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Effects of Aging, Handedness and Saccadic Bilateral Eye Movements on Autobiographical Episodic Memory Recall

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ABSTRACT

Past research has shown that saccadic bilateral eye movements, handedness and age affect performance on recall tasks focussing on episodic autobiographical memory recall. Research has not looked at the interactions between these elements to see if they have a combined effect on episodic autobiographical memory recall. The current experiment will look to test the effects of handedness, age and eye movements on episodic autobiographical memory recall, by assessing recall for both episodic memory and semantic memory with participants aged 18-89. Participants followed an eye movement (bilateral or still) and then answered various recall questions such as 'recall of events from 5-11 years old'. It was found that overall saccadic bilateral eye movements and handedness had no effect on recall, however there were significant main effects of age. These findings illustrate that the influences of saccades and handedness may be due to hemispheric lateralisation not due to corpus callosum size or communication between the hemispheres. Future research should consider whether retrieval is explained by the reminiscence bump and if there are other processes which cause a link between eye movements and memory recall.

KEY WORDS:	HANDEDNESS	BILATERAL EYE MOVEMENTS	AGING	EPISODIC AUTOBIOGRAPHICAL MEMORY	

Introduction

Autobiographical memory refers to a personal memory which consists of both semantic memory (general facts about oneself and others) and episodic memory which is specific experiences and events (Parker and Dagnall, 2010; Conway et al., 2001). Episodic autobiographical memory is the recollection of specific events but with recall of emotions and sensory information (Baddeley et al., 2001; Tulving, 2002). Ample research has suggested that interhemispheric interaction is the basis for accurate episodic memory; consequently, this is associated with superior episodic memory (Propper et al., 2005; Parker et al., 2009; Manenti et al., 2011). It has been suggested that episodic memory can be increased by interhemispheric interaction by introducing bilateral saccadic eye movements (Lyle et al., 2008; Christman et al., 2003).

This experiment is looking specifically at episodic memory as this is impacted by age. Older adults are impaired at retrieving the context for the episodic memory, whereas semantic memory does not suffer these effects (Levine et al., 2002). With reference to the HAROLD (Hemispheric Asymmetry Reduction in Older Adults) model, introduced by Cabeza (2002) it proposes that prefrontal activity in older adults is less lateralised than younger adults. This is important regarding episodic memory as both encoding, and retrieval require activation of the prefrontal cortex (Cabeza, 2002). Another explanation for these effects is top-down processing (Jacques et al., 2012), whereby the top-down influence of the pre-frontal cortex on the hippocampus is what modulates the episodic richness of autobiographical memory and age-related changes in this are associated with a decline in the top-down variation of the hippocampus (Jacques et al., 2012). Regarding the HERA model (Hemispheric Encoding/Retrieval Asymmetry), eye movements and handedness interlink when considering autobiographical memory recall (Habib et al., 2003). These are seen to be the HERA effects. Habib et al. (2003) showed, the left prefrontal cortex is involved in episodic memory encoding and the right prefrontal cortex is involved in episodic memory retrieval. These models provide important considerations when looking at age related differences in episodic memory recall, as there are apparent impacts of handedness and eye movements on recall.

When looking at episodic autobiographical memory and how to enhance recall we must consider the effects of eye movements. As autobiographical memory requires interhemispheric communication (Propper et al., 2005; Parker et al., 2009; Cabeza, 2002), saccadic bilateral eye movements have been shown to temporarily increase this communication (Propper et al., 2010). Further research has shown that the bilateral movement (side to side) preceding memory recall increases the amount recalled but only when following this eye movement (Parker and Dagnall, 2012; Parker et al., 2013). Findings also suggest that bilateral eye movements enhance access to early childhood memories (Parker and Dagnall, 2012). However, an explanation for this is that bilateral eye movements reduces the magnitude of retrieving a false memory (misinformation effect) and the magnitude was greater for this effect than retrieving the memories desired within the research (Parker et al., 2009; Christman et al., 2006). Through this, we cannot be sure what aspect of memory bilateral eye movements help to increase or decrease. Literature must consider the misinformation effect on recall, as it is apparent that instead of recalling more episodic memories the participants just recalled less false memories therefore it is not clear to assume bilateral eye movements enhance episodic memory (Christman et al., 2006).

