then memory could be a potential link between effortful control and later cognitive outcomes.

In this paper, I considered further how memory may contribute to later cognitive outcomes; specifically, by mediating the relationship between effortful control and later cognitive outcomes. To this end, I first review basic memory concepts as they are considered in the general developmental literature. I then discuss how memory may underlie relationships between effortful control and subsequent cognitive function. I then propose an empirical study which tests one hypothesis generated by this proposed relationship.

As defined by Bauer (2004), memory can be divided into two very broad types: declarative memory and nondeclarative memory. Declarative memory "permits recall and recognition of names, dates, places, and events. This type of memory is specialized for rapid, even 1-trial learning and its operation is conscious: individuals are aware that the memory representation is based on a past experience" (Bauer, 2004, p. 348). Declarative memory is further divided into episodic and semantic memory. Episodic memory refers to memory of personal experiences, while semantic memory refers to memory of facts (Hayne, 2007). Nondeclarative memory, in contrast, refers to memory for skills and procedures, often motor-based. Nondeclarative memory forms gradually, usually over multiple trials (Bauer, DeBoer, & Lukowski, 2007).

A distinction can also be made between working memory and long-term memory (LTM; Bauer, 2004). Working memory, the temporary storage and management of information (Lowe, Erickson, MacLean, & Duvall, 2008), allows a person to remember task-related information during performance of that task. Working memory can be detected in infants as early as 5-6 months of age (Reznick, 2007). In contrast, long-term declarative memory begins to develop around the end of the first year of life and continues to improve throughout the second year (Carver, Bauer, & Nelson, 2000). Six-month-old infants, the youngest children tested with long-term memory tasks, remember for only about 24 hours. By 24 months, however, memory remains robust even after delays of several months (Bauer, 2004).

Bauer and colleagues have suggested that the age-related differences seen in LTM are due, at least in part, to differences in the process through which memories are formed (e.g. Bauer, 2004; Bauer, Weibe, Carver, Waters, & Nelson 2003; Hayne, 2007). The mnemonic processes by which memories are created include encoding, consolidation and storage, and retrieval (Bauer, 2004). In this regard, encoding is defined as the initial registration and temporary maintenance of information in working memory (Bauer, 2004). After initial encoding, the beginnings of a memory trace are formed. During memory trace formation, memories are consolidated and then stored. Bauer, Güler, and Starr (2011) described consolidation and storage as “the process by which initially labile memory traces are stabilized and integrated into long-term storage” (p. 558), noting that it does not immediately take place upon presentation of a stimulus. It can continue over months or even years (Bauer, 2004). The final process involved in long-term memory is retrieval, which, like other mnemonic processes, improves as children get older (Bauer, 2004).

Surprisingly, relatively little empirical research has demonstrated a relationship between effortful control and memory in young children, although there is plenty of reason to believe that the two domains ought to be related. As noted above, it has previously been hypothesized that the attentional aspect of effortful control contributes to children’s cognitive outcomes (Zhou et al., 2011). The ability to volitionally allocate attention should allow for better focus and less distractibility, which should thus promote successful encoding, consolidation, storage, and retrieval. Effortful control could facilitate encoding in particular. As argued by Dixon et al. (2011), children high in effortful control should be more successful in allocating their attention to novel information and suppressing the dominant response of attuning to other distracting stimuli. Thus, these children should demonstrate both more effective encoding and subsequent recall. Furthermore, because declarative memory is formed consciously, the ability to willfully allocate attention associated with effortful control should be helpful in recalling declarative memories in particular. Bell and Morasch (2007) further argued that attention is an important element of working memory in that “individuals high in this controlled attention ability are more effective at blocking distracting, task-irrelevant information and maintaining a focus on pertinent information” (p. 30) to be encoded.

In the handful or so of studies attempting to link effortful control processes with memorial processes in the first three years of life, results have been generally consistent with expectations. But few of these have focused explicitly on links between effortful control processes and long-term declarative memory. For example, two studies focused on effortful control and implicit long-term memory (Flom & Bahrick, 2010; Kopp & Lindenberger, 2011). In this regard, Kopp and Lindenberger (2011) found that in 9-month-old infants, joint attention modulated recall of implicit long-term memory after a 1-week delay. That is, ERP data indicated that the infants high in joint attentional abilities remembered a visual stimulus after the delay. Additionally, Flom and Bahrick (2010) reported that nine-month-old infants’ attentional abilities facilitated long-term recall after a delay of one-month. In this study, 9-month-old infants displayed a preference for a familiar audiovisual stimulus following the one-month delay.

