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Early Development of Auditory-Verbal and Visual-Spatial Short-Term Memory: Age and Sex Effects

By

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Abstract

Memory is a multi-component cognitive ability to retain and retrieve information presented in different modalities. Research on memory development has shown that the memory capacity and the processes improve gradually from early childhood to adolescence. Findings related to the sex-differences in memory abilities in early childhood have been inconsistent. Although previous research has demonstrated the effects of the modality of stimulus presentation (auditory versus verbal) and the type of material to be remembered (visual/spatial versus auditory/verbal) on the memory processes and memory organization, the recent research with children is rather limited. The present study is a secondary analysis of data, originally collected from 530 typically developing Turkish children and adolescents. The purpose of the present study was to examine the age-related developments and sex differences in auditory-verbal and visual-spatial short-term memory (STM) in 177 typically developing male and female children, 5 to 8 years of age. Dot-Locations and Word-Lists from the Children's Memory Scale were used to measure visual-spatial and auditory-verbal STM performances, respectively. The findings of the present study suggest age-related differences in both visual-spatial and auditory-verbal STM. Sex-differences were observed only in one visual-spatial STM subtest performance. Modality comparisons revealed age- and task-related differences between auditory-verbal and visual-spatial STM performances. There were no sex-related effects in terms of modality specific performances. Overall, the results of this study provide evidence of STM development in early childhood, and these effects were mostly independent of sex and the modality of the task.

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Introduction

Memory is a multi-component system that encompasses various cognitive processes such as encoding, maintaining and retrieving information (Klatzky, 1980). Memory has been defined as the “persistence of learning in a state that can be revealed at a later time” (Squire, 1987, p. 3). There are multiple memory systems (Ashby & O’Brian, 2005; Squire, 1987; 1992). These include working memory (WM), short-term memory (STM) and long-term memory (LTM). Research demonstrated that the modality of information presentation (i.e. auditory versus visual) has an effect on the subsequent recall regardless of the type of memory involved (Constantinidou, Danos, Nelson, & Baker, 2011; Penney, 1989; Pierce & Gallo, 2011). Moreover, it has been shown that both auditory-verbal and visual-spatial memory improves with age (Haden, Ornstein, O’Brian et al., 2011), however the studies of the direct comparison of modalities in children and adolescents are rather limited (Alloway, Gathercole, & Pickering, 2006; Hale, Bronik & Fry, 1997). The results of the studies on age-related memory development show that the ability to remember is evident in the early stages of life (Dirix, Nijhuis, Jongsma, & Hornstra, 2009; Haden et al., 2011; Liston & Kagan, 2002; Rose, Feldman, & Jankowski, 2001; Rovee-Collier, 1997) and gradually develop from childhood to adolescence (Chuah & Maybery, 1999; Kail & Ferrer, 2007; Luna, Garver, Urban, Lazar, & Sweeney, 2004; Sprondel, Kipp, & Mecklinger, 2011).

Besides age-related differences in memory research, performance variations between males and females have been a topic of interest within the literature. Although previous studies have demonstrated the effects of sex on verbal and visual-spatial memory performance (i.e. females outperform males on verbal memory tasks and males outperform females on visual-spatial memory), overall findings have been inconsistent. For example, Honda and Nihei (2009)

showed that females performed better than males in an object location memory task, which requires spatial ability. However, an earlier study by Cherney and Ryalls (1999) did not find significant sex-related differences in object recall. In a more recent study, using spatial-span tasks, Aparacida et al. (2011) also failed to demonstrate any significant differences between male and female children and adolescents between 6 to 18 years of age. The majority of findings on sex differences pertaining to memory and cognitive development point to more specific, task-, age-, context- and modality-dependent performance differences between males and females.

Given the gaps and the inconsistencies among the research findings outlined above, the focus of the present study is to examine age- and sex-related differences in auditory-verbal and visual-spatial STM in typically developing children, 5 to 8 years of age. Another interest of this investigation is to examine the effects of modality of the stimulus presentation, and the type of material on memory performance in males and females across ages. It is important to note that the data used in the present study is part of a larger data set originally collected from middle and upper-middle socio-economic status of Turkish children and adolescents ($N = 530$) from the city of Bursa, Turkey. The goal of the original investigation was to provide age-based Turkish norms of a group of neuropsychological tests for the school-based psychometric assessments and clinical evaluations in Turkey.

The following sections contain overviews of research on memory systems, cognitive development in relation to memory systems and modality specific memory performances. Sex-related differences pertaining to memory and cognitive development are also reviewed. Lastly, the rationale and research questions are presented.

A Brief Overview of Memory

Memory involves three systems: STM, WM and LTM (Ashby & O'Brian, 2005; Squire,

1987; 1992). Initial theoretical frameworks for the first two systems, STM and WM were proposed by Atkinson and Shiffrin (1968) and Baddeley and Hitch (1974), respectively.

Following this, Baddeley introduced his WM model in greater detail (Baddeley, 1986).

Baddeley's WM model includes three components: a central executive (CE), and the two slave components; the phonological loop (PL), and the visuospatial sketchpad (VSSP). The CE is a system that regulates attention, action, and problem solving. This component is also thought to control and regulate the slave systems: the PL and the VSSP (Baddeley, 1986). The PL stores auditory-verbal information for a very brief period of time. It is responsible of the articulatory rehearsal of verbal information (Baddeley, 1986). The VSSP stores and manipulates visual-spatial information (Baddeley, 1986; 1998). Gathercole, Pickering, Ambridge and Wearing (2004) assessed Baddeley's (1986) WM model and suggested that components of WM are evident at 6 years of age and performances were found to improve into mid-adolescence.

STM was originally referred to as "primary memory" as it consists of current and immediate attention and information (Squire, 1987). Without external interferences, STM involves short periods (up to thirty seconds) of retained information (Baddeley, 1998). Studies have utilized executive suppression tasks to interfere with task performances and suggest that these tasks impair WM performances more so than STM performances (Ang & Lee, 2008; Ang & Lee, 2010). There are many differences between WM and STM, but typically, WM involves performing cognitive tasks while mentally manipulating information. For example, STM can be examined by the recall of items. A task that can be used may include a forward span task in which the correct order of items is recalled immediately or after a brief period of time (Klatzky, 1980). In opposition to this, WM is often examined by a backward span task in which the individual repeats a random sequence of numbers backwards. In this task, the individual not only

rehearses the items, but also, mentally manipulates the information.. Studies have shown that the forward sequences are recalled better than the backward sequences, specifically, if the information is spatial (Luciana, Conklin, Hooper & Yarger, 2005).

Lastly, LTM is the “permanent storehouse for knowledge about the world” (Klatzky, 1980, p. 8). It is thought to include everything someone has learned or remembered, such as conversations, songs, and how to ride a bike (Klatzky, 1980). LTM has two divisions: declarative and procedural memory (Squire, 1987). Declarative, or explicit, memory involves consciously remembering events or facts which can be retrieved from our LTM (Ashby & O’Brian, 2005). There are also two subdivision of declarative memory: episodic and semantic memory. These two memory subsystems often involve recognition and recall tasks and refer to memory for faces, scenes, stories and words (Squire, 1992). In opposition, procedural, or implicit, memory involves unconscious skill learning and conditioning (Ashby & O’Brian, 2005). Research suggests that implicit memory is present at birth and ready to process information (Rovee-Collier, 1997). Perez, Peynircioglu, and Blaxton (1998) showed that procedural performances did not change but declarative memory improved across the lifespan. Memory abilities and cognitive skills, specifically, the speed in which information is processed and recalled improves across the lifespan (Chuah & Maybery, 1999; Kail & Ferrer, 2007).

Cognitive Development and Memory

According to Piaget (1973), children develop through distinct and successive stages across time and cognitive abilities improve as children get older; older children are more competent than younger children. Piaget (1973) posits that due to cognitive maturity, there are inherent limits to what someone can do. Expanding on the perspectives of Piaget, Neo-Piagetian theorists, Case (1985) and Pascual-Leone (1987), reflected on individual differences in

developmental rates of cognition. Both addressed the speed and rate in which information is processed and the developmental capacity (span) limitations. As children get older, their cognitive capacity increases. In general, younger children's capacity and memory span is thought to be much smaller and limited than older children's and adolescents' memory span. Conklin, Luciana, Hooper, and Yarger (2007) examined WM with forward digit and letter span tasks and found that children aged 9 to 10 years displayed shorter spans than children aged 13 to 17 years.

According to the Information Processing Approach, processing speed can be defined as the brain's capacity and its speed to engage in task related goals and it also responds to the demands of a task. Subsequently, processing speed is thought to affect memory performance. Kail and Ferrer (2007) found that processing speed improved across ages with performances rapidly improving throughout childhood. McAuley and White (2011) examined processing speed, response inhibition and WM among American children, adolescents and adults aged 6 to 24 years. They found that all three cognitive abilities rapidly improved from 6 to 12 years of age, after which, few improvements were reported. In the same study (McAuley & White, 2011) significant age-related improvements in WM due to improved processing speed were also reported. Neo-Piagetian theorists also discuss WM and STM capacity and link WM performances to increases in processing speed.

Case, Kurland, and Goldberg (1982) found that an individual can process information faster overtime with practice, and by becoming familiar with the content. Although practice and familiarity can improve performance, there are cognitive limitations pertaining to the age of an individual. For example, a young child will process information slower than an older adolescent (Kail & Ferrer, 2007). Thus, brain development and cognitive maturation plays a role in how someone processes information (Conklin et al., 2007).

Chuah and Maybery (1999) suggested that increases in verbal and spatial span throughout development may be influenced by processing speed. One explanation for adolescents' matured cognitive abilities compared to younger children's may be due to adolescents' quicker processing speeds. Adolescents are able to process information at a greater cognitive speed and accuracy than preadolescents and children (Luna et al., 2004). Protracted frontal lobe development is suggested as a mechanism underlying cognitive maturation involved in executive functioning, working memory and problem solving (Case et al., 1982; Conklin et al., 2007; Luciana et al., 2005). Another aspect of cognitive maturation and memory capacity is the children's ability to use strategies. As children age, their ability to remember increases and subsequently, children's memory strategies become more sophisticated (Schneider, Kron-Sperl, & Hunnerkopf, 2009).