Neuroimaging research suggests that episodic memory is increased through the interaction between the two hemispheres when following a bilateral eye movement (Habib et al., 2003; Parker et al., 2009). Despite some research suggesting the HERA model effects are due to material-specific processing, it was concluded and supported that successful performance on episodic tasks is dependent on the interaction of the hemispheres (Propper et al., 2010; Habib et al., 2003). When looking at the effects of eye movements on episodic autobiographical memory recall it is important to consider the links with handedness as it has been found to increase sensory memories such as emotion or seeing (Parker and Dagnall, 2010). Bilateral eye movements are similar to handedness effects as they also appear to be associated with retrieval of event-specific information (Parker and Dagnall, 2010). Lyle et al. (2008) found that bilateral eye movements benefited participants who are strong right handed as they had increased correct recall and reduced false recall, whereas in mixed handed individuals it increased the false memories. Contradictory to what Parker et al. (2009) found as they suggested being mixed handed reduces false memories.

One proposal for the effects of eye movement is the idea of ‘Saccade-Induced Retrieval Enhancement’ (SIRE), which specifies that bilateral saccades increase retrieval (Lyle and Martin, 2010). This is supported by early research from Christman et al. (2003) who elicited enhanced recall following bilateral saccades. Although, findings from Lyle and Martin (2010) suggest that the saccades do not enhance performance on letter matching tasks and do not increase interhemispheric interaction, which challenges the concept of SIRE. Saccades do not always enhance memory recall, as findings are not consistent throughout literature (Parker et al., 2018). Consequently, it could be possible that saccades do increase a component of interaction that is responsible for memory retrieval, however it is unclear what this is (Lyle and Martin, 2010). It was also discussed by Lyle and Martin (2010) that there is a dissociation between handedness and saccades on memory retrieval, proposing interhemispheric interaction is affected by both components in different ways.

Handedness can refer to strong right, strong left, or mixed handed. Large bodies of research have shown that mixed handedness is associated with superior recall of real world-based memories (e.g. Christman and Butler, 2011; Luders et al., 2010). However, for mixed handed individuals, improved recall is only seen in episodic memory- in line with the HERA model- as the interaction between hemispheres in mixed handers is greater (Sahu and Christman, 2014; Christman and Butler, 2011) and episodic memory recall requires this interaction (Habib et al., 2003). Consequently, those who are seen to be strong right handed have a decrease in interhemispheric interaction and then in turn have inferior episodic memory as this is associated with interaction between the left hemisphere (encoding) and the right hemisphere (retrieval) (Christman and Butler, 2011). This effect is supported by fMRI studies such as Habib et al. (2003).

One reason for these differences is due to the size of the corpus callosum (Luders et al., 2010; Lyle and Martin, 2010). The corpus callosum is responsible for transferring episodic information between the two hemispheres and mixed handers have been found to have a larger corpus callosum (Luders et al., 2010), so presumably this would reflect greater interaction therefore greater recall (Propper et al., 2005). It has also been found that inconsistent handers had better recall of earlier autobiographical memories from childhood, further suggesting that handedness is important for memory tasks that recall event-specific memories (Parker and Dagnall, 2010). Although, it has been suggested that handedness lateralisation is the link to corpus callosum size and episodic memory, not how dominant the hands are (Luders et al., 2010). It was found by Luders et al. (2010) that if there is a decrease in lateralisation then there are bigger callosal dimensions, which could be the reason for differences in memory recall seen in mixed and right-handers. Given the research mentioned, it is apparent that both bilateral saccades and inconsistent handedness can increase episodic autobiographical memory recall. Therefore, suggesting that autobiographical memory can involve multiple component processes (Parker and Dagnall, 2010).