To the extent that research has focused on declarative memory, it has been mostly limited to working memory rather than long-term memory. In older children, namely 3- and 4- year olds, Wolfe and Bell demonstrated links between effortful control and working memory (e.g. Wolfe & Bell 2004, 2007). Wolfe and Bell (2007), for example, found a positive association between working memory and effortful control in preschool children. The authors argued that “the attention component allows for the voluntary, focused, and exclusive processing and maintenance of task-relevant information in the presence of internal and/or external distracters” (p. 432). Thus, the study constituted a test of declarative memory.

In one of the only studies to document a link between effortful control and both encoding and long-term recall in the second year, Dixon et al. (2011) examined the effects of endogenous factors and exogenous distracters on 15- to 21-month-olds’ immediate and long-term declarative memory. Endogenous factors included effortful control. The authors examined specifically whether exogenous distraction impacted children’s encoding and subsequent recall, as well as whether effortful control mediated this effect. The distraction condition was a useful way to elicit effortful control, as effortful control is particularly necessary when performing cognitive tasks under burdensome conditions (Blair & Razza, 2007). Dixon et al. found that although effortful control at 21 months was predictive of long-term recall, effortful control at 15 months interestingly was not. Additionally, effortful control was not associated with successful encoding. Obviously, these findings are not consistent with the expectation that effortful control should facilitate declarative memory.

In explaining their null findings, Dixon et al. (2011) suggested that such effects could be an artifact of an insufficiently developed effortful control system in the second year of life. They hypothesized effortful control may not be “an especially powerful regulator of declarative memory formation early on, but may begin emerging as a significant regulator of declarative memory operations toward the end of the second year" (p. 28). One limitation of Dixon et al.'s study was that effortful control's effect on long-term memory was examined beginning at 15 months of age. It is possible that effortful control is not yet involved as a mediator at this age. That is, effortful control may not facilitate long-term declarative recall until later in the second year. In the present study, the relationship between effortful control and long-term memory will be examined beginning at the midpoint of the second year.

The purpose of the present investigation was to determine whether children's effortful control at 18 months was predictive of long-term declarative recall at 21 months. Although there has been a large amount of research concerning effortful control and long-term memory individually, little is known about how effortful control may facilitate long-term memory. In the present study, I hypothesized that children's effortful control at 18 months would act as a mediator of long-term declarative recall at 21 months.

Method

Participants

Data for this investigation were derived from toddlers who participated in a previous short-term longitudinal investigation. For that study, 43 children (n= 26 boys) visited the lab at 18 months (Visit 1; *M* age = 18.59 months, *SD* = .42 months), and 22 children returned to the lab at 21 months (Visit 2; *M* = 21.21 months, *SD* = .69 months). The majority of the participants were Caucasian. Twenty of the children were firstborns, while the remaining 42 were later born. Twenty parents reported attaining graduate school education; 23, 4-year college degree; 14, some college or 2-year college degree; 2, trade or vocational school; and 3, high school degree or GED.

Materials/Tasks

Elicited Imitation Task (Short-Term LTM)

An elicited imitation task was used as the first measure of declarative long-term recall. This task was derived from a procedure used by Shore, O'Connell, and Bates (1984), in which children were asked to engage in a symbolic play sequence, such as "having breakfast," first using an appropriate object (e.g., a spoon) and then a counter-conventional object (e.g., a comb). In the present study, a single-gesture version of the task, referred to as the Elicited Imitation with Incongruent Object Substitution (EIIOS) task was used. In this task, children were presented with a known object, but the object was depicted with a counter-conventional gesture. The four object-gesture combinations included: driving a teddy bear, drinking from a hairbrush, brushing hair with a teacup, and hugging a toy car. Children were asked to reproduce the action immediately after it was demonstrated, and to test long-term memory, the child was asked to reproduce the action after a delay of 10 minutes. We conceptualized this task as reflecting short-term LTM because although children had to recall the action after a delay, the delay was not long enough for the information to be fully consolidated into long-term storage (Bauer 2004), but it was still too long to be accounted for by short-term memory.

Word Learning Task (Long-Term LTM)

As a longer-term measure of LTM, children were asked to recall at Visit 2 a set of four novel words they learned during Visit 1. This task was based on the Baldwin (1991) novel word-learning procedure. Thus, for each novel word learned at the 18-month visit (Visit 1), children were shown a plastic bucket containing two unfamiliar household objects. They were allowed to handle both objects for 20-30 seconds before the experimenter placed one of the objects back in the plastic bucket. Then, based on the "discrepant labeling" condition of Baldwin's procedure, when the child was looking at his own object, the experimenter looked at the object in the bucket and said, "It's an

X," where "X" was one of the four novel words such as "Dax" or "Noop." The process was repeated four times so that each novel object was labeled in this manner a total of four times, always when the child was focused on the object before him rather than the one in the bucket held by the experimenter.