Strategy use is thought to progressively develop in early childhood (Schneider et al., 2009). Overtime, children are increasingly able to recall a greater number of items (Chuah & Maybery, 1999; Luciana et al., 2005). Grammer, Purtell, Coffman, and Ornstein (2011) suggests that these changes occur when children are able to understand the processes involved in memory, specifically, the storage and retrieval of information. Alloway, Gathercole, and Pickering (2006) suggests that as children grow older, verbal rehearsal strategies are utilized to code visual material specifically, and visual codes are utilized more frequently by younger children.

Schneider et al., (2009) studied verbal STM and strategy development among young German children age 6 to 10 years using a series of recall and capacity measures. Children who used strategies outperformed the children that did not use any strategies. Older children (7-10 years) were more likely to use categorization which increases recall performance significantly (Schneider et al., 2009). This research indicates that strategy use improves over time and across ages. It also suggests that utilizing multiple strategies improves memory performance. Older

children are able to use more sophisticated strategies to assist in recalling information, both short- and long-term (Schneider et al., 2009).

In a recent study conducted by Schwenck, Bjorklund, and Schneider (2009), 4-8 year old German children were examined while performing immediate recall for visual-spatial tasks, and utilizing recall strategies. All children were tested two weeks later to see if they remembered the relevant items. The children's performances improved from time 1 to time 2 (Schwenck et al., 2009). Older children outperformed younger children on tests of recall, and they also used more strategies than younger children. These findings support the Schneider et al. (2009) study as older children performed significantly better than younger children in both studies.

Auditory-Verbal and Visual-Spatial Memory in Children

The modality of stimulus presentation (auditory versus visual) and the type of material to be remembered (visual/spatial versus auditory/verbal) have an effect on memory processes and memory organization (Penney, 1989). Consistent with the behavioural findings, research in neuroscience also show various modality and material specific activation of memory networks in the brain (Shucard, Tekok-Kilic, Shiels & Shucard, 2009). In terms of developmental changes, the processing of visual information is thought to develop early on. Rose et al. (2001) studied infant recognition memory among 5, 7, and 12 month-old infants through look duration, and gaze shift, towards novel stimuli. Infants with shorter look durations process information faster and more efficiently (Rose et al., 2001). The researchers reported that the ability to recognize novel stimuli increased with age, as older infants displayed shorter look duration and higher shift rates (Rose et al., 2001). The ability to distinguish and remember external stimuli improves across infancy. This ability could be considered as the beginning of visual memory.

Improvements in auditory-verbal and visual-spatial STM are evident across age groups (Alloway et al., 2006; Luna et al., 2004). Alloway et al. (2006) studied the structure of verbal and spatial STM and WM among British children age 4 to 11 years. The results revealed significant performance differences across age groups. Alloway et al. (2006) found linear age increases in STM and WM performances. It is suggested that the ability to remember precise spatial information over brief periods may develop until age 7. Moreover, Luciana et al. (2005) examined nonverbal (spatial) WM and STM across ages (9 to 20 years) and reported improved memory performances throughout childhood and into adolescence. Young adults aged 16 to 20 years performed significantly better than children and adolescents aged 9 to 15 years (Luciana et al., 2005). Also, younger children (9 to 10 years) performed worse than older participants aged 13 to 20 years (Luciana et al., 2005); while among the older age groups, performances did not differ. Although the Luciana et al. study provides a comprehensive analysis of spatial STM development across childhood and adolescence, the study does not include early childhood. The findings from the Luciana et al. (2005) study further illustrate cognitive maturation with age pertaining to memory development. Other studies (Conklin et al., 2007) have also shown age-related improvements pertaining to spatial WM performance.

Conklin et al. (2007) also examined spatial and verbal WM performances among American children and adolescents age 9 to 17 years. Younger children (9-10 years) could recall fewer digits and letters on forward and backward span tasks than older children, and adolescents (13-17 years), and preadolescents (11-12 years) recalled fewer digits than older adolescents (16-17 years). Overall, children and preadolescents (9-12 year olds) made more errors than adolescents aged 13 to 17 years (Conklin et al., 2007). Conklin et al. also reported that performances were typically better on spatial tasks than verbal WM tasks. However, the

participants in the Conklin et al. study included children and adolescents with above average intellectual abilities and functioning, which may not represent the general population.

Vuontela, Steenari, Carlson, Fjallberg, and Aronen (2003) indicate that audio-spatial and visual-spatial WM performances improve with age. Vuontela et al. (2003) examined visual and auditory object location tasks among 6 to 13 year olds in Finland, and found that performance speed and accuracy increased with age. Also, visual-spatial tasks were performed faster and with greater accuracy than auditory-spatial tasks, which suggests that visual WM reaches functional maturity earlier than auditory WM (Vuontela et al., 2003). However, the Vuontela et al. (2003) study examined auditory-spatial memory which is different from auditory-verbal memory. It is unknown if these age differences are evident between visual-spatial and auditory-verbal memory performances in young children.

Earlier research has examined the typical development of visual memory in late childhood and mid-adolescence. In one experiment conducted in Scotland, Flin (1985) used images of flags to examine object recognition and recall among children and adolescents age 8 to 15 years. From 8 to 12 years of age, performances improved then slightly decreased at age 13 then increased again. In a second experiment, Flin (1985) examined children and adolescents age 7 to 15 years. Again, from 7 to 12 years of age, performances improved then slightly decreased at age 12 to 13 then increased again. This finding suggests nonlinear development across the lifespan. Flin (1985) attributed this decrease in performance to pubertal changes. Other researchers (Maccoby & Jacklin, 1974) have suggested that the effect of hormones and psychosocial influences appear post-puberty are responsible for the cognitive differences between males and females.

Gathercole et al. (2004) examined WM and found the three components of WM (phonological loop, central executive and the visual-spatial sketchpad) evident at 6 years. Gathercole et al. (2004) found a linear trend in performances across the ages. Similar to these findings, Ang and Lee (2008) also found that older children (age 11) outperformed younger children (age 8) on spatial WM and STM tasks. A recent study by Ang and Lee (2010), examined the potential executive differences between visual STM and WM among 8 to 11 year olds. Visual WM performance was impaired significantly by the executive suppression task. WM requires executive resources more so than STM during visual tasks. In addition to these findings, Ang and Lee (2010) found that older children outperformed younger children on tasks involving visual memory. All three studies (Gathercole et al., 2004; Ang & Lee, 2008; 2010) were conducted in England.

Congruent with previous findings, Ang and Lee (2010) demonstrated that as children grow older, memory performances in spatial WM and STM tasks improve. Alloway et al. (2006) studied the structure of verbal and visual-spatial STM and WM in children age 4 to 11. The results revealed significant performance differences across age groups. Specifically, all components of WM are evident by 4 years of age. This finding suggests earlier development of WM components compared to previous findings by Gathercole et al. (2004), but also supports the previous findings relating to linear age increases in STM and WM performances. In addition to age-related differences in memory performances, researchers have also examined the sex differences pertaining memory and cognition.

Sex Differences in Cognition

Studies have examined sex differences pertaining to cognition across the lifespan, including intelligence, reasoning abilities, reading and writing skills, as well as spatial abilities

(Geiser, Lehmann, & Eid, 2008). Research indicates that sex differences pertaining to spatial skills may be evident at an early age (Moore & Johnson, 2008). Levine, Huttenlocher, Taylor, and Langrock (1999) found that American boys under the age of 5 displayed greater spatial skills than girls, especially on mental rotation tasks in which participants are required to mentally rotate three-dimensional cube shapes. A study conducted in Germany by Geiser et al. (2008) examined age and sex-related differences in mental rotation tasks among males and females age 9 to 23 years, and reported that across ages, males outperformed females. Also, the mental rotation performances increased with age in both males and females (Geiser et al., 2008). However, this study does not address young children prior to the age of 9. Also, the Geiser et al. (2008) study does not focus on visual-spatial memory performance, but it does provide evidence for sex-related differences in spatial cognition.

Sex Differences in Auditory-Verbal and Visual-Spatial Memory

Research on the sex differences in modality-specific memory tasks presents conflicting findings. It is important to note that most studies related to sex differences have been conducted with adolescents and adults, and research with younger children is limited. Although some research suggests that females exhibit superior verbal abilities pertaining to memory and cognitive tasks, specifically the recall of words (Lewin et al., 2001; Krueger & Salthouse, 2010), this finding has also been contested in other studies which concluded that sex differences are not evident for the recall of words (Ionescu, 2004).

In addition to this, researchers often report that males exhibit superior spatial abilities pertaining to memory and cognitive tasks (Geiser et al., 2008; Lowe, Mayfield, & Reynolds, 2003; Newhouse, Newhouse, & Astur, 2007; Schoenfeld et al., 2010), specifically mental rotation tasks (Choi & L'Hirondelle, 2005; Lawton, & Hatcher, 2005; Lewin, Wolgers, &

Herlitz, 2001; McBurney, Gaulin, Devineni, & Adams, 1997; Sanders, Bereczkei, Csatho, & Manning, 2000; Schoenfeld, Lehmann, & Leplow, 2010; Sharps, Welton, & Price, 1993).

However, some researchers have also reported that females exhibit superior spatial abilities for object and facial recognition and recall (Harness, Jacot, Scherf, White, & Warnick, 2008; Horgan, Schmid Mast, Hall, & Carter, 2004; Lewin et al., 2001; Poulin, O'Connell, & Freeman, 2004).

Females often outperform males on tasks of object location recall (Honda & Nihei, 2009; Choi & L'Hirondelle, 2005; Voyer, Postma, Brake, & Imperato-McGinley, 2007). A study conducted in Japan by Honda and Nihei (2009) examined sex-related differences in long-term object location memory in adults. Participants recalled object locations after 3 minutes or after 1 week. Honda and Nihei (2009) examined sex-related differences in *Location-exchanged* and *Location-maintained* objects. Participants were instructed to remember the location of several objects then asked to identify objects previously viewed (Location-maintained objects) and objects not previously evident (Location-exchanged objects). Females outperformed males on the ability to recognize displaced objects after 3 minutes (immediate recall) but not 1 week later (Honda & Nihei, 2009). This research suggests that females outperform males on spatial skills pertaining to the displacement of object locations, but only immediately after object displacement (Honda & Nihei, 2009). This study examined adults only, so it is unknown if these sex differences are evident among young children.