Taking into consideration the links between aging and episodic autobiographical memory recall, this area is under-researched (Manenti et al., 2011; Levine et al., 2002; Tromp et al., 2015). Episodic memory shows the largest age-related decline (Manenti et al., 2016). As older adults experience a decline in episodic autobiographical memory in comparison to younger adults due to natural aging (Friedman, 2013; Levine et al., 2002). Despite the natural deterioration of episodic memory, when it comes to recall, the degree of the deficit depends on the recall task (Tromp et al., 2015). Age related differences are more prominent in tasks that require spontaneous recall (Tromp et al., 2015). The right hemisphere declines more than the left in the aging brain with functional connectivity also being reduced in the right hemisphere (Li et al., 2009).

One theory put forward as to why spontaneous recall is most effected is the theory of cognitive slowdown (Tromp et al., 2015; Levine et al., 2002). Whereby changes in processing speed for functions such as attention or memory lead to a decline in cognitive performance. Subsequently leading to less effective coding and more time needed to retrieve stored information (Tromp et al., 2015; Li et al., 2009). It is possible that therefore older people do not retrieve as much as young people. However, there is research to suggest that there are different mechanisms which potentially underlie the recall of autobiographical memories (Dijkstra and Janssen, 2016). Even though older adults report fewer details, they perform like younger adults when retrieval support such as ‘what happened’ is provided (Dijkstra and Janssen, 2016). Additionally, the reminiscence bump also challenges the theory of cognitive slowdown as the research argues older adults may be able to remember more from their childhood (Steiner et al., 2014). From the theories and proposals mentioned it is unclear what mechanisms underpin autobiographical memory recall, as there is no overall conclusive finding.

Prefrontal activity is less lateralised in older adults meaning a decline in autobiographical memory recall can be linked to decreased prefrontal activity (Li et al., 2009). Neuroimaging studies have also shown that damage to the parietal region of the brain impairs some aspects of episodic memory as this area is associated with age related declines in episodic memory (Tromp et al., 2015). However, age does not have an impact for general semantic memory, as this is not related to specific experiences and involves language (Levine et al., 2002). Episodic memory decline is accelerated in neurodegenerative diseases such as Alzheimer’s and is the most affected part of declarative memory through aging as it is memory of events and experiences throughout the lifespan (Manenti et al., 2016; Manenti et al., 2011).

Hippocampal structure and function are essential to episodic memory, when an individual develops Alzheimer's they show hippocampal atrophy which has been suggested to lead to poor episodic memory performance (Vuoksimaa et al., 2013). Yet literature has also found that a decrease in hippocampal volume is associated with a decrease in episodic memory in healthy older adults, despite there being no abnormal loss of neurons (Vuoksimaa et al., 2013; Kramer et al., 2007).

The experiment proposed incorporates all the gaps in the research areas mentioned previously. From the literature above, it is apparent that eye movements and handedness do impact episodic memory interchangeably as they increase hemispheric interaction both individually and collectively as component processes (Parker and Dagnall, 2010). Additionally, we can also see significant effects of age on episodic memory decline (Levine et al., 2002; Manenti et al., 2016; Friedman, 2013). However, despite research to suggest these effects it is not always clear if the effects are because of dominant hands as opposed to lateralisation (Luders et al., 2010), or if the effects are seen due to the SIRE effect (Christman et al., 2003). Considering all these points, this research is being conducted as no research has looked at the interactions between age, handedness, and bilateral eye movements collectively on episodic autobiographical memory recall. There is a lack of understanding of how these factors interact with each other, but also whether there is an interaction between these processes. Furthermore, there is no research to consider the effects of bilateral eye movements on episodic memory recall in older participants and this research is creating an understanding of whether eye movements will still improve memory recall in healthy aging. This research will aim to prove links between aging, handedness and eye movements on autobiographical episodic memory recall.