To test encoding immediately after training on each novel word, that is, after all four of the labeling trials associated with each word, children were then asked questions such as "Can you put the X in the bucket?" The children were given four opportunities to select the correct object. Because the target object was always paired with a foil object on each of the four trials, the correct selection of the target object would be expected to happen on two of the trials by chance. Consistent with Dixon et al. (2011), half of the children were distracted during the encoding portion of the task. During the 21-month visit, children were tested on their recall of the novel words learned three months previously. To maximize the similarity in recall conditions presented during Visit 1, during Visit 2 the children were given two objects (the target and the foil) and asked "Can you put the X in the bucket?" Both the first object touched and the object placed in the bucket were recorded, and the children were given four opportunities (i.e. four trials) to select the correct object.

Effortful Control

Effortful control was assessed through parent report using the Early Childhood Behavior Questionnaire (ECBQ; Putnam, Ellis, & Rothbart, 2001). The ECBQ is often used to assess temperament in children from 18-30 months. The questionnaire consists of 201 questions about the frequency of certain behaviors, with responses ranging from 1 (never) to 7 (always). Effortful control is derived from the ECBQ by averaging the subscales of inhibitory control, attention shifting, low-intensity pleasure, cuddliness, and attention focusing (Putnam, et al., 2006).

Procedure

Parents were mailed an informed consent document and the ECBQ prior to arriving for Visit 1. When the parents and children arrived for their session, they were met in the parking lot and escorted to the laboratory observation room. The parent was briefed about the study procedure while the child acclimated to the lab room and the experimenter. The lab visit lasted approximately one hour and was recorded for later coding. The children remained seated on the parent's lap while they completed the word learning and EIIOS tasks, as well as several other tasks unrelated to the present study.

Results

The means and standard deviations for all of the ECBQ temperament dimensions completed at Visit 1 can be found in Table 1. Note, however, that Effortful Control was the only dimension used in the present study.

EIIOS Task (Short-Term LTM)

To test for differences in Short-Term LTM performance as a function of effortful control, children were first divided into high and low effortful control groups via median split. An independent samples *t*-test was conducted to compare short-term LTM performance between high versus low effortful control children for each of the object-gesture combinations in the EIIOS task. Table 2 shows the means and standard deviations for performance on the EIIOS task, both for the number of actions imitated immediately after being shown the gesture and after the 10-minute delay. With two exceptions, children high in effortful control did not perform significantly differently than children low in effortful control (see Table 2) for either immediate or 10-minute delayed memory. The exceptions were the number of drinks imitated immediately, which was significant at the .01 level (*p* = .000), and the number of drives imitated after a delay, which was significant at the .05 level (*p* = .03).

Word Learning Task (Long-Term LTM)

To test for differences in long-term LTM performance, children were again divided into high and low effortful control groups via median split, and an independent samples *t*-test was used to compare performance between the two groups. We found that children who were higher in effortful control did not show commensurately better 3-month novel word recall than children low in effortful control. Table 3 shows the means and standard deviations of children's recall for all four novel words, both as demonstrated by the first object touched immediately upon presentation of the objects and the object the child placed in the bucket. Table 3 also shows mean performance averaged across all four novel words. On the whole, and contrary to expectations, children high in effortful control did not demonstrate better word-learning recall when measured using either the first object touched (M = .54) or first object placed into the bucket (M = .63) than children low in effortful control (M = .55, M = .55, respectively).

Discussion

The purpose of the present study was to investigate whether children's effortful control at 18 months was predictive of declarative long-term LTM. Contrary to expectations, the results showed that children who were high in effortful control did not perform significantly better than children low in effortful control in either a short-term LTM task (the EIIOS task) or a long-term LTM task (the word-learning task). This was a surprising finding, given that children higher in effortful control should have been better able to focus their attention and ignore distractions (Dixon et al. 2011), thus allowing for better encoding of the incongruent gestures in the EIIOS task and the novel words in the word-learning task.