A study by Conklin et al. (2007) included young children and adolescents (9-17 years) and found no significant sex differences on any spatial WM task, which included an object location task. Barnfield (1999) studied 4 year old Canadian children to examine object location memory. No significant sex differences were found. Similar to these findings, Young and Wilson

(1994) and Cherney and Ryalls (1999) also did not find significant sex differences among young children in any object recall task. Young and Wilson (1994) examined children age 5 to 11 years, while Cherney and Ryalls (1999) examined children aged 3 to 6 years. Cherney and Ryalls (1999) did note that females remembered more feminine objects and males remembered more masculine objects. This finding was also evident in an earlier study conducted by Levy (1995) and also mirrors similar findings from a recent study with adults by Gallagher, Neave, Hamilton, and Gray (2006) conducted in England.

Newhouse et al. (2007) studied visual-spatial learning and memory skills among prepubescent American children age 8 to 10 years through the use of a Virtual Morris Water Task. This memory task requires participants to locate various hidden and visible platforms underwater from various starting locations. If a participant required more than 60-seconds to locate the hidden platform then the platform became visible. During the trial sessions, participants took less time finding the platforms overtime, but males performed faster than females (Newhouse et al., 2007). Since males were able to quickly relocate the platforms, Newhouse et al. (2007) suggested that males appeared to use spatial strategies more often than females. Similar to Geiser et al. (2008), these findings suggest sex differences in spatial ability among prepubescent children. It further demonstrates males' superior visual-spatial memory abilities.

A recent study conducted by Bull et al. (2010) examined sex and individual differences in visual-spatial STM, numerical skills among 5 year old Scottish children, and the amount of prenatal estrogen and testosterone exposure. Ratio of the 2nd to 4th finger digit (2D:4D) is used as an index of prenatal estrogen and testosterone exposure and typically, males display lower 2D:4D than females (Voracek, Dressler, & Manning, 2007). Although Bull et al. (2010) found

no significant sex differences for basic arithmetical, numerical or visual-spatial STM between males and females, the girls with lower 2D:4D displayed better visual-spatial skills than girls with higher 2D:4D (Bull et al., 2010). Bull et al. (2010) suggest that in early development, there may be few sex differences in visual-spatial processing; however, there may be more individual variability among females in terms of visual-spatial processing due to prenatal testosterone exposure. Overall the results of this study indicate that visual-spatial STM does not differ among young children, specifically, between males and females at 5 years of age (Bull et al., 2010).

Another study conducted by Lowe et al. (2003) examined sex differences on fourteen measures of STM among American children and adolescence 5 to 19 years of age. Lowe et al. (2003) found that males outperform females on object location spatial tasks, and females outperform males on verbal tasks (Object Recall and Word Selective Reminding). Although this study has found sex differences on spatial tasks, the specific age-related differences were not addressed. Research indicates sex-related differences for object location memory, but results are inconsistent in whether or not males outperform females and there is no consensus of how early spatial sex differences in memory are evident.

Specifically, Bull et al. (2010) found no differences among 5 year old children in regard to visual-spatial memory. Lowe et al. (2003) reported spatial and verbal memory differences between males and females 5 to 19 years of age but did not report age specific differences. Also, Newhouse et al. (2003) report sex differences among children age 8 to 11 for spatial memory tasks. Males performed faster in spatial memory tasks than females (Newhouse et al., 2003). However, sex-related differences for spatial memory may be task-dependent. Males typically outperform females on tasks pertaining to mental rotation, however there are mixed findings in

whether or not females excel on tasks of object recall (Young & Wilson, 1995; Honda & Nihei, 2009). Overall, these mixed findings suggest that further research is needed to address sex-related differences pertaining to auditory-verbal and visual-spatial memory, especially in young children.

The Present Study

The first purpose of the present study is to investigate the developmental trends pertaining to auditory-verbal and visual-spatial memory among young children 5 to 8 years of age. A second purpose of the present study is to investigate possible sex differences in auditory-verbal and visual-spatial memory tasks. In contrast to previous studies the present study has a larger sample size with almost equal representation in each age group and for both sexes. This study also utilizes a memory scale specifically developed for children and adolescents.

The present study is a secondary analysis of the data, collected from the various kindergartens, elementary and secondary schools located in Bursa, Turkey by the thesis supervisor, Dr. Ayda Tekok-Kilic. Numerous studies have examined memory function and ability with North American participants, but fewer studies have been conducted elsewhere (Alloway et al., 2006; Gallagher et al., 2006; Honda & Nihei, 2009). Although the cross-cultural comparisons were not targeted in this study, it is important to note that examining memory development in a different culture may provide information about possible culture-dependent aspects of cognitive development.

Research Questions

The present study addresses the following research questions:

Research question 1: Are there significant age- and sex-related differences in visual-spatial short-term memory performances?

Research question 2: Are there significant age- and sex-related differences in auditory-verbal short-term memory performances?

Research question 3: Are there significant age- and sex-related differences between modality- specific memory performances?

Methods

Participants

The sample of this present study consisted of a total of 177 (47% female) typically developing children 5 to 8 years of age, a sub-sample that was chosen from a larger normative study (please see Procedures section below for the details of the Original Study). The participants were recruited from three kindergartens, and eight elementary schools encompassing the middle, upper-middle SES districts of the city of Bursa, Turkey (See Table 1 for the number of participants in each age group).

Table 1

Number of Participants (Male/Female) in Each Age Group

Age (Years)	Female	Male	Total
5	20	27	47
6	23	29	52
7	17	17	34
8	24	20	44
Total	84	93	177

Measures

Children's Memory Scale (CMS): The CMS is a comprehensive learning and memory battery developed to assess learning, short-term and long-term recall and recognition in visual-spatial and auditory-verbal domains in children ages 5 to 16 years (Cohen, 1997). The scale includes six core and three supplemental subtests which examine verbal and nonverbal memory, immediate and delayed memory, WM, attention and concentration. The present study used performance scores from Dot Locations and Word List subtests. Dot Locations assesses memory in visual-spatial domain and Word List assesses memory in auditory-verbal domain.

Dot Locations: This subtest assesses visual/nonverbal learning and memory. Children are assessed on their ability to recall various spatial locations using blue round chips. Children are presented with a display of 6 response chips on a 3x4 response grid [See Figure 1]. After the initial presentation, children must immediately recall the correct display of dot locations (Trial 1) by placing the blue chips on the response grid. Following this, there are two additional Learning Trials (Trials 2, 3). The score range is 0-6 for each trial, for a Total Recall score of 0-18 (Trials 1, 2, 3). After the third trial, there is a fourth trial in which the child is presented with a new 3x4 response grid using red round chips. This fourth trial is a distractor display, and is an interference task. After the child recalls the distractor display, the child is then asked to immediately recall the original blue dot locations display (Short Term Recall After an Interference). This recall assesses spatial recall after an interference task which measures the short-term recall of already rehearsed and learned information. This type of recall is also referred to as Retroactive Interference. The score range is 0-6 Short Term Recall After an Interference.

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Figure 1. Dot Locations. Example of a display of 6 response chips on a 3x4 response grid (adapted from Cohen, 1997)

Word Lists. This subtest assesses auditory/verbal learning and memory. Children are assessed on their ability to recall an unrelated list of words across four trials. The score range is 0-10 for each trial, for a Total Recall score of 0-40 (Trials 1, 2, 3, 4). First, the examinee reads off a list of 10 words after which the child recalls the list of words randomly. After Trial 1 only, the child is reminded of the words not recalled then asked to recall the list of 10 words. After Trials 2, 3 and 4, there is a fifth trial in which the child is presented with a new list of 10 unrelated words. This fifth trial is a distractor list and is an interference task. After the child recalls the distractor list, the child is then asked to immediately recall the original list of words (Short Term Recall After an Interference). This recall assesses verbal/auditory recall after an interference task which measures the short-term recall of already rehearsed and learned information. This type of recall is also referred to as Retroactive Interference. The score range is also 0-10 for Short Term Recall After an Interference. For this study, the words in the Word List test were translated in Turkish.

Procedure

The Original Study. The original study (2001-2004) was supported by the Turkish State Planning Department (DPT 2000-3) and Uludag University (Tekok-Kilic, & Elmastas-Dikec, 2001). The complete research protocol was submitted for an approval to the Ethics Board of the Bursa Chamber of the Turkish Ministry of National Education. After the ethics clearance were granted, the participating schools were chosen from kindergartens, elementary, middle and high schools located in the middle and upper-middle socio-economic areas of the city of Bursa. In the participating schools, parental informed consents including the description of the study were sent to the parents. The children whose parents gave permission, but did not match the selection criteria, still took the tests, but their data were not included in the analyses. The CMS was administered individually to each participant in one session at school by trained technicians. Additional tests measuring abstract thinking (Children's Category Test), gross-motor and fine motor abilities (Hand-Dynamometer, Pegboard, Benton Finger Localization), visual-motor coordination (Beery-Bucktenica VMI) were also administered to all participants during the same session. An approximate duration of testing was one to one and a half hour for CMS. The whole testing session for individual child was 2 -2.5 hours. Within-tests breaks were permitted as necessary. The data collection took place during 2001-2004. A total of 530 males and females ages 5 to 16 years were recruited for the original study.

The Present Study. The present study is the secondary analyses using part of the data set described above (5-8 years). As stated in the REB application, with regard to the confidentiality and protection mandates, the researcher of this study was responsible to conduct the statistical analyses on the main computer, and she did not retain a copy of the data of her own. The researcher was blind to the identities of the participants as the participants were coded by subject

numbers in the data base. The present study was approved by Brock University Research Ethics Board (10-227) for secondary data utilization (See Appendix for the REB approval).

Results

Overview of the Design and Analyses

This study utilized a quantitative approach and a cross-sectional design to answer research questions pertaining to the developmental trends and sex-related effects in auditory-verbal and visual-spatial short-term memory tasks. In this study, there were two attribute (age, sex) and one active (modality) independent variables. The dependent variables were the various performance scores (interval scale) from Dot Localization and Word Lists subtests.

The sample of this study consists of a total number of 177 typically developing girls ($n = 84$; 47 %) and boys ($n = 93$, 53%) between 5 to 8 years of age (see Table 1). In this study, possible age and sex-related differences in visual-spatial and auditory-verbal short-term memory and learning were tested separately using Between-Groups, Within- Subjects and Mixed Designs. Word List raw recall scores were used as performance measures in auditory-verbal domain. In visual-spatial domain, Dot Location raw recall scores were entered in the analyses (see Table 2 for means and standard deviations of performance scores). In order to compare visual-spatial and auditory-verbal memory performances across ages, the raw recall scores were transformed into percent correct scores for each test in both modalities. These percentages were then used to compare short-term memory and learning performances in visual and verbal modalities. Significant interaction effects were further tested with One-Way ANOVAs. The significance level was set to .05 for each analysis.