This research will consider several hypotheses:

1. Older participants will not remember as much as younger participants in bilateral eye movement condition.

2. There will be no difference in the amount of memories in each eye movement condition for older participants.

3. Mixed handed individuals will remember more in both conditions.

4. Handedness will not influence the number of memories recalled for older participants.

5. Overall, younger participants will remember more than older participants.

6. Younger participants in the bilateral eye movement condition will remember more than the younger participants in the still eye movement condition.

Method

Design: For this experiment there were two independent variables, and formed a two (age condition; young, 18-34 years or old, 66-89 years, in accordance with (Levine et al., 2002)) between-subjects by two (eye movement condition; bilateral or still) between subjects' ANOVA. The dependent variable was the amount of memories recalled for the episodic autobiographical memory task, for periods of 5-11 and 12-18 years.

Participants: There was a total of 60 participants aged 18-82 which is in line with the sample size of previous research looking at similar variables (Parker et al., 2013). By having over 56 participants this accounts for the pilot study and in case of any drop out. This gives an effect power of 80 which means there is an 80% chance of detecting an effect if one exists and having a medium effect size of .50 (Wilson and Morgan, 2007; Cohen, 1988; Cohen, 1992). They were randomly assigned to either the bilateral eye movement condition (Mean Age = 40.07 years) or the still eye movement condition (Mean Age = 38.77 years). Age and gender were the only demographic variables collected from the participants as the research is looking at the effects of aging on autobiographical memory. Participants were recruited using opportunity snowball sampling. This method was used because of the nature of the study requiring lots of different ages and lack of a long period of time to gather participants, meaning they were largely known to the researcher. All participants took part voluntarily after giving informed consent to taking part.

Measures and Apparatus: Before the experiment test booklets were prepared which had three main sections (Appendix 4). The first was where participant information was recorded and a consent form seen and signed. The second was the handedness inventory where only 10 of the original 20 sub tests were used as this is still suitable for providing accurate assessment (Oldfield, 1971). The third section was the experiment and instructions for the episodic autobiographical memory task, the semantic autobiographical memory task and the general semantic memory task. These were all divided into sub categories based on age groups -with the exception of the general semantic memory task – the episodic task was memories from ages 5-11 and 12-18 and the semantic was ages 5-18. The booklets were used to record the data in a tally format; these are adapted from Parker et al. (2013).

A timer was used to time 90 seconds for each memory task, and a Dictaphone was used to record what the participants were saying for each task. This gave the experimenter chance to listen back and discard any repeated responses from the participants. The recordings were deleted after they were played. The eye movement dot was generated on a computer programme based on similar research. It was a black circle flashing on a white screen which lasted 30 seconds and was either going side to side (bilateral) or flashing in the middle (still movement). The circle flashed once every 500ms and during the movements it was located at approximately 27° of visual angle apart. The screen the dot was played on was 19 inches in width, viewing distance was modified to maintain the visual angle.

Procedure: Each participant was randomly assigned to either the bilateral eye movement condition or the still eye movement condition, they were all tested individually. First, the participant was given the test booklet to read the participation information sheet, agree and sign the consent form and fill in the demographic information (age, gender and level of education) (Appendix 4). They then completed the Handedness Inventory (Oldfield, 1971) which had 10 activities including throwing, writing and using scissors (Appendix 4). The participant had to choose which hand they prefer for that activity and the scale ranged from Always left to Always right, with a no preference option in the middle. Once this had been completed the booklet was given back to the researcher.

The participant then faced the computer and were told the next part of the experiment has started. Depending on the condition, they had either the bilateral eye movement or the still eye movement. They were told after the eye movement the memory tests would follow on. The experimenter watched to ensure the participant was complying and following the dot which lasted 30 seconds. After this the experiment began, this was repeated three times, once prior to each recall test. The instructions for the memory test were read aloud to the participant according to which memory type was tested (Appendix 4).

