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Developmental Differences in Episodic Memory across School Ages:

Evidence from Enacted Events performed by Self and Others

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Abstract

The aim of this study was to examine action memory as a form of episodic memory among school-aged subjects. Most research on action memory has focused on memory changes in adult populations. This study explored the action memory of children over time. A total of 410 school-aged child participants, comprising 201 girls and 208 boys in four age groups (8, 10, 12, and 14), were included in this study. We studied two forms of action encoding, subject-performed tasks (SPTs) and experimenter-performed tasks (EPTs), which were compared with one verbal encoding task (VT) as a control condition. At retrieval, we used three memory tests (free recall, cued recall, and recognition). We observed significant differences in memory performance in children aged 8 to 14 years with respect to free recall and cued recall but not recognition. The largest memory enhancement was observed for the SPTs in the 8- to 14-year-old participants under all test conditions. Participants performed equally well on the free recall of SPTs and EPTs, whereas they displayed better performances on the cued recall and recognition of SPTs compared to EPTs. The strategic nature of SPTs and the distinction between item-specific information and relational information are discussed.

Keywords: developmental differences, episodic memory, action memory, enactment effect,

school-aged children

Episodic memory is central to the human experience and is the capacity to register and retrieve specific past events (Tulving, 1972-1983). Episodic memory pertains to episodes or events from the personally experienced past, existing in subjective time and space. Episodic memory can be studied as both verbal events and enacted events with separate phases corresponding to encoding and retrieval. During the encoding phase of episodic memory, learning by hearing, learning by doing, and learning by seeing are considered. Recall and recognition are commonly tested at the retrieval level. Furthermore, episodic memory is thought to be a memory system that develops in an evolutionary manner with a distinct age pattern and the last unique memory system to develop in an individual, especially during childhood (Tulving, 2002).

Exploring age-related differences in the episodic memory of children is a primary interest of developmental psychologists. Children exhibit age-related differences in their ability to recall specific details of past events and personal experiences (Farrar & Goodman, 1992), which are retrieved from episodic memory (Tulving, 1972-1983-1993). Although several studies have indicated that young children already have an extraordinary ability to remember past events (Bauer, 2007), age differences or developmental changes exist in the episodic memory of children. Older children show more complex and elaborated reports than younger children (Price & Goodman, 1990). Few studies have investigated episodic memory over a wide range of school ages. Therefore, we studied the developmental pattern of the episodic memory of children during the encoding and retrieval phases.

Most differences in memory performance among school-aged children are due to the development of language (Simcock & Hayne, 2003) and, more importantly, knowledge (Schneider, 2015). Children in higher grades have superior levels of knowledge, which affects

memory in three main ways (Schneider, 2015). First, knowledge facilitates the use of memory strategies. The use of memory strategies develops rapidly from elementary school through high school (Coffman, Ornstein, McCall, & Curran, 2008), i.e., older children use more strategies for encoding and retrieving events and items than younger children (e.g., Kron-Sperl, Schneider, & Hasselhorn, 2008; Schneider, Kron-Sperl, & Hünnerkopf, 2009; Schneider, Kron, Hünnerkopf, & Krajewski, 2004). Second, knowledge makes memory items more discriminable and vivid and improves item-specific processing, indicating. It means that knowledge enhances the distinctiveness of specific items and produces age differences in children's the memory performance of children. By using lists of unrelated items or presenting single items, older children recall more items than younger children because a particular item is more discriminable and accessible than other items (Bjorklund, 1987; Ghatala, 1984). Third, knowledge facilitates activation among sets of items and promotes memory of the association and connection between items. When children are presented with pairs of items and instructed to determine whether each item could fit among the other items, older children associate items and concepts more strongly than younger children. This superiority is likely due to better semantic knowledge and relational information processing abilities (Bjorklund & Bjorklund, 1985; Bjorklund & Zeman, 1982).

Although older children exhibit better memory performance than younger children, there are two main problems in interpreting the observed developmental differences in laboratory tests. In laboratory experiments, participants are passive encoders of information (Zimmer & Cohen, 2001), which is not an appropriate approach for working with children. Furthermore, most developmental research on memory involves verbal tasks (e.g., Coffman et al., 2008). Therefore, the performance of older children, who have superior language skills and knowledge, is overestimated compared to the performance of younger children. The importance of actions and

action images in cognitive development is recognized in the education of young children (Cohen, 1989; Rubin, Fein, & Vandenberg, 1983). Moreover, children of different ages benefit from learning by doing even after the development of language and well into their elementary school years (Ballantyne & Packer, 2009). To overcome the shortcomings of the experimental approach for working with children and to study the role of the manipulation of information to support children's learning, an "enactment paradigm" in the context of episodic memory is an appropriate paradigm.