Table 2

Dot Location and Word Lists: Means (standard deviations) of subtest scores

Subtest	5 Years		6 Years		7 Years		8 Years	
	Female	Male	Female	Male	Female	Male	Female	Male
	<i>M</i> (<i>SD</i>)							
Dot Location								
Trial 1	3.9 (0.9)	3.7 (1.1)	4.4 (.95)	3.9 (1.1)	4.5 (0.9)	4.6 (1.1)	5.0 (0.9)	4.9 (1.1)
Total recall	12.2 (3.2)	12.0 (2.7)	14.4 (2.9)	12.5 (2.9)	14.6 (2.7)	15.4 (2.2)	15.6 (2.7)	16.3 (1.7)
Interference	4.1 (1.3)	4.0 (1.2)	4.7 (.98)	3.9 (1.3)	4.3 (1.4)	4.9 (1.3)	5.3 (1.0)	5.6 (0.9)
Word List								
Trial 1	2.6 (1.6)	2.6 (1.2)	3.2 (1.6)	2.3 (1.4)	4.9 (1.5)	4.2 (1.6)	4.3 (1.8)	5.0 (1.8)
Total recall	16.5 (7.2)	17.1 (4.9)	20.7 (7.1)	20.1 (6.5)	28.8 (4.7)	25.4 (6.9)	26.5 (7.5)	27.7 (4.6)
Interference	3.1 (2.9)	2.3 (2.3)	4.4 (2.3)	4.1 (2.8)	7.1 (2.2)	6.6 (2.7)	7.0 (2.7)	7.1 (2.1)

Research Question 1: Are there significant age- and sex-related differences in visual-spatial short-term memory performances?

For Dot Locations, three separate Sex X Age (4) ANOVAs were conducted to examine possible age and sex differences on Trial 1, Total Recall (sum of all three trials), and Short-Term Recall After an Interference task. In addition, to examine the visual-spatial learning, a Sex X Age (4) X Trial (3) design with repeated measures on the last factor was conducted.

Trial 1: There was a significant main effect for age [$F(3, 169) = 10.20, p = 0.00$]. Pairwise comparisons across the four age groups revealed that 5 and 6 year olds did not differ. 5 year olds performed significantly worse in comparison to both 7 and 8 year olds. Also, 6 year

olds performed significantly worse than 8 year olds; while 7 and 8 year olds had similar performances [See Figure 2].

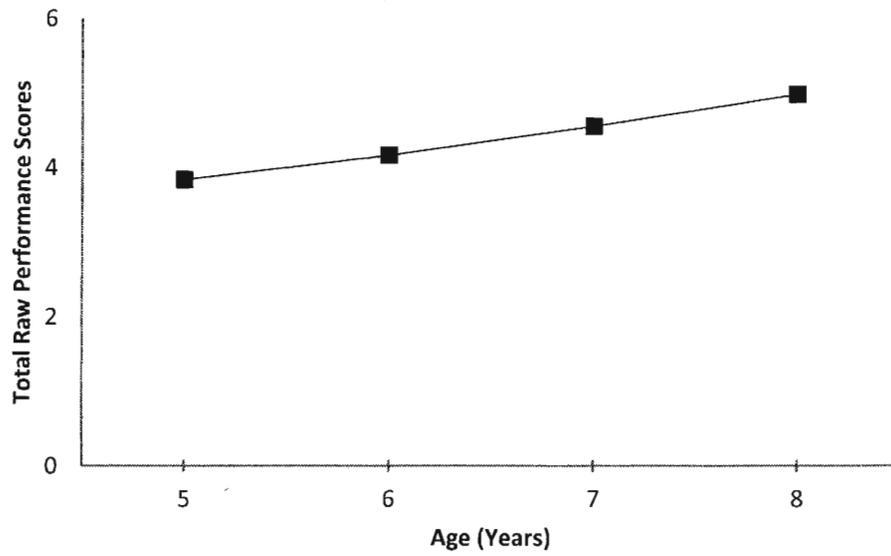


Figure 2. Mean performance scores for Dot Locations, Trial 1.

Total Recall: Age main effect was significant [$F(3, 169) = 17.93, p = 0.00$]. There was no main effect for sex and the sex X age interaction was not significant. Pairwise comparisons across the four age groups revealed that 5 year olds performed significantly worse than the older participants. Also, 6 year olds performed significantly worse than 7 and 8 year olds; but there were no significant differences among 7 and 8 year olds [See Figure 3].

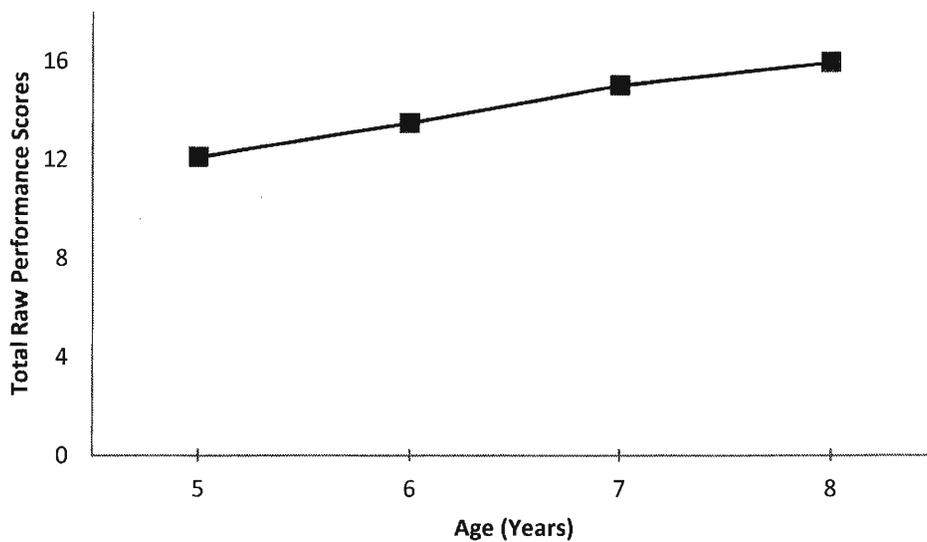


Figure 3. Mean performance scores for Dot Location, Total Recall (Across All 3 Trials).

Short-Term Recall After an Interference: Results revealed that there was a significant main effect of age, [$F(3, 169) = 11.88, p = 0.00$] and a significant age X sex interaction [$F(3, 169) = 2.95, p = .03$]. Specifically, 5 and 6 year olds did not significantly differ from one another, but 5 year olds performed significantly worse than 7 and 8 year olds. Also, 6 and 7 year olds did not significantly differ, however both performed significantly worse than 8 year olds. As main effects are explained by the interaction only the significant interaction was probed by conducting One-Way ANOVAs comparing boys and girls in each age group [See Figure 4]. Among 5 year olds, boys and girls did not significantly differ [$F(1, 46) = 0.76, p = .8$] but 6 year old girls performed significantly better than 6 year old boys [$F(1, 51) = 6.01, p = .018$]. Moreover, 7 year old boys and girls [$F(1, 33) = 2.02, p = .165$] and 8 year old boys and girls did not significantly differ from one another [$F(1, 43) = .73, p = .39$].

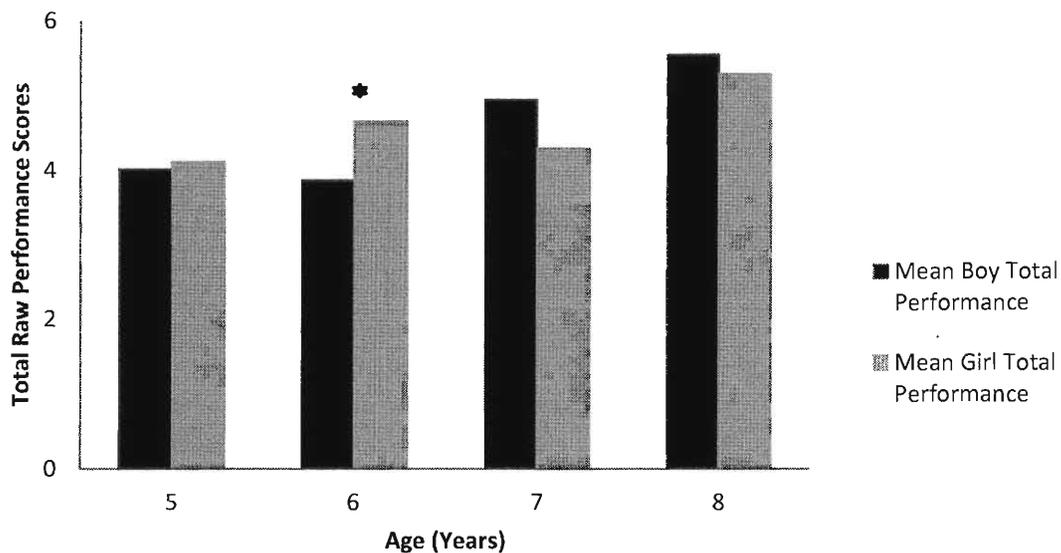


Figure 4. Mean performance scores for Dot Location, Short-Term Recall After an Interference.

Short-term visual-spatial learning: A sex X age (4) X Trial (3) within-between ANOVA with repeated measures on the last factor was conducted to examine the performance differences among three consecutive trials of Dot Location recalls. Results showed a significant main effect for trial [$F(2, 169) = 37.16, p = 0.00$]. All participants performed significantly worse on trial 1 than trials 2 and 3, however, performances on trials 2 and 3 did not significantly differ. There was a significant main effect for age [$F(2, 169) = 19.48, p = 0.00$]. Specifically, 5 year olds performed significantly worse than 6, 7, and 8 year olds. Also, 6 year olds performed significantly worse than 7 and 8 year olds, who did not significantly differ. Two- and three-way interactions were not significant [See Figure 5].