The first memory type was episodic autobiographical memory, this was tested by asking the participants to recall personal memories from two periods in their lives. The first period was memories between 5-11 years old and the second period was 12-18 years old. The participants had 90 seconds to recall as many memories as they could. Participants were asked 'to name specific event memories, such as 'the time I beat my best friend in the school swimming competition' rather than general memories such as 'having a paper round'. They were also told not to go into detail about each memory and to state each one as it comes to mind and move onto the next. Before the time started they were asked if they had any questions, this happened for each memory type.

The second memory type was semantic autobiographical memory, this was tested by asking participants to recall as many autobiographical facts from 2 periods in their lives. The first was recalling as many names of friends from ages 5-18, and the second was recalling as many names of teachers from ages 5-18. The participants had 90 seconds for each recall and were again told not to go into detail.

The third memory type was general semantic memory, this was tested by asking participants to generate as many examples from two semantic categories. They were given an example saying, 'if I was to say types of transport you would list as many examples as you can', this ensured the participants knew what was meant by 'semantic categories'. They were given 90 seconds again to generate as many examples, without giving any detail. The two recall periods were examples of vegetables and examples of animals.

The experimenter gave the participant the debrief sheet once the experiment was over and asked if they had any questions about the experiment (Appendix 4). They created the unique personal identification code and thanked for their participation in the research.

Results

Subsection for Age and Eye Movements Data

These results were analysed using a 2 (Age; young vs. old) x 2 (Eye Movement; still vs bilateral) independent factors ANOVA. Comparing the effects of age and eye movements on episodic memory recall.

Table 1 – Number of Events Recalled from Ages 5-11, with the Effects of Age and Eye Movements

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*=20)		M	SD
EM						
Still	11.42	3.52	11.30	3.71	11.38	3.52
Bilateral	10.90	3.14	7.70	2.75	9.88	3.34
Overall	11.15	3.29	9.50	3.68		

Note. EM = Eye Movement

There was no significant main effect of age *F* (1, 56) = 3.37, *p* = .072. There was a significant main effect of eye movements *F* (1, 56) = 5.12, *p* = .027, η_p^2 = .084, this is a medium effect size as it is above 0.06 (Cohen, 1992). The interaction was not significant, *F* (1, 56) = 2.9, *p* = .094 (see Table 1).

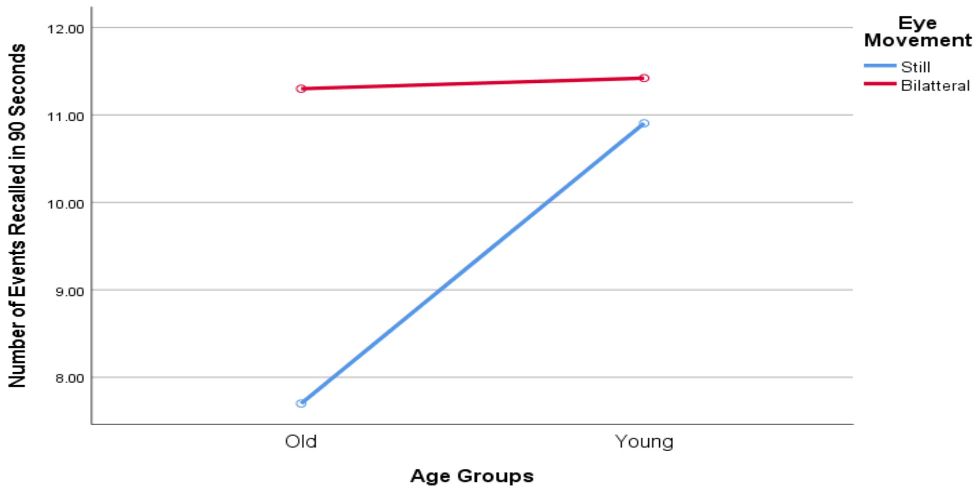

Figure 1: Graph Showing the Effect of Eye Movements and Age on the Number of Events Recalled for 5-11 Years

Table 2 – Number of Events Recalled from Ages 12-18, with the Effect of Age and Eye Movements.