In the enactment paradigm, child is given a number of action events, which are compared with verbal events as a control condition. In action events, a simple sentence that includes one action verb and one object is used (e.g., "lift the spoon" or "push the bottle"). The action can be self-enacted (subject-performed task), or the subject may watch another individual perform the action (experimenter-performed task). The memory for these events is typically examined via recall and recognition tests (for review see Nilsson, 2000; Zimmer et al., 2001). Action performance during encoding produces different memory effects than memories based on information that is learned verbally or passively watched. It has been well documented that, especially in adults, the ability to remember simple action phrases is considerably improved when the subject performs the action (for reviews, see Engelkamp, 1998; Kormi-Nouri, 1995; Nilsson, 2000). Although this robust psychological finding has been replicated consistently in the literature as an enactment effect (e.g., Engelkamp & Cohen, 1991; Knopf, Mack, Lenel, & Ferrante, 2005; Kormi-Nouri & Nilsson, 2001), there are limited studies that have systematically evaluated developmental differences in enactment effects across school ages.

Cohen's study showed that younger children (Grade 4) recall as much as older children (Grade 8) when they learn through action but not when they are exposed to only verbal

information (Cohen & Stewart, 1982). To explain these findings, Cohen (1981/1983) proposed various memory laws. He argued that the non-strategic and automatic nature of action encoding is independent of age. Thus, encoding of performed action events does not require the use of cognitive resources and intentional strategies, such as rehearsal, organization and elaboration, for action items. Cohen's study is one of the few experimental investigations that did not identify developmental differences in action memory performance. In contrast to Cohen's study, other researchers have identified memory enhancement with age; older children exhibit a larger enactment effect than younger children (e.g., Kormi-Nouri, Moniri, & Nilsson, 2003; Kormi-Nouri et al., 2008). These studies stress the importance of strategy use in action items, especially when elementary school students are instructed to interact physically with objects during learning. In two different studies, Kormi-Nouri and his colleagues (2003/2008) observed developmental effects in recall tests of action memory in children aged 8 to 16 years. The authors assumed that the interaction between self and object is crucial for action memory performance. That is, an active learning episode can be viewed as encoding support (Kormi-Nouri, 2000; Kormi-Nouri & Nilsson, 1998), and increasing the episodic integration enhances memory performance. Episodic integration is the result of integration between self and tasks and integration between environment and person. When episodic integration interacts with self-involvement at the encoding level, the enactment effect leads to memory enhancement (Kormi-Nouri, 1995; Kormi-Nouri, Nyberg, & Nilsson, 1994).

This developmental pattern in the enactment effect has been related not only to strategic aspects of memory but also to distinctiveness and association among items in memory (Schneider, 2015). In adults, the degree of item-specific and relational information processing plays a crucial role in memory performance (e.g., Hunt & Einstein, 1981; Smith & Hunt, 2000).

During encoding, the processing of individual items or events leads to item-specific information and increases the distinctiveness of items in memory. There is wide agreement that information processing during enactment is based on item-specific processing (e.g., Hunt & Einstein, 1981; Kormi-Nouri, 1995). Subject-perform tasks (SPTs) increase planning and executing actions, and participants are instructed on what to do and forced to focus on each item and event (Engelkamp, 1998). SPTs improve item-specific information processing and distinctiveness more than verbal encoding tasks (VTs) (Engelkamp & Dehn, 2000; Steffens, Jelenec & Mecklenbräuker, 2009; Steffens, Jelenec, Mecklenbräuker, & Thompson, 2006; von Essen, 2005). In contrast, relational information, which refers to classification and association among classes of items or events, is not improved in SPTs (Engelkamp & Zimmer, 2002). However, there are other procedures that may increase relational information without influencing item-specific information (Golly-Haring & Engelkamp, 2003; von Essen, 2005). For example, the observation of the enactment of others facilitates the processing of relational information more than self-enactment (Engelkamp & Dehn, 2000). In experimenter-performed tasks (EPTs), participants are instructed to watch the actions that are performed by an experimenter during encoding. Subjects must focus on the connections among items and the associations between actions and their contexts (Golly-Haring & Engelkamp, 2003; Steffens, 2007). Thus, individuals engaged in SPTs and EPTs act differently with respect to item-specific and relational information processing (Engelkamp, 1998; Engelkamp & Dehn, 2002; Feyereisen, 2009; Golly-Haring & Engelkamp, 2003).

Few studies have addressed children's memory of self-performed actions with an observation control condition. Using isolated action phrases (i.e., action verbs without objects), Foley and Johnson (1985) found that 6-year-olds recalled self-performed actions and other-performed actions equally well, whereas 9-year-olds recalled their own actions better than other