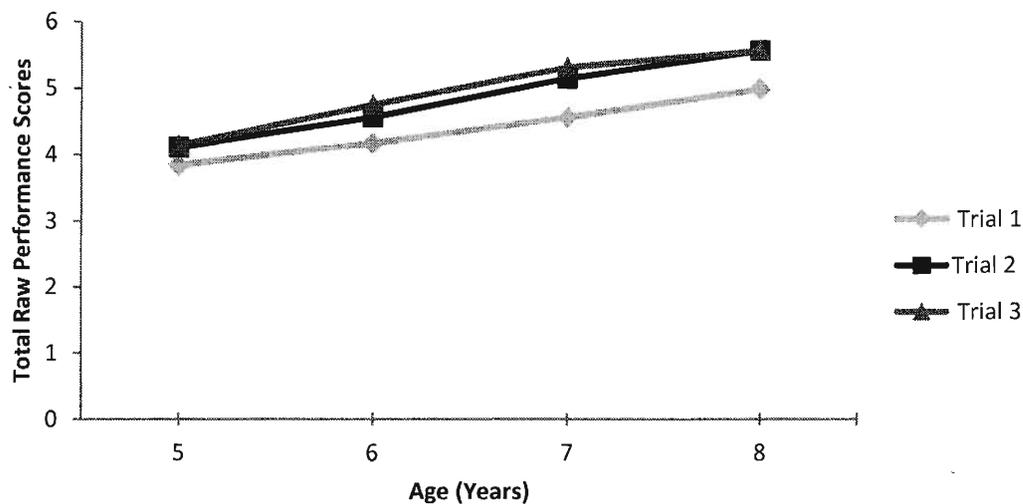


Figure 5. Mean performance scores for Dot Location, Learning (Trials 1, 2, 3).

Summary of the results of visual-spatial short-term memory: Visual-spatial short-term memory performance was measured by using three performance scores obtained from the Dot Location Subtest. The children's immediate recall, after having been exposed to the visual

stimuli only once, was measured by their scores in Trial 1. The results indicated that 5 and 6 year olds display similar performances but they are outperformed by 7 and 8 year olds who also showed similar performances. Total Recall scores reflected significant age differences in performance. There was a linear performance increase from age 5 to 7 years, whereas 7 and 8 year old children performed similarly. Children's short-term visual-spatial recall was also measured after being exposed to a visual-interference display. The results of this analysis revealed that younger children (5 and 6 years) were more vulnerable to retroactive interference than the older children (7 and 8 years). The lowest performance was observed in 5 year olds, and the highest performance was achieved by 8 year olds.

Overall, the results indicate that boys and girls in earlier ages show similar developmental progression of visual-spatial short-term memory, and learning when this cognitive capacity is measured by a simple spatial recall task. The data also suggests that males and females may show differential vulnerabilities to memory interference and these vulnerabilities are age dependent. For instance, 6 year old girls performed better than the 6 year old boys when they were exposed to an immediate interference. In terms of serial learning, results showed that regardless of age and sex, all children performed worse on trial 1 and improved by trial 2 and kept the same performance level on the last trial. Also, children's performances improved until age 7. Children age 7 and 8 displayed similar performances.

Research question 2: Are there significant age- and sex-related differences in auditory-verbal short-term memory and learning performances?

Similar to the analyses for Dot-Location, separate, Sex X Age (4) ANOVAs were conducted to examine age and sex effects on Trial 1, Total Recall (sum of all four trials), and

Short-Term Recall After an Interference. In addition, to examine the auditory-verbal learning, a Sex X Age (4) X Trial (4) design with repeated measures on the last factor was conducted.

Trial 1: The results of the ANOVA showed only a significant main effect of age [$F(3, 169) = 18.95, p = 0.00$]. Group comparisons across the four age groups revealed that, 5 and 6 year olds did not significantly differ from each other, while both age groups performed significantly worse than 7 and 8 year olds. Also 7 and 8 year olds did not significantly differ [See Figure 6].

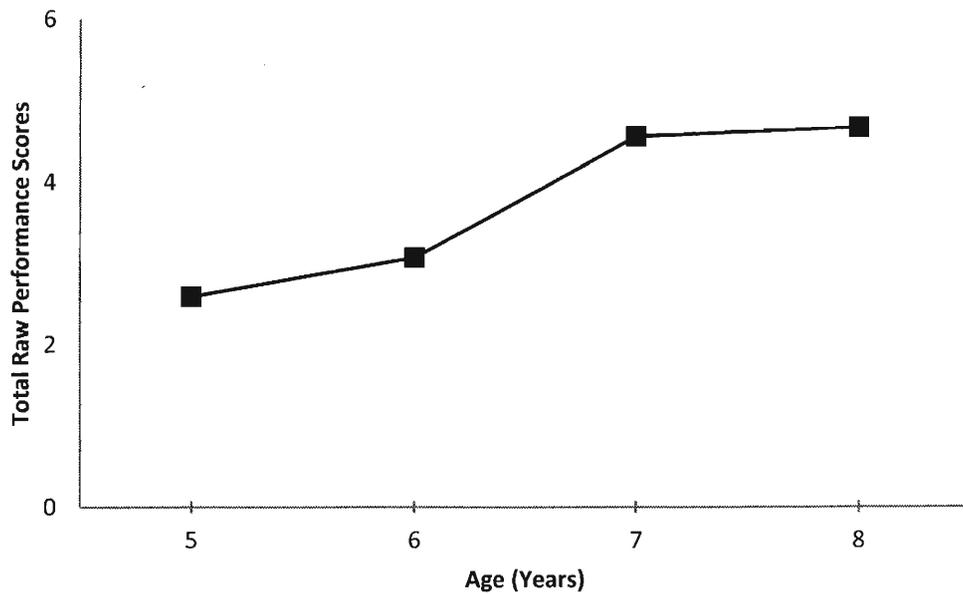


Figure 6. Mean performance scores for Word Lists, Trial 1.

Total Recall: Across all four trials for Word Lists, there was a significant main effect of age [$F(3, 169) = 27.91, p = 0.00$]. Pairwise comparisons across the four age groups revealed that 5 year olds performed significantly worse than the older participants. Also, 6 year olds performed significantly worse than 7 and 8 year olds; but there were no significant differences among 7 and 8 year olds [See Figure 7].

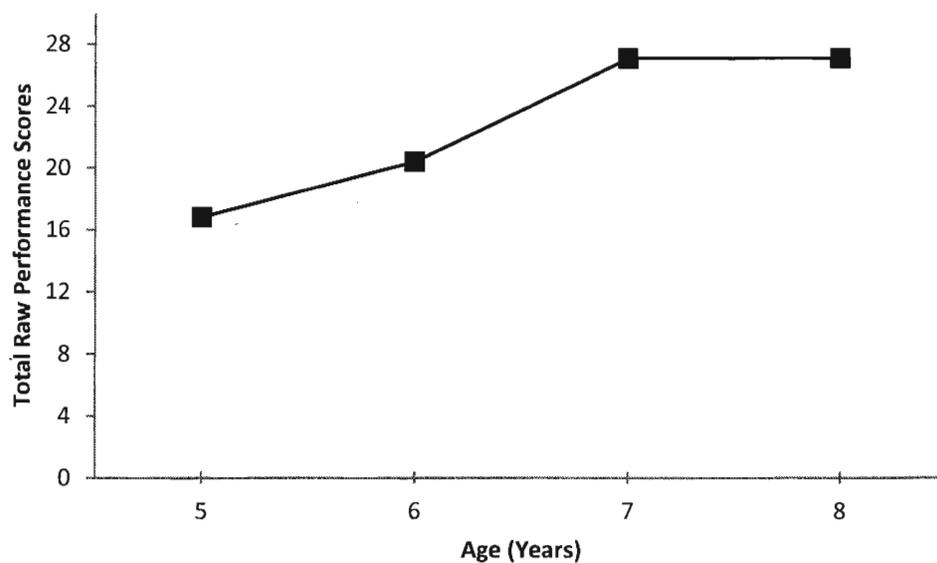


Figure 7. Mean performance scores for Word Lists, Total Recall (Across All 4 Trials).

Short-Term Recall After an Interference. Results showed that there was a significant main effect of age, [$F(3, 169) = 29.71, p = .00.$] Pairwise comparisons across the four age groups revealed that 5 year olds performed significantly worse than the older participants. Also, 6 year olds performed significantly worse than 7 and 8 year olds; but there were no significant differences among 7 and 8 year olds [See Figure 8].

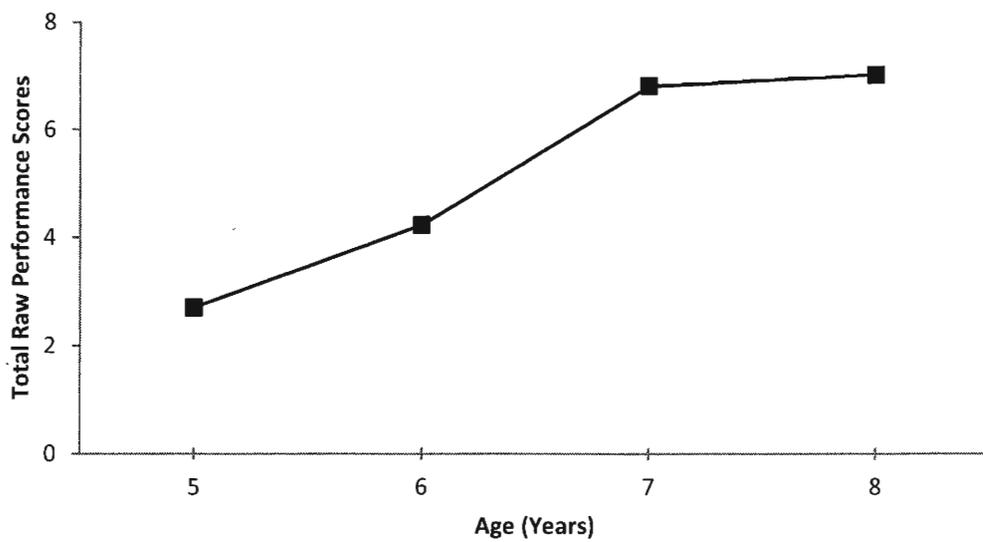


Figure 8. Mean performance scores for Word Lists, Short-Term Recall After an Interference.