	Age					
	Young		Old			
	M (*n*=40)	SD	M (*n*= 20)	SD	Overall M	Overall SD
EM						
Still	12.23	3.53	10.00	2.71	11.48	3.52
Bilateral	11.90	3.69	7.70	2.55	9.88	3.34
Overall	12.08	3.57	9.20	2.69		

Note. EM = Eye Movement.

There was a significant main effect of age, F (1, 56) = 10.01, p = .003, η_p^2 = .152, this is a large effect size as it is above 0.14 (Cohen, 1992). There was no significant main effect of eye movements, F (1, 56) = 1.15. p = .287. The interaction also was not significant, F (1, 56) = 0.46, p = .499 (see Table 2).

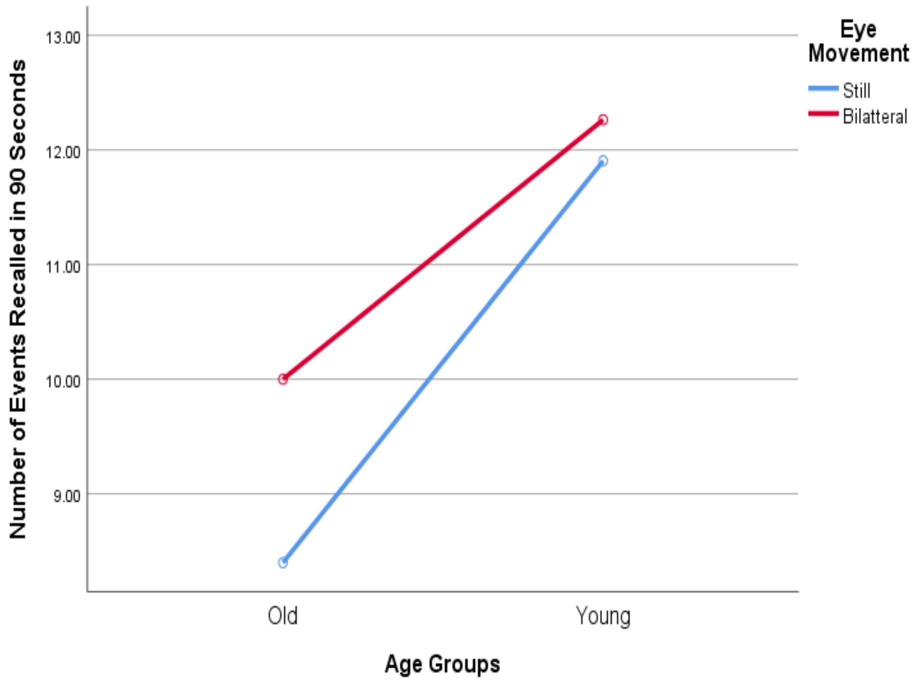

Figure 2: Graph Showing the Effect of Eye Movements and Age on the Number of Events recalled for 12-18 Years.

Table 3 – Number of Friends Names Recalled, with the Effect of Age and Eye Movements

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
EM						
Still	25.02	11.47	11.00	4.78	20.51	11.79
Bilateral	24.05	5.85	13.90	4.25	20.55	7.21
Overall	24.58	9.14	12.45	4.65		

Note. EM = Eye Movement.

There was a significant main effect of age, F (1, 56) = 30.22, p = < .001, η_p^2 = .350, this is a large effect size as it is above 0.14 (Cohen, 1992). There was no significant main effect of eye movement, F (1, 56) = 0.19, p = .667. The interaction also was not significant, F (1, 56) = 0.78, p = .380 (see Table 3).

Table 4 – Number of Teachers' Names Recalled, with the Effect of Age and Eye Movements

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
EM						
Still	16.38	7.73	5.80	2.25	12.97	8.16
Bilateral	15.63	5.06	7.40	3.89	12.79	6.10
Overall	16.03	6.53	6.60	3.20		

Note. EM = Eye Movement

There was a significant main effect of age, F (1, 56) = 35.93, p = < .001, η_p^2 = .391, this is a large effect size as it is above 0.14 (Cohen, 1992). There was no significant main effect of eye movement, F (1, 56) = 0.07, p = .787. There interaction also was not significant, F (1, 56) = 0.56, p = .457 (see Table 4).