individuals' actions. The authors proposed that younger children have greater difficulty distinguishing what they did from what they saw than older children. Moreover, older children and adults can discriminate between self-generated and perceptual memories, leading to an advantage of SPTs over EPTs. In contrast, Baker-Ward, Hess, and Flanagan (1990) presented activities using familiar toys and games. The authors found that self-performed actions were recalled significantly better than other-performed actions, and first graders and fourth graders both exhibited better recall for performed actions than observed actions. The authors suggested that performed actions enhanced both the availability and accessibility of memories, thereby leading to better recall of information regarding activities performed by oneself than by others. Ratner and Hill (1991) enrolled first and fourth graders and young adults in a memory study and found that the recall performance of 9-year-olds was increased compared to 6-year-olds, whereas older children and adults performed equally well. Additionally, there were no memory differences between acted and observed actions. However, the youngest group was better able to recall what they observed than what they performed. Performing actions compared to verbal encodings facilitated the recall ability of first graders, fourth graders, and adults; although the improved recall ability was the equal among fourth graders and adults but lower in first graders. The authors explained that the task of creating and encoding specific actions may require too many mental resources for less experienced children and, therefore, leads to decreases in SPT memory compared to EPT memory. Taken together, the findings concerning SPTs and EPTs in child populations are somewhat contradictory, as various studies have employed different experimental methodologies, different age groups of children, different types of memory materials, and different types of memory tests.

Thus, limitations exist in previously reported studies. First, previous studies are limited with respect to the age range of children. Focusing on only two groups of children in primary school is not sufficient for studying developmental patterns of memory performance in children. Second, the actions and instructions used in these studies were different with respect to the difficulty level for children. For example, the Foley and Johnson (1985) study used complicated instructions that were more difficult for younger children to understand for their knowledge level. However, the materials used in the studies of Baker-Ward et al. (1990) and Ratner and Hill (1991) were more age-appropriate and easily understandable, even for very young children. Third, they incorporated different memory tests in their studies. Ratner & Hill (1991) used only free recall test, whereas Baker-Ward et al. (1990) administered free recall and cued recall tests in a fixed order. Foley & Johnson (1985) also used free recall and recognition in a fixed order. Therefore, we sought to fill the methodological gaps of previous studies by incorporating a wide age range of children, the most common action memory materials used by researchers in the field, and all three explicit memory tests.

The present study investigated age-related differences in the episodic memory of children in the form of actions to provide a developmental perspective on memory strategies and information processing. We examined a more diverse set of memory encoding conditions and memory tests, as most previous studies only used one or two encoding conditions and/or retrieval tests. Therefore, the first goal of the present study was to investigate the episodic memory of school-aged children by considering enactment across a wide range of ages (from 8- to 14-year-olds) to provide a more detailed and comprehensive developmental view. The second goal of the present study was to examine and compare episodic memory under various encoding conditions (i.e., VTs, EPTs and SPTs). Although the superiority of SPTs over VTs has been well

documented in previous research, it remains unknown whether memory for EPTs more closely resembles memory for SPTs or memory for VTs. This finding is a particularly important question for children because the actions and observations of younger children may initiate different encoding processes than those of older children. The third goal of the present study was to compare VTs, SPTs, and EPTs in different memory tests. Previous studies have demonstrated that, in the adult population, enactment effects differ for recall and recognition (e.g., Kormi-Nouri & Nilsson, 1998). Whether the enactment effect can be regarded as only an encoding support or whether it also depends on the level of difficulty at retrieval remains controversial (Kormi-Nouri et al., 1994; Mohr, & Sellen, 1994; Norris & West, 1993). Additionally, it is well documented that recall tasks are more difficult than recognition tasks and are dependent on different information processing (Mohr, Engelkamp, & Zimmer, 1989; Nyberg et al., 2003). Furthermore, from a developmental perspective, recall and recognition differ as a function of age. That is, age-related differences are greater for recall than for recognition (Bäckman, Mäntylä, & Herlitz, 1990; Cohen & Stewart, 1982; Nyberg et al., 2003).

Methods

Participants

A total of 421 school pupils in Tehran served as participants. A statistical power analysis was run based on data from a pilot study (N=30) for sample size estimation. The effect size (ES) in the study was 0.21, which is considered a central value according to Cohen's (1988) criteria. For an alpha of 0.05 and a power of 0.80, the sample size needed for this effect size (GPower 3.1) was approximately N = 378 for the between-group comparison. Thus, considering a 10% drop-out rate, approximately 421 participants are required. All participants were chosen from the

schools affiliated the "Education Organization of Tehran". The participants and their parents were fully informed about the study, and the participation of the children was voluntarily. The children were allowed to leave the study at any time. The participants were selected randomly from four age groups. As shown in Table 1, the gender and non-verbal IQ of the groups were comparable. All subjects were given the coloured progressive matrices for the Raven test (Raven, Court, & Raven, 1988) to assess intelligence level (Raven's Progressive Matrices; Mean IQ = 109, SD= 1.8). Students with a low score on the Raven test were excluded from the study. There were 7 children (3 children aged 8 years, 1 child aged 10 years, 2 children aged 12 years, and 1 child aged 14 years) who had IQ values < 90. These children were also diagnosed with a learning disability and/or attention-deficit and hyperactivity disorder, and 5 of these children received medicine for their disability. An additional 4 children were excluded from the analysis: 1 child was excluded due to a hearing problem, and 3 children were excluded because they did not provide any responses during the memory tests. Therefore, these pupils were excluded from the sample population. This study was approved by Regional Research Ethics Committee in Tehran, Iran.