Although these null results were not consistent with the hypothesis of this study, they can be viewed as a replication of Dixon et al.’s (2011) null findings. Recall that Dixon et al. found that effortful control at 15 months failed to predict long-term declarative memory at 21 months. They hypothesized that an insufficiently developed effortful control system could be responsible for these findings. In order to test the limitations of Dixon et al.’s study, it was hypothesized in the present investigation that 18-month-old children would demonstrate a more advanced effortful control system and thus would display better long-term recall. However, this hypothesis was not supported with the older age group used in the present study. Thus, although effortful control begins to emerge in the first year (Rothbart & Bates, 2006), and continues to improve over time (e.g., Kochanska et al. 2000), it may not play a significant role in the performance of memory tasks until even later into the second year than was tested in the present investigation.

Of course, limitations in the measures employed in this investigation may also have contributed to the null findings. Although elicited imitation tasks have been used as measures of memory (e.g., Bauer, Wenner, Dropik & Wewerka 2000), they have not previously included incongruent object substitution as was used in the EIIOS task. Thus, the applicability of the EIIOS task as a measure of memory can be questioned.

Additionally, it is unclear whether the EIIOS task and the word-learning task are adequate measures of “pure” long-term memory. While Shore, O’Connell, and Bates (1984) asked children to imitate a multi-gesture sequence, for the EIIOS task in the present study, a single-gesture version of the task was used. It could be that a single-gesture task was too simple for this age group, and future research should investigate whether children in this age group are more interested in and demonstrate better recall of a multi-step sequence.

In terms of the word-learning task, it is possible that memory for the novel words was confounded with linguistic development. Thus, less linguistically developed children may have had more difficulty in recalling the novel words; not because of memory per se, but because of an insufficiently developed semantic network within which children could incorporate any new words. If so, then failure to recall in the word-learning task may be more attributable to children's linguistic sophistication than to their memory.

Although the present investigation did not find the expected results, improvements in the two tasks used could aid in future research. Future research could statistically control for children's linguistic development in the word-learning task in order to obtain a nonlinguistic measure of memory. Additionally, making the EIIOS task more engaging and age-appropriate for this age group may improve children's performance on reproducing the gestures. The changes to these tasks may provide a more accurate measure of memory and may allow a link to be established between effortful control and long-term memory.

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Table 1

Means and Standard Deviations for 15-Month Early Childhood Behavior Questionnaire (ECBQ) Dimensions

ECBQ Dimension	M	SD
Effortful Control	3.69	0.31
Attentional Focusing	3.92	0.98
Attention Shifting	4.56	0.60
Cuddliness	4.83	0.83
Inhibitory Control	3.68	0.98
Low-Intensity Pleasure	4.86	0.73
Surgency	3.69	0.56
Activity Level	5.11	0.73
High-Intensity Pleasure	4.82	0.98
Impulsivity	5.17	0.93
Sociability	5.54	0.83
Negative Affectivity	1.69	0.49
Discomfort	1.93	0.73
Fear	2.07	0.70
Frustration	3.69	0.94
Perceptual Sensitivity	3.41	0.97
Sadness	3.01	0.96
Shyness	3.09	1.01
Soothability	5.70	0.62

Table 2

Means and Standard Deviations for Performance on EIIOS Task

Measure	Low E C		High E C	
	M	SD	M	SD
Number of Drives (Immediate)	1.08	1.16	0.56	0.85
Number of Drives (10-Minute Delay)*	0.17	0.39	0.00	0.00
Number of Drinks (Immediate)**	1.54	1.21	0.37	0.69
Number of Drinks (10-Minute Delay)	0.33	0.73	0.09	0.29
Number of Brushes (Immediate)	0.72	0.84	0.35	0.63
Number of Brushes (10-Minute Delay)	0.16	0.50	0.04	0.21
Number of Hugs (Immediate)	0.35	0.75	0.07	0.27
Number of Hugs (10-Minute Delay)	0.00	0.00	0.00	0.00

*Significant at the .05 level

**Significant at the .01 level

Table 3

Means and Standard Deviations for Performance on Word-Learning Task

Measure	Low E C		High E C	
	M	SD	M	SD
Word Recall				
Word 1				
First Touched	0.44	0.27	0.40	0.22
Delivered into Bucket	0.45	0.24	0.63	0.19
Word 2				
First Touched	0.63	0.12	0.60	0.22
Delivered into Bucket	0.56	0.21	0.73	0.18
Word 3				
First Touched	0.56	0.21	0.52	0.24
Delivered into Bucket	0.67	0.21	0.48	0.23
Word 4				
First Touched	0.58	0.26	0.63	0.25
Delivered into Bucket	0.51	0.29	0.69	0.62
Word Overall				
First Touched	0.55	0.13	0.54	0.14
Delivered into Bucket	0.55	0.12	0.63	0.14