Table 5 – Number of Vegetables Recalled, with the Effect of Age and Eye Movements.

	Age					
	Young		Old		Overall	
	M	SD	M	SD	M	SD
	(*n*=40)		(*n*= 20)			
EM						
Still	16.86	4.68	14.70	5.95	16.16	5.16
Bilateral	17.63	6.50	16.00	5.03	17.07	5.99
Overall	17.23	5.56	15.35	5.40		

Note. EM = Eye Movement

There was no significant main effect of age, F (1, 56) = 1.53, p = .221. There was also no significant main effect of eye movement, F (1, 56) = 0.46, p = .500. The interaction also was not significant, F (1, 56) = 0.03, p = .864 (see Table 5).

Table 6 – Number of Animals Recalled, with the Effect of Age and Eye Movements.

	Age					
	Young		Old		Overall	
	M	SD	M	SD	M	SD
	(*n*=40)		(*n*= 20)			
EM						
Still	16.86	4.68	14.70	5.95	16.16	5.16
Bilateral	17.63	6.50	16.00	5.03	17.07	5.99
Overall	17.23	5.56	15.35	5.40		

Note. EM = Eye Movement.

There was a significant main effect of age, F (1, 56) = 20.11, p = < .001, η_p^2 = .264, this is a large effect size as it is above 0.14 (Cohen, 1992). There was no significant main effect of eye movements, F (1, 56) = 1.52, p = .223. The interaction also was not significant F (1, 56) = 0.23, p = .635 (see Table 6).

Sub Category of Handedness and Age Results

These data sets were analysed using a 2 (Age; Young vs. Old) x 2 (Handedness; Mixed vs. Strong) independent factors ANOVA. Comparing the effects of age and handedness on episodic memory recall.

Table 7 – Number of Events Recalled from Ages 5-11, with the Effect of Age and Handedness.

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
HG						
Strong	10.96	3.07	9.43	3.94	10.38	3.45
Mixed	11.41	3.67	9.67	3.33	10.96	3.59
Overall	11.15	3.29	9.50	3.68		

Note. HG = Handedness Group.

There was no significant main effect of age, F (1, 56) = 2.60, p = .112. There was also no significant main effect of handedness, F (1, 56) = 0.12, p = .734. The interaction was also not significant, F (1, 56) = 0.01, p = .915 (see Table 7).