Insert Table 1 about here

Design

The factors considered in this study corresponded to 4 (age: 8, 10, 12, and 14) $\times$ 2 (gender: girls, boys) $\times$ 3 (encoding condition: VTs, SPTs, and EPTs) $\times$ 3 (retrieval test: free recall, cued recall, and recognition). The first and second factors were varied among subjects, and the last two factors were within-subjects factors.

Materials

The memory materials consisted of three lists of 16 simple action phrases. These action phrases were presented in imperative form and included one action verb and one concrete noun (e.g., “Read the book”, “Give me the spoon”, and “Hug the doll”). We excluded bizarre actions (“to shake the sand”), body part actions (“to touch the hair”) and actions with abstract objects (“to add 11 and 6”). The items were chosen from a pool of items in a normative study (Kormi-Nouri, 1995; Kormi-Nouri et al., 2003). The lists included the same number of items from each of the four categories of action phrases (tools, school materials, kitchen utensil, and personal hygiene). It was ensured that all lists involved a similar degree of difficulty.

In a pilot study, we presented 75 verbs and nouns to an independent sample (30 children) to test the difficulty level and age appropriateness of the items and lists. These children who did not participate in the main study, included eight 8-year-olds (mean age = 8.5 years, SD= 1.1), seven 12-year-olds (mean age = 10.6 years, SD=0.93), nine 14-year-olds (mean age = 12.4years, SD= 1.02), and six 14-year-olds (mean age = 14.3 years, SD= 1.4). The participants of this pilot study were asked to indicate the difficulty level of each item according to a 5-point scale (1 = very easy, 2 = easy, 3 = medium, 4 = difficult, 5 = very difficult). Very easy and very difficult items were excluded, leaving a total of 48 items with an average level of difficulty for use as the memory material. There were no repeated actions or objects among the items.

The lists were used in three orders: one-third of the items were presented as a verbal task (VT), one-third were presented as an encoded experimenter-performed task (EPT), and one-third were presented as an encoded subject-performed task (SPT). The encoding conditions (VT, EPT, and SPT), the item lists (list 1, list 2, and list 3), and the item orders in each list were counterbalanced across the participants. That is, across children all items had the possibility of being encoded as VTs, EPTs and SPTs and were administered in different parts of the study lists.

Procedure

Each testing session lasted approximately 50 minutes and was conducted individually in a private and quiet room provided by the schools. The participant was seated at a table, and the experimenter was seated in front of the participant on the other side of the table with a clear view of one another. The participants were informed about a memory test consisting of three lists of action events (VT, EPT, and SPT) and were instructed to remember as many items as possible (i.e., both verb and noun). The items were presented one-by-one using a recorded mp3 file. There were three item lists in this study. These files were recorded in-studio to ensure the quality of the sound. Then, all of the files were revised and edited using Acoustica Premium Edition software. Each file was 166 seconds in duration, which included a 3-second gap in at the beginning and at the end of the recording, and 7-seconds item presentations and 3-seconds intervals for between each item. These files were presented in a counter-balanced order to the participants. There were four experimenters in this study, all who were trained in a workshop and who followed the same instruction. Before starting the experiment, each participant received two example items (not presented in the memory lists) in each encoding condition to become familiarized with the procedure. For the VT condition, the participants were instructed to hear the phrase and repeat it aloud. For the EPT condition, the participants were instructed to watch the experimenter carefully while carrying out the actions. For the SPT condition, the participants were instructed to perform the action indicated by the sentences on their own. All of the items were matched with respect to real objects compared to imaginary objects. That is, half of the participants in each of the encoding conditions received real objects, whereas the other half were instructed to act on an imaginary object control the effect of the object's presence. This was based on the results of previous studies in action memory that showed some differences between

adult and child populations with respect to the presence of an object (Kormi-Nouri, 2000; Kormi-Nouri, et al., 2008). Some studies of adults have shown that there is no significant difference among participants' performances when either real objects or imaginary objects are presented (Kormi-Nouri, 2000), whereas, in children, SPTs with real objects corresponded to a higher performance than imaginary objects (Kormi-Nouri et al., 2008). Therefore, we controlled this issue by presenting both real and imaginary objects such that half of the participants in each of the encoding conditions received real objects, and the other half were instructed to act on an imaginary object. To create an interval between the three encoding conditions, we used the backward and forward digit span of Subtest for the Wechsler Intelligence Scale for Children - Fourth Edition for 1 minute.