Short-term auditory-verbal learning: A sex X age (4) X trial (4) within-between ANOVA with repeated measures on the last factor was conducted to examine the performance differences among the four consecutive trials of word list recalls. Results showed a significant main effect for trial [$F(3, 169) = 203.51, p = 0.00$]. Performances significantly improved across trials, such that participants performed significantly worse on trial 1 than trials 2, 3, and 4. There was a significant main effect for age [$F(3, 169) = 27.92, p = 0.00$]. Specifically, 5 year olds performed significantly worse than 6, 7, and 8 year olds. 6 year olds performed significantly worse than 7 and 8 year olds, who did not significantly differ from another. Two- and three-way interactions were not significant [See Figure 9].

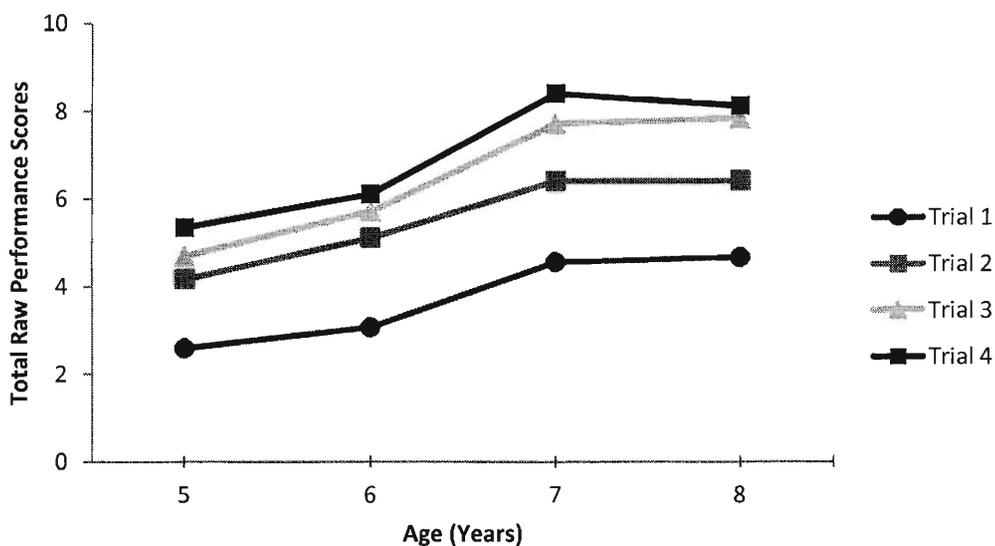


Figure 9. Mean performance scores for Word Lists, Learning (Trials 1, 2, 3, 4).

Summary of the results of auditory-verbal short-term memory: Overall, there was no significant sex differences between boys and girls in and across trials, there was age effects only. For Trial 1, 5 and 6 year olds display similar performances but are outperformed by 7 and 8 year

olds who display similar performances on Trial 1. Across all trials, 5 year olds performed significantly worse than 6, 7, and 8 year olds. Within and across trials, 7 and 8 year olds did not significantly differ. In terms of immediate recall performances after having exposed to an interference list, significant age differences were observed. Similar to visual-spatial results, 5 olds performed significantly worse than the 6, 7 and 8 year olds, but 7 and 8 year olds did not significantly differ. Overall, for Word Lists trials, participants performed significantly worse on trial 1 than the later trials regardless of age.

Research Question 3: Are there significant age- and sex-related differences between modality- specific memory performances?

Sex X Age (4) X Task Modality (Verbal, Visual) Repeated Measures ANOVA with between-subject variables were conducted separately for Trial 1, Total Recall, and Short-Term Recall After an Interference.

Trial 1: The results showed significant age [$F(3, 170) = 25.75, p = 0.00$] and modality [$F(1, 170) = 420.59, p = .00$] main effects. Group comparisons across the four age groups revealed that 5 year olds performed significantly worse than 6 year olds, who performed significantly worse than 7 and 8 year olds, who did not significantly differ [See Figure 10]. Furthermore, there was no significant main effect of sex, or a significant sex X modality interaction on Trial 1.

Modality main effect revealed that the visual-spatial Trial 1 performance is significantly better than word recall during the first trial.

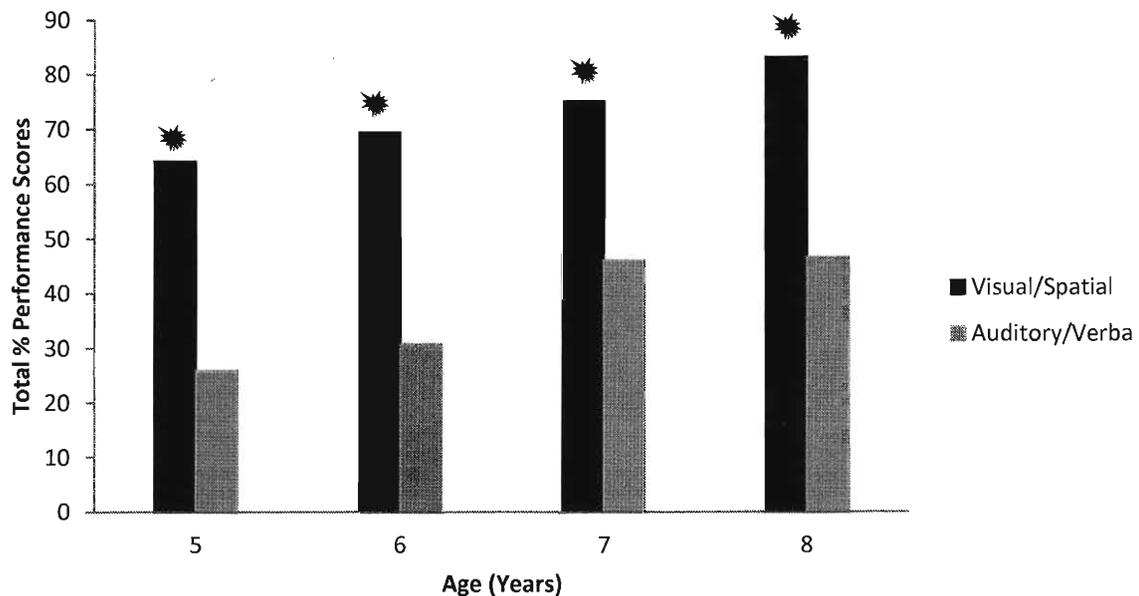


Figure 10. Mean performance scores for Modality (verbal, visual), Trial 1.

Total Recall: Results of the ANOVA showed a significant main effect of age [$F(3, 170) = 38.64, p = 0.00$] and modality [$F(1, 170) = 192.61, p = 0.00$]. Age X modality interaction was not significant. Participants scored significantly worse on Word Lists than on Dot Locations. Group comparisons across the four age groups revealed that 5 year olds performed significantly worse than 6 year olds, who performed significantly worse than 7 and 8 year olds, who did not significantly differ [See Figure 11].

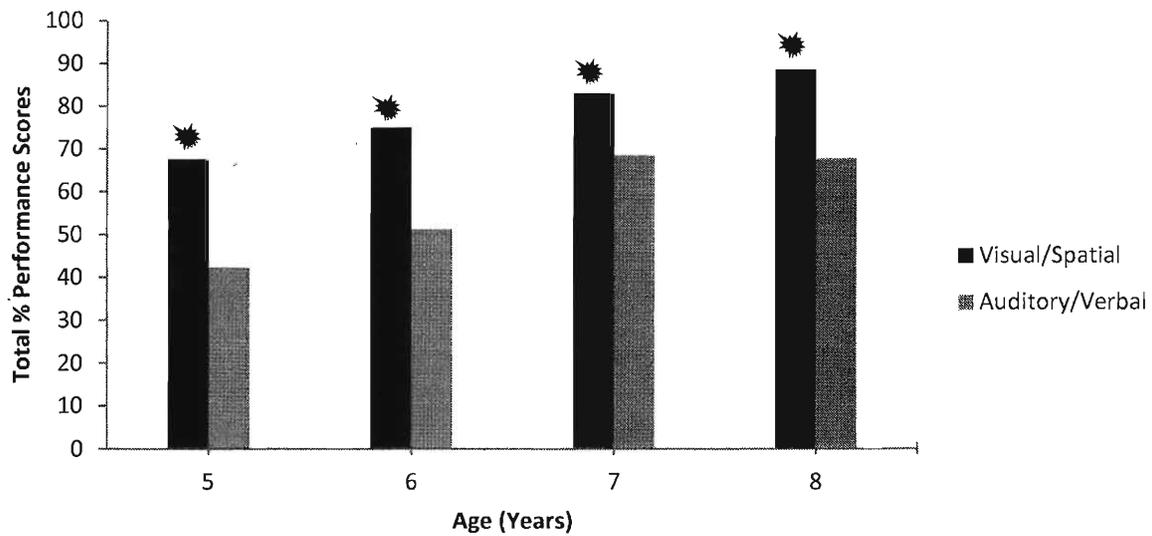


Figure 11. Mean performance scores for Modality (verbal, visual), total scores for Total Recall.

Short-Term Recall After an Interference: The results showed significant age [$F(3, 170) = 9.19, p = 0.00$] and modality [$F(1, 170) = 115.66, p = .00$] main effects, but not a significant modality X age interaction. Participants scored significantly worse on Word Lists than on Dot Locations after a distraction stimuli [See Figure 12]. Group comparisons across age groups revealed that 5 year olds performed significantly worse than 6, 7, and 8 year olds. Children aged 6 performed significantly worse than 7 and 8 year olds. Lastly, 7 year olds performed significantly worse than 8 year olds.