After administering all of the memory lists, the participants performed three successive memory tests were given to the participants (a free recall, a cued recall, and a recognition test) in a fixed order, as suggested by Mecklenbrauker and her colleagues (2011). In line with this study, we also reasoned that presenting a less demanding test (e.g., recognition) during the last stage induces a smaller carryover effect. First, the participants were instructed to remember the entire action events (both the verb and noun) from all of the encoding conditions (VTs, EPTs, and SPTs). The subjects were allotted three minutes to complete the free recall test (the appropriate time was estimated in the pilot study). The experimenter recorded all of the recalled items for each participant on a form. The cued recall test followed the free recall test with no time limit. For half of the items in each of the encoding conditions, action verbs were used as cues, and the nouns (objects) were used as targets. For the other half, the nouns were used as cues, and the action verbs were used as targets. The cues were presented one-by-one. The experimenter recorded all recalled items on the forms. Finally, the participants received a recognition test in

which target items were mixed with hard and easy distractor items (Kormi-Nouri & Nilsson, 1998-1999). In total, 48 recognition items (included 24 target items and 24 distractor items) were selected in the recognition test in a random order. The items were presented one-by-one by the experimenter, and the participants responded “yes” or “no” to each item referring to the presence or absence of the items in the study list. The participants’ responses were recorded by the experimenter with no time limit. At the end of the experiment, the participants were given a package of storybooks to thank them for their participation.

Results

A strict procedure for scoring was adopted. Remembered action events were accepted only if they were exactly the same as or synonymous with target items from the study list. The children were required to recall both the noun and verb of each phrase for the response to be considered correct for free recall. The descriptive data (mean proportions and standard deviations) are presented in Table 1. A 4 (age: 8, 10, 12, and 14) $\times$ 3 (encoding: VT, SPT, EPT) mixed design ANOVA was run separately for each of the three memory tests (i.e., free recall, cued recall, and recognition). Because the preliminary analyses revealed that there were no gender differences and no interactions ($ps > 0.70$), the data were collapsed across this variable in all of the analyses.

Insert Table 2 about here

Free recall

We conducted a 4 (age: 8, 10, 12, and 14) $\times$ 3 (encoding condition: VT, SPT, and EPT) ANOVA for the free recall memory performance. The ANOVA revealed an interaction of the

age $\times$ encoding condition [$F(6, 804) = 4.46, p < .001, \eta^2 = .03$]. The simple effect of this interaction showed that although the performance in the SPT condition was better than that of the EPT condition in the 14-year-olds, EPTs were recalled better than SPTs in the 8-year-olds. The interaction also indicated that the increase in performance in children aged 8 to 14 years was more pronounced for SPTs than for VTs and EPTs (see Figure 1). Regarding the estimation of the effect size in the repeated measure analysis, the eta square coefficient showed that the within-subject independent variable explained 23% of the within-subject variance of free recall. Differences among VT, SPT, and EPT explained 23% of the free recall, whereas the interaction between age and type of encoding explained 3%. Regarding the effect size (eta square), the between-subject independent variable explained 19% of the between-subject variance of free recall (VT, SPT, and EPT).

Insert Figure 1 about here

Cued recall

A 4 (age: 8, 10, 12, and 14) $\times$ 3 (encoding condition: VTs, SPTs, and EPTs) ANOVA was run. The ANOVA for the cued recall memory performance revealed a significant age $\times$ encoding condition interaction [$F(6, 804) = 2.47, p < .05, \eta^2 = .02$]. The simple main effect of the interaction indicated that, in children aged 8 years, there was no significant difference between SPTs and EPTs. However, in children aged 12 to 14 years, SPTs were recalled significantly better than EPTs. Again, in children aged 8 to 14 years, the increase in memory performance was more pronounced for SPTs than for VTs or EPTs (see Figure 2). Regarding the estimation of the effect size in the repeated measure analysis, the eta square coefficient showed that the within-subject independent variable explained 27% of the within-subject variance cued

recall. Differences among VT, SPT, and EPT explained 27% of the cued recall, and the interaction between age and type of encoding explained 2%. Regarding the effect size (eta square), the between-subject independent variable explained 5% of the between-subject variance in cued recall (VT, SPT, and EPT).

Insert Figure 2 about here

Recognition

We conducted a 4 (age: 8, 10, 12, and 14) $\times$ 3 (encoding condition: VT, SPT, and EPT) ANOVA for the recognition memory performance. The hits (correct responses) minus the false alarms (the items falsely recognized as correct items) were analysed in the recognition test. The ANOVA revealed that there was no significant age $\times$ encoding interaction [$F(6, 806) = 1.16, p > .05, \eta^2 = .01$] (see Figure 3). Regarding the estimation of the effect size in the repeated measure analysis, the eta-square coefficient showed that the within-subject independent variable explained 20% of the within-subject variance recognition. Differences among VT, SPT, and EPT explained 20% of the recognition.

We also analysed only false alarm data. The pattern of data was similar to hit-minus-false alarm data. That is, there were no differences between older and younger children.

Insert Figure 3 about here

Discussion

The aim the present study was to investigate the developmental pattern of action memory as a form of episodic memory in school-aged children. Thus, the memory effects of different

types of encoding (VT, EPT, and SPT) were examined across different school-aged groups (8, 10, 12, and 14) and assessed via different test conditions (free recall, cued recall and recognition). The most important finding was that the SPT resulted in the largest memory enhancing effect in children aged 8 to 14 years. Although this effect was observed in a similar manner for all three memory tests, the effect was largest in the free recall test and lowest in the recognition test. The enactment effect for SPTs (i.e., the difference between SPT and VT) was systematically increased across school ages under all test conditions, and the development of an enactment effect for EPTs (i.e., the difference between EPT and VT) was less or unobservable or absent under different test conditions.

Consistent with previous studies (e.g., Kormi-Nouri, 1995-2000; Kormi-Nouri et al., 2003-2008), these findings demonstrate that SPT encoding is strategic and affected by developmental differences. This contrasts with the nonstrategic view of SPT encoding proposed by Cohen (1981/1983/1989). Cohen found that younger children performed more poorly in VTs than older children, but no age differences were found for SPTs. These results led Cohen to conclude that SPT learning provides optimal encoding that is not improved by the use of strategies (Cohen, 1981-1983-1989). However, in the present study, the older children performed significantly better on SPTs than younger children, and this age effect was even more pronounced than for EPTs and VTs. It has been well documented in the literature that children differ with respect to their usage of memory strategy and information processing (Schneider, 2015). A primary source of developmental differences in memory performance of children is due to the different strategies used either at the encoding level (such as rehearsal, organization, and elaboration) or at the retrieval time (access to stored information in long-term memory) (Bjorklund, Dukes, & Brown, 2009). Generally, older children may be more proficient in using

memory strategies, whereas younger children are less likely to apply a mnemonic strategy. For example, older children are more likely to actively rehearse items and use more flexible strategies, and they exhibit high levels of organization or group items based on categories (Schneider et al., 2004-2009). The efficacy of memory strategies is linked to the effect of schooling and the rapid development of memory strategies from elementary school through high school (Coffman et al., 2008) according to two aspects: age differences in acquisition memory strategies and the spontaneous display of one or more memory strategies (Bjorklund et al., 2009). Younger children use simple memory strategies such as single-item rehearsal whereas older children use more complex and sophisticated strategies such as elaboration. Additionally, the number of strategies used by children increases across school ages (Schneider et al., 2004-2009). Therefore, differences in education level have been shown to affect the active implementation of strategies, and an increased number of strategies yields higher levels of memory performance in older children than younger children (Kron-Sperl et al., 2008; Schneider et al., 2004-2009). However, further studies are needed to determine which strategies and how many strategies are used in action memory.

Additionally, there are age-related differences in the use of information processing. Older children require less mental effort to execute most cognitive operations relative to younger children (Bjorklund, 1987; Ghatala, 1984). In older children, an item may be active and accessible easily. Moreover, older children have more semantic knowledge that helps them to better integrate and organize information in their memory (Bjorklund & Bjorklund, 1985; Bjorklund & Zeman, 1982).

Interestingly, in the present study, the effect of developmental differences in SPTs was observed for all test conditions. This finding indicates that this is a robust finding that is more

related to encoding conditions than to test conditions. However, this effect was stronger in free recall than in cued recall and recognition conditions. This result is consistent with research demonstrating that free recall is more difficult and strategy demanding than cued recall or recognition tests (e.g., Engelkamp & Zimmer, 1997; Hunt & Einstein, 1981; Mohr et al., 1989) and more age sensitive (Nyberg et al., 2003). Thus, our findings indicate that the developmental differences found in SPTs are more observable under difficult task conditions because the demands of self-initiated processing and retrieval operations are increased from easy to difficult tasks (e.g., Bäckman et al., 1990). This finding is also in agreement with the findings of Kormi-Nouri's studies on action memory that demonstrated that the enactment effect could differ depending on the level of item difficulty and test difficulty. In this research, the authors demonstrated that the enactment effect was strongest for well-integrated items on the free recall test or poorly integrated items on the cued recall test. If the task, either at encoding or at retrieval, requires more effort, the enactment effect as an encoding support will be more observable. In the free recall test, which is a more effortful task, both semantic integration (well-integrated items) and episodic integration (SPT encoding) are required for good memory performance. In cued recall and recognition tests, which are less effortful tasks, only the effect of enactment improves memory performance (Kormi-Nouri, 1995; Kormi-Nouri & Nilsson, 1998; Kormi-Nouri et al., 2008).

In the present study, the comparison between the SPTs and EPTs revealed that there are both similarities and dissimilarities in these two types of enactment. Generally speaking, within each school-aged group, comparable memory enhancing effects was observed for both SPTs and EPTs under all test conditions. In the action memory literature (both on adults and children), whether the enactment effects in SPTs and EPTs are comparable has been a controversial issue.