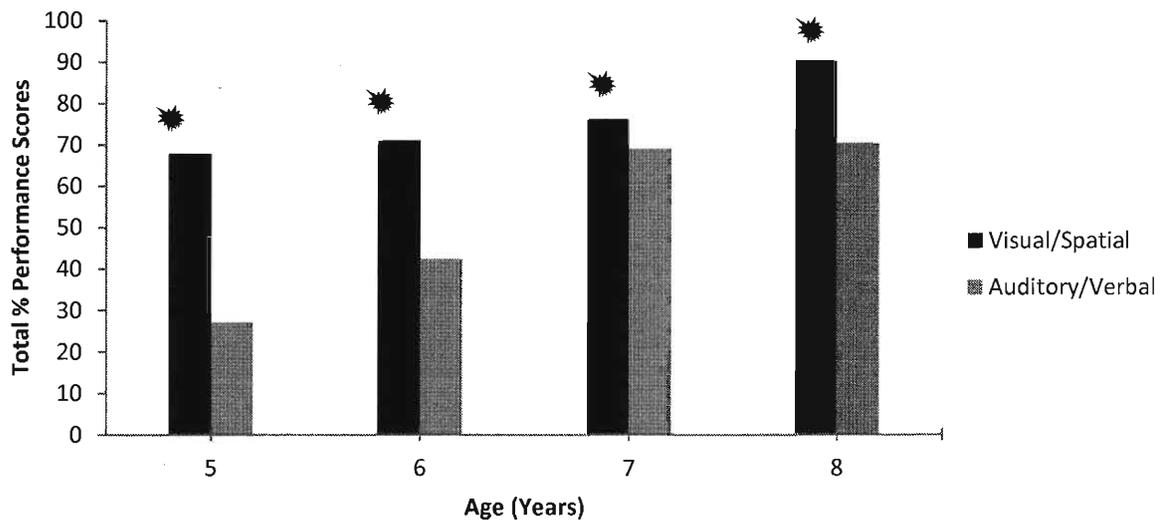


Figure 12. Mean performance scores for Modality (verbal, visual), Short-Term Recall After an Interference.

Summary of the results of Modality Comparisons: Overall, there were no significant sex differences between boys and girls for modality performances; however there were age and modality-specific differences. For Trial 1, 5 year olds performed significantly worse than 6 year olds, who performed significantly worse than 7 and 8 year old, who did not significantly differ.

Also, visual-spatial performance on Trial 1 is significantly better than word recall during the first trial. Similar results were observed for Total Recall scores in both modalities. All participants scored significantly worse on Word Lists than on Dot Locations. Also, 5 year olds performed significantly worse than 6 year olds, who performed significantly worse than 7 and 8 year olds, who did not significantly differ. Lastly, there were significant age and modality differences in short term recall after interference. Although the interference tasks were detrimental to the short term retention, interference in the verbal modality seemed more detrimental to short term memory compared to the visual-spatial modality.

Discussion

Although it has been well-documented that cognition and memory abilities gradually develop and improve across childhood and into adolescence (Chuah & Maybery, 1999; Luna et al., 2004), there has been limited research on the sex- and age-related auditory-verbal and visual-spatial short-term memory performances among typically developing young children. In addition, there have been contradictory findings, related to early sex-related differences in visual-spatial memory performances (Cherney & Ryalls, 1999; Honda & Nihei, 2009). Also, there have been numerous studies examining sex-related differences pertaining to auditory-verbal and visual-spatial memory among adults (Ionescu, 2004), but few of these recent investigations involve young children. Lastly, there are relatively few studies comparing modality-specific performances (Conklin et al., 2007), with young children. Given these contradictions among research findings and insufficient data in young children, the purpose of the present study was to examine the developmental trends and sex differences in auditory-verbal and visual-spatial short-term memory in typically developing children 5 to 8 years of age. The present study suggests that there are early age-related differences in visual-spatial and auditory-verbal short-term

memory performances, but very few early sex-related differences pertaining to visual-spatial memory. The present findings did not support early sex-related differences in auditory-verbal memory performances. Three main research questions were examined in the present study.

The first question addressed if there were significant age- and sex-related differences in visual-spatial short-term memory performances. Overall, the findings suggest that there are early age-related differences in visual-spatial memory abilities. For example, 5 and 6 year olds did not significantly differ on Trial 1 recall performance; although 6 year olds performed just as well as 7 year olds. After Trial 1, 6 year olds outperformed 5 year olds; however, 7 year olds outperformed 6 year olds who did not differ originally. On Trial 1 and across all three trials (Total Recall), 7 and 8 year olds had similar performance scores. These results suggest that visual-spatial performances measured by on Dot Locations improve from 5 years of age until 7 years of age, at which performances do not differ from 8 year olds. Overall, for Dot Locations trials, participants in each age group performed significantly worse on trial 1 than the later trials; however, performances on trials 2 and 3 did not significantly differ.

These age-related findings are consistent with previous research. Studies have found that older children outperform younger children on short-term spatial recall tasks (Ang & Lee, 2008; Conklin et al., 2007; Luciana et al., 2005). Specifically, Schwenck et al. (2009) found that recall performances improved across childhood, such that older children (age 8) outperformed the younger children (age 4) on the recall of visual-spatial tasks. Similar to this, Alloway et al. (2006) found linear age-related increases for spatial recall in children age 4 to 11. Also, Vuontela et al. (2003) found age-related improvements for object location recall among 6 to 13 year olds. Also, in the present study, an interference task affected memory performances. After an interference task, 6 and 7 year olds had similar performances and both had performed worse than

8 year olds. Consistently, 7 and 8 year olds had similar performances, however it could be concluded that 7 year olds are cognitively different than 8 year olds. This specific age-related finding is also consistent with previous research (Sameroff & McDonough, 1994).

The literature addresses the physical, psychosocial and cognitive development of children age 5 through 7, referred to as the “5 to 7 Year Shift” (Sameroff & McDonough, 1994). The theory, originally termed by White (1965), addresses developmental transitions and suggests that there are a number of changes occurring between the ages of 5 and 7 years, but also, children before age 5 and after age 7 think remarkably different (Sameroff & McDonough, 1994). As such, children mature overtime, which relates back to previously mentioned theorists. Piaget (1973) suggested that children develop through distinct and successive stages across time; cognitive abilities improve as children get older. Case (1985) and Pascual-Leone (1987) examined individual differences in developmental rates of cognition; children’s capacity and memory span is thought to be much smaller and limited than older children’s and adolescents’ memory span.

Aside from age-related differences, the first question addressed the sex-related differences for visual-spatial short-term memory performances. In terms of sex-related differences for visual-spatial short-term memory, males and females did not significantly differ on trial 1 and across all three trials. After the interference task was introduced, 6 year old girls outperformed 6 year old boys. These findings suggest that there might be cognitive differences in how 6 year old females and males process spatial information. This specific age- and sex-related difference among 6 year olds is probably not explained by prenatal estrogen and testosterone exposure (2D:4D ratio). Previous research by Bull et al. (2010) examined sex-related differences in visual-spatial short-term memory and the amount of prenatal estrogen and testosterone

exposure. Bull et al. (2010) did not find sex-related differences among 5 year olds but stated that young girls with lower 2D:4D ratios (similar to boys) performed better than girls with higher 2D:4D ratios. However, if there was an influence of sex-related hormones, sex differences before and after age 7 should be evident. A more plausible explanation may surround whether or not 6-year old boys and girls are using different strategies.

Strategy use develops across childhood (Schneider et al., 2009) and allows children to recall a greater number of items overtime (Chuah & Maybery, 1999; Luciana et al., 2005). A research study by Alloway et al. (2006) suggested that as children grow older, rehearsal strategies are utilized to code visual material specifically and visual codes are utilized more frequently by younger children. However, the Alloway study did not examine sex-related differences, so it is unknown whether or not young males and females differ on strategy usage. Also, Schwenck et al. (2009) examined strategy use when recalling visual-spatial tasks. Older children outperformed younger children on tests of recall and used more strategies than younger children (Schwenck et al., 2009). Again, this study did not examine sex-related differences. It is possible that there are sex-related differences among young children's strategy use, specifically when recalling visual-spatial material.

Overall, these findings suggest that there are early sex-related differences in spatial cognition. Previous research examining sex-related differences for spatial recall in early childhood have been inconsistent. For instance, Conklin et al. (2007) found no significant sex differences for object location recall, which does not support the present findings. However, the Conklin et al. (2007) study did not include children below age 9. Young and Wilson (1994) did include 5 to 8 year olds and found no significant sex differences on an object recall task. This finding does not support the present findings as 6 year old males and females did differ from

another. In addition to this, Newhouse et al. (2007) examined 8 to 10 year old children and found that males outperformed females on a spatial recall task. This finding does not support the present findings as the male and female 8 year olds in the present study did not significantly differ from another. Lastly, Bull et al. (2010) also did not find sex-related differences among 5 year old children and this supports the present findings. It is important to note that the present study did not find main effects for sex but did find an interaction for age and sex when examining visual-spatial recall after an interference task was introduced. Overall, males and females did not significantly differ but there was a specific age-related difference between males and females at age 6.

It is possible that the findings of the present study as well as previous research were task-specific as each study included different spatial memory tasks. The present study included the recall of dots, while the Bull et al. (2010) and Conklin et al. (2007) studies used blocks, for example. Also, some studies, such as the Newhouse et al. (2007) study involved spatial navigation and remembering the location of previous found objects. The Newhouse et al. (2007) study includes a different spatial recall task than the present study as it involves a virtual environment where the children need to remember spatial objects in the environment. Aside from the structure of the task, the level of task difficulty could have also affected results. For instance, it is possible that the number of objects to be remembered affects recall performances. For instance, children had to remember the location of 9 blocks in the Bull et al. (2010) study, while the present study included 6 objects to be recalled.

The second research question in the present study addressed if there were significant age- and sex-related differences in auditory-verbal short-term memory performances. Overall, these findings suggest that there are early age-related differences in auditory-verbal memory abilities.

It could be concluded that auditory-verbal performances on Word Lists improve from 5 years of age until 7 years of age, at which performances do not differ from 8 year olds. Although at times 6 year olds outperformed 5 year olds, both 5 and 6 year olds consistently performed significantly worse than 7 and 8 year olds. Overall, for Word Lists trials, participants performed significantly worse on trial 1 than the later trials. Performances significantly improved across trials for Word Lists. Furthermore, these age-related findings are consistent with previous research. Studies have found that typically, older children outperform younger children on tasks of verbal recall. Specifically, Schneider et al. (2009) found that children aged 7 to 10 years outperformed 6 year old children on verbal recall tasks. Alloway et al. (2006) also examined young children age 4 to 11 years and found that verbal memory performances improved throughout childhood. These findings also relate back to the “5 to 7 Year Shift” (Sameroff & McDonough, 1994) as performances improved from age 5 to age 7, after which 7 year olds performed similar to 8 year olds.