Feyereisen (2009) reported that EPT and SPT encoding conditions facilitate adults' relational processing and item-specific integration, respectively, which leads to similar memory performance. By contrast, Engelkamp and Zimmer (1989) reported that SPT memory is better than EPT memory and therefore argued for a motor-encoding view of SPTs. Baker-Ward et al. (1990) found that children's memory of SPTs was better than their memory of EPTs. The authors argued that memory of self-performed actions were more available and accessible than that of other-performed actions. Ratner and Hill (1991) found that EPTs and SPTs were recalled equally well in all ages; however, younger children were more sensitive to observing the actions of others. The authors argued that because SPTs required specific actions, SPTs might take too many mental resources for younger children. Foley and Johnson (1985) reported equal performance on SPTs and EPTs in younger children (6-year-olds) but better performance on SPTs than EPTs in older children (9-year-olds). The authors argued that younger and older children were different with respect to distinguishing between what they do by their own and what others do and that younger children were confused about the origin of memory.

The present results, which used typical action events (i.e., simple action events including one action verb and one concrete object) and wider age groups of school-aged children, indicate that the enactment effect is robust and observable either as self-involvement or as observer-involvement. Thus, physical activity is not necessarily an essential part of enactment. Rather, mental activity and involvement in action by either the self or others are important. This is also consistent with research demonstrating that the effect of enactments in SPTs with real verbs/real objects was comparable with that in SPTs with imaginary verbs/imaginary objects (Kormi-Nouri, 2000). This finding was explained by the episodic integration view that places no special role on

either physical movement or the physical object, stating that imaginary instruction for action is sufficient to boost recall to a level at which no further improvement is needed.

In the present study, there were also some differences between the SPTs and EPTs. First, as mentioned previously, the developmental difference (memory enhancement in children aged 8 to 14 years) was particularly enhanced for SPTs, but EPTs and VTs resulted in smaller and similar differences. For the free recall and cued recall tests, the developmental effect from 8- to 14-year-olds was the largest, more than twice as important for the SPTs compared to the EPTs and VTs. For recognition test, although there was still a small developmental effect for SPTs, this effect disappeared for EPTs and VTs. This finding indicates that the strategic nature of SPTs is even more detectable than that of EPTs and VTs. Thus, SPT is an effective and strategic encoding support that can be useful across school ages. Second, an interesting finding of the present study was an interaction effect between SPTs and EPTs from the 8-year-olds to 14-year-olds. For children aged 8 years, EPTs were recalled better than SPTs, but the opposite was true for children aged 14 years. This is consistent with a previous study by Foley and Johnson (1985), which demonstrated that 9-year-old children exhibited better recall performance for SPTs than EPTs, but that there was no difference between SPTs and EPTs among 6-year-old children. This finding is also consistent with the study by Ratner and Hill (1991), who showed that younger children are more sensitive to EPTs. In the present study, this effect was more pronounced for the free recall than the cued recall or recognition tests, suggesting that younger children are less able to perform action by themselves. This may be a result of the benefit of observing the physical performance of the action phrases without having to spend limited mental resources to perform the action correctly. This may also be explained by the strategic view of SPTs which states that older children can use SPTs more effectively than younger children.

A third difference between SPTs and EPTs can also be discussed in the present study. Although there was no significant difference between SPTs and EPTs in the free recall test, SPT memory was slightly but significantly better than EPT memory in the cued recall and recognition tests. It has been suggested that acting phrases (performing and observing the action) provoke different types and levels of cognitive and motivational processing (Knopf, et al., 2005). In SPTs, individuals are led to concentrate on each action phrase; hence, there is an increased distinctiveness in item learning and more detailed item-specific information (Steffens et al., 2006; Steffens et al., 2009; von Essen, 2005). By contrast, the level of organization and relational processing is superior in EPTs relative to SPTs (Golly-Haring & Engelkamp, 2003; Steffen, 2007). In free recall, there is a general agreement that both item-specific and relational information processing is required (Engelkam and Dehn, 2000; Steffens, 2007). It is therefore reasonable that using either of these two information processes in free recall can lead to comparable results for SPTs and EPTs, as was observed in the present study. This is also similar to the findings of Steffens (2007) and Steffens et al. (2006/2009). In recognition tests, item-specific information is sufficient to recognize the retrieval cues (Steffen et al., 2009). The fact that both SPTs and recognition are more facilitated by item-specific information processing can explain our finding of better performance for SPTs than for EPTs in terms of the recognition test. SPT memory was also better than EPT memory in the cued recall test. It can be argued that cued recall better follows the rules of recognition than does free recall. The cues have a critical role in cued recall and rely on an item-specific recall more than relational information processing (von Essen, 2005).

Practical views

These findings have several practical implications. In an experimental setting in which subjects are active observers and encoders (Zimmer & Cohen, 2001), enactment is a suitable way to examine the memory performance of children.

In pedagogy, educators have identified that experience-based learning plays a critical role in student learning. There are various types of experience-based learning: learning by doing and learning by observation have been suggested as the two main types of experience-based learning (Ballantyne & Packer, 2009). In learning by doing, students are actively involved in hands-on exploration and investigation, whereas in learning by observation, students visualize and understand the environment to evaluate and learn (Ballantyne & Packer, 2009). Students believe that learning events through their own experience, observing teachers actively, or a combination of the two said in learning, which contributes to longer-lasting learning (Ballantyne & Packer, 2009). Thus, students remember more of what they do and what they observe than what they hear. The findings of the present study support this idea by showing that the magnitude of encoding conditions was a large determinant factor in the variance of memory performance. Although both types of encoding enactment (i.e., SPT and EPT) were superior to verbal encoding (VT) in all ages and all test conditions, there were some differences. Across the school ages, the superiority of self-enactment was more pronounced than the superiority of others-enactment. This finding was particularly obvious for the free recall test compared with the cued recall and recognition tests. Interestingly, however, younger children's memory performances were better under EPT encoding conditions than SPT encoding conditions. However, older children exhibited better memory performance under SPT encoding conditions relative to EPT conditions. Pedagogically, this indicates that teachers play a special role in the

enacted learning and experience-based learning of younger children. For older children, however, self-involvement and self-initiated enactment becomes more important than enactment performed by others. This emphasizes the role of self-involvement and more active learning as children get older and enter the upper grades of their education.

The findings of the present study demonstrated that the recognition memory test can produce the best memory performance for school-aged children but is less age-sensitive. In contrast, the free recall test can produce the lowest memory performance but is more age-sensitive. The cued recall test was associated with moderate memory performance and moderate age sensitivity. Our results showed that the magnitude of the effect size in age was largest in the free recall test, whereas it was small in the cued recall. Additionally, there was no effect size on memory performance of the recognition memory test. It is important for teachers and instructors to understand what type of memory supports (either at the encoding or the retrieval stage) are most effective for students in each school-aged group.

Although the present study sought to fill the gaps of previous studies regarding important methodological issues, there remain some methodological limitations in the present study. For example, the recognition test was administered after the free recall and cued recall memory tests in a fixed order. It is possible that the memory performance of children for recognition was influenced by recall tests and may be the reason that we had some ceiling effects in our recognition results. Similar to most previous studies in the field, we also used a within-subject design with respect to our encoding and test conditions. The results would be more generalizable if a between-group design were utilized with these variables. Thus, the conclusions that can be drawn from our results should be interpreted with caution. These limitations need to be investigated in future research.

In conclusion, action memory warrants additional research, especially in regard to school children, and a new approach that focuses on children may be required. There remains a strong need for further studies of children that employ different experimental designs (especially longitudinal) and different materials (e.g., the presence or absence of objects and different levels of item integration and categorization) to gain additional insight into the factors underlying the enactment effect.

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Table 1

Participant characteristics with respect to age and IQ

<i>Age group</i>	<i>Participant characters</i>				
	Number	Gender Girl/boy	Age Mean (SD)	Raven Mean (SD)	
8-year-olds	104	52/52	8.7 (0.5) Min=8 Max=8.10	108 (1.3) Min=101	Max=119
10-year-olds	102	50/52	10.05 (0.51) Min=10 Max=10.06	110 (1.9) Min=99	Max=120
12-year-olds	102	50/52	12.6 (0.48) Min=12 Max=12.09	109 (1.7) Min=105	Max=118
14-year-olds	102	50/52	14.8 (0.49) Min=14 Max=14.10	104 (2.1) Min=103	Max=119

Table 2

Mean proportion of items correctly memorized as a function of school grade, encoding as well as retrieval condition. (The numbers in parentheses are standard deviations)

	Free recall			Cued recall			Recognition		
	VT	EPT	SPT	VT	EPT	SPT	VT	EPT	SPT
8-year-olds	0.12 (0.10)	0.22 (0.12)	0.18 (0.12)	0.44 (0.15)	0.54 (0.15)	0.53 (0.13)	0.72 (0.16)	0.85 (0.12)	0.83 (0.15)
10-year-olds	0.14 (0.10)	0.26 (0.14)	0.26 (0.12)	0.44 (0.15)	0.56 (0.14)	0.58 (0.17)	0.74 (0.14)	0.83 (0.14)	0.84 (0.14)
12-year-olds	0.17 (0.12)	0.30 (0.15)	0.32 (0.15)	0.46 (0.14)	0.59 (0.16)	0.63 (0.14)	0.74 (0.17)	0.84 (0.15)	0.87 (0.12)
14-year-olds	0.18 (0.14)	0.31 (0.15)	0.34 (0.16)	0.49 (0.16)	0.58 (0.17)	0.65 (0.16)	0.71 (0.18)	0.83 (0.14)	0.89 (0.12)

Figure 1. Percentage of action events recalled as a function of type of encoding (VT, EPT, and SPT) and school ages

Figure 2. Percentage of action events in cued recalled as a function of type of encoding (VT, EPT, and SPT) and school ages

Figure 3. Percentage of action events in recognition as a function of type of encoding (VT, EPT, and SPT) and school ages