There are relatively few current studies examining the auditory-verbal memory abilities of young children. Many recent studies include adults only (Harness et al., 2008; Horgan et al., 2004). Also, the studies often include auditory-spatial memory, such that participants verbally recall the location of objects. These objects may include facial recognition and recall (Harness et al., 2008; Horgan et al., 2004). A more recent study by Simcock and Hayne (2003) did examine verbal and nonverbal memory and included young children age 2 to 4 years old. Specifically, they studied event recall and not the recall of word lists; however, they did find age-related improvements and memory abilities related to vocabulary and language skills. Although the present study did not examine children below age 5, it is possible that age-related improvements could be the result of vocabulary and language skills. The present study did not examine

language proficiency or language skills. A recent study by Alloway and Archibald (2008) found that children (age 6-11) with language impairments displayed poor performances on verbal memory tasks compared to visual-spatial tasks. Thus, examining language abilities and verbal memory tasks together would be beneficial as it could provide further insight into age-related differences.

Aside from age-related differences, question two also addressed the sex-related differences for auditory-verbal short-term memory performances. In terms of sex-related differences, there were no significant sex differences between males and females in and across trials all four trials. These findings suggest that there are no early sex-related differences in auditory-verbal memory and cognition. Although children aged 5 to 8 differ from one another, males and females at this age did not significantly differ. Previous research examining sex-related differences for auditory-verbal recall in early childhood have been inconsistent and often include adults only (Bleecker et al., 1988). For instance, Lowe et al. (2003) found that adult females outperformed males on verbal tasks. However, this study included adults, while the present study examined young children.

An earlier study by Kramer, Delis, Kaplan, O'Donnell, and Prifitera (1997) found sex-related differences for verbal learning and memory among children and adolescents age 5 to 16 years. Kramer et al. (1997) found that girls outperformed boys on the immediate and delayed recall of verbal word lists. The Kramer et al. (1997) study was similar to the present study; however, the present study included fewer words to be recalled. Kramer et al. (1997) suggested that girls outperform boys because of their superior vocabulary skills. Bleecker et al. (1988) also suggested that vocabulary accounted for a proportion of variance in verbal learning and memory scores among adults. The present study did not examine vocabulary scores. It is unknown if the

males and females in the present study differed on vocabulary abilities and whether this affected the results.

The third and final research question in the present study addressed if there were significant age- and sex-related differences between modality-specific memory performances. Potential differences between modalities were examined because there are relatively few studies pertaining to the short-term memory. It is important to examine these differences because it enables us to understand if young children process auditory-verbal versus visual-spatial memory tasks differently. Modality comparisons revealed age-related differences. 5 year olds performed significantly worse than 6 year olds and 6 year olds performed significantly worse than 7 and 8 year olds, who did not significantly differ on trial 1 and across all trials. In terms of the short-term recall after an interference, 5 year olds performed significantly worse than 6, 7, and 8 year olds. Also, children aged 6 performed significantly worse than 7 and 8 year olds, while 7 year olds performed significantly worse than 8 year olds. This is an important finding as it suggests that 8 year olds are not affected by a distraction, but 7 year olds are. 8 year olds are not affected by distraction and while 7 year olds are still vulnerable to distraction in tasks requiring short-term retention of information. This finding further reiterates the “5 to 7 Year Shift” (Sameroff & McDonough, 1994) as children age 5 to 7 years were affected by a distraction, while the 8 year old children were not.

These findings suggest that there are early age-related differences in auditory-verbal and visual-spatial memory abilities. Overall, participants in each age group performed significantly worse on the auditory-verbal task than the visual-spatial task at first trial, across all trials, and for short-term retention. Few research studies have actually compared the performances between auditory-verbal and visual-spatial memory among young children. One study, by Conklin et al.

(2007) did and reported that children performed better on spatial tasks compared to verbal tasks. The finding from Conklin et al's study is consistent with the present study. Another study by Alloway et al. (2006) compared verbal and visual-spatial short-term and working memory and found comparable improvements from age 4 to 11. This finding supports the results of the present study as age-related improvements were found from age 5 to 8.

Aside from age-related differences, question three also addressed the sex-related differences between modality-specific memory performances. In terms of sex-related differences between modality-specific memory performances, there were no significant sex differences between males and females for modality performances. Although children aged 5 to 8 differ from one another, males and females at this age did not significantly differ. Other research (Lewin et al., 2001) has also examined modality differences among adults only. Lewin et al. (2001) found that males excel on visual-spatial recall tasks, while females excel in verbally recalling object locations. This study did not examine auditory-verbal recall, however. Other research by Alloway et al. (2006) compared verbal and visual-spatial short-term and working memory and did not find sex-related differences across ages 4 to 11. This finding does support the results of the present study as sex-differences were not found between modality performances across ages 5 to 8.

Overall, the present study found age-related differences for visual-spatial STM. The results suggest that visual-spatial performances, measured by Dot Locations, improve from 5 years of age until 7 years of age, at which performances do not differ from 8 year olds. Also, these findings suggest that there might be cognitive differences in how 6 year old females and males process spatial information. Aside from these findings, the present study also found age-related, but not sex-related differences for auditory-verbal STM. Performances improved from

age 5 to 7 years of age, after which, performances were comparable between 7 and 8 year olds. Interestingly, males and females between ages 5 to 8 do not differ on auditory-verbal recall. Lastly, modality comparisons revealed age- and task-related performance development between auditory-verbal and visual-spatial STM performances. STM among children age 5 to 7 is greatly affected after an interference task, while the STM of 8 year old children is not affected by such task. This finding suggests the superior cognitive abilities of 8 year olds in comparison younger children. There were no sex-related effects in terms of modality specific performances.

Strengths and Limitations

For a better understanding of auditory-verbal and visual-spatial developmental trajectories, the inclusion of older children would be beneficial. Also, the inclusion of early, mid- and late adolescents would extend the breadth of knowledge surrounding the cognitive maturation of childhood through to adolescence. Although not necessarily a limitation, the present study did not examine long-term retention. The present study chose to examine short-term memory only, however including long-term retention would extend the breadth of knowledge surrounding memory and learning research. Also, the present study did not examine language abilities, which may account for the age-related differences that were found. Also, data was collected from only middle and upper-middle SES, thus the findings may not be equally applicable to children from lower SES due to lack of opportunities for learning various tasks. Hilferty, Redmond, and Katz (2010) suggest that poverty negatively affects children's readiness to learn and readiness for school.

In addition to the limitations, the present study also had a number of strengths. One of the strengths involves utilizing a memory scale specifically for children (Cohen, 1997). Using a scale specifically for children to examine children's memory allows us to get a better

understanding of how children develop. Using scales specifically for children ensures that the children understand what is being asked of them. The present study also provides recent research for the typical development of young children. Numerous studies surrounding young children's auditory-verbal and visual-spatial memory performances are often outdated and examine atypical development, for example, children with language impairments (Mainela-Arnold, Evans, & Coady, 2010). Understanding how memory works also helps us understand when it does not, thus it is important to continue studying typical development. Only when we understand typical development can we understand what is not typical and then assist those individuals. Also, in contrast to previous studies the present study has a larger sample size with almost equal representation in each age group and for both sexes. Lastly, one other strength of the current study involves comparing modality performances in young children. Previous research examining spatial recall for both age- and sex-related differences together has been limited. The few studies that have examined early childhood have often focused on each modality separately.

Implications and Directions for Future Research

The present study can help us in understanding memory functioning of male and female children (age 5-8) across different modalities of memory. Using a non-North American sample can help us seek data from a cross-cultural sample which was not used in the past research on memory development. Results of this study can provide us a basis for comparison among studies to observe similarities and differences on memory development and functioning across children of different cultural background. Role of cultural factors, diverse upbringing and learning experiences, and use of various learning strategies across different cultures and its potential impact on memory development could be identified and may make valuable addition to the existing body of knowledge on this area. The present study provides a wealth of knowledge to

the literature surrounding auditory-verbal and visual-spatial memory in young children. In particular, the results of the present study have implications for early childhood education. For instance, the results of the present study are relevant within the classroom as it provides insight into the short-term memory capacities of young children. As such, children's scores significantly decreased after an interference task was introduced. This task can also be viewed as a distraction. It could be suggested that young children should be taught one lesson at a time up until age 7. Also, when children are being taught a lesson, there should be few distractions in the classroom.

The present study further reiterates the importance of understanding the physical, psychosocial and cognitive development of children age 5 through 7, known as the "5 to 7 Year Shift" (Sameroff & McDonough, 1994). During this time there are developmental transitions and children before age 5 and after age 7 think remarkably different (Sameroff & McDonough, 1994). Piaget (1973) suggested that children develop through distinct and successive stages across time; cognitive abilities improve as children get older. Future research may also want to explore long-term retention of information among young children. As previously mentioned, examining long-term retention would extend the breadth of knowledge surrounding memory and learning. Understanding long-term retention, in comparison to short-term retention may allow researchers to get a better understanding of how young children learn and retain information. Also, future research may consider examining a wider age range to get a better understanding of the developmental trajectories of auditory-verbal and visual-spatial memory.

Conclusion

This study examined the developmental trends and sex differences in auditory-verbal and visual-spatial short-term memory in typically developing children 5 to 8 years of age. Importantly, there were age-related differences in the recall of auditory-verbal and age- and sex-

related differences in the recall of visual-spatial information. Performances significantly improved overtime and across ages. Also, there were age-related, but no sex-related differences between modality-specific memory performances. The present study contributes to the understanding of young children's auditory-verbal and visual-spatial memory abilities and has implications for how children learn within the classroom. These findings provide insight into how young children differ from one another on auditory-verbal and visual-spatial recall tasks.

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Appendix



Brock University
 Research Ethics Board
 Tel: 905-688-5550 ext. 3035
 Email: reb@brocku.ca

 Certificate of Ethics Clearance for Human Participant Research

DATE: 3/15/2011
 PRINCIPAL INVESTIGATOR: TEKOK-KILIC, Ayda - Child & Youth Studies
 FILE: 10-227 - TEKOK-KILIC
 TYPE: Masters Thesis/Project STUDENT: Monika Ovsenka
 SUPERVISOR: Ayda Tekok-Kilic

TITLE: Turkish norm and standardization study of tests measuring memory, executive functions, sensory-motor functions and attention in children ages between 5-17 years

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW

Expiry Date: 3/31/2012

The Brock University Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 3/15/2011 to 3/31/2012.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 3/31/2012. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page.

In addition, throughout your research, you must report promptly to the REB:

- a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
- b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
- c) New information that may adversely affect the safety of the participants or the conduct of the study;
- d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Jan Frieters, Acting Chair
 Research Ethics Board (REB)

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.