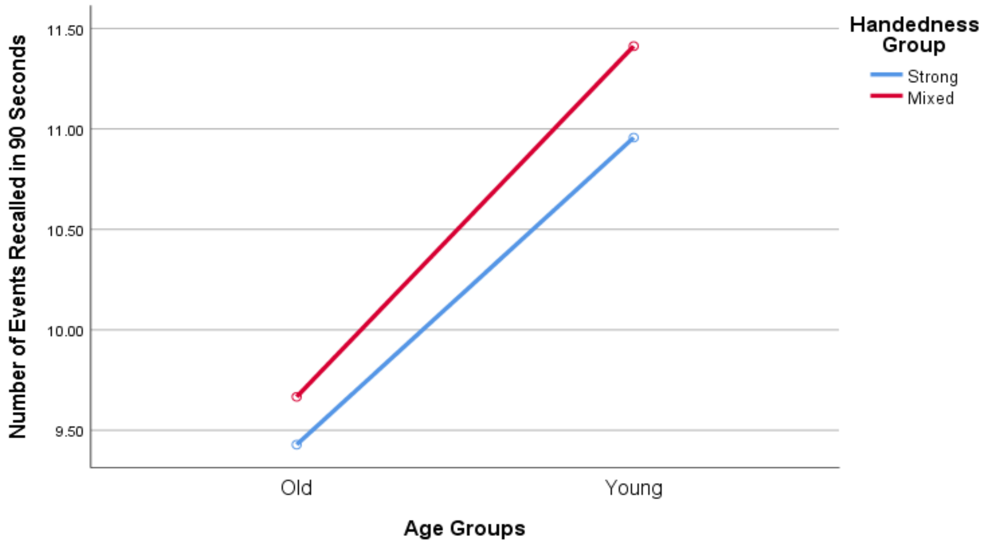

Figure 3: Graph Showing the Effect of Age and Handedness on the Number of Events recalled for 5-11 Years

Table 8 – Number of Events Recalled from Ages 12-18, with the Effect of Age and Handedness.

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
HG						
Strong	11.57	3.46	8.93	2.46	10.57	3.35
Mixed	12.76	3.70	9.83	3.31	12.00	3.77
Overall	12.08	3.57	9.20	2.69		

Note. HG = Handedness Group.

There was a significant main effect of age, F (1, 56) = 8.27, p = .006, η_p^2 = .129, this is a medium effect size as it is above 0.06 (Cohen, 1992). The main effect of handedness was not significant, F (1, 56) = 1.18, p = .282. The interaction was also not significant, F (1, 56) = 0.02, p = .880 (see Table 8).

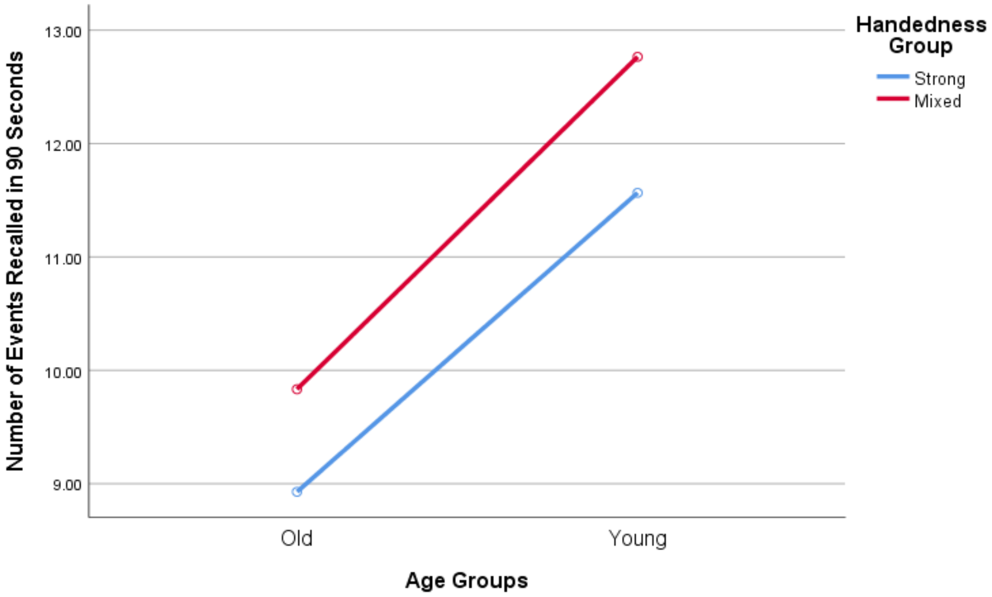

Figure 4: Graph Showing the Effects of Age and Handedness on the Number of Events Recalled for 12-18 Years

Table 9 – Number of Friends Names Recalled, with the Effect of Age and Handedness.

	Age					
	Young		Old		Overall	
	M	SD	M	SD	M	SD
	(n=40)		(n=20)			
HG						
Strong	22.65	7.52	11.50	4.93	18.43	8.57
Mixed	27.18	10.64	14.67	3.27	23.91	10.79
Overall	24.58	9.14	12.45	4.65		

Note. HG = Handedness Group.

There was a significant main effect of age, F (1, 56) = 26.9, p = < .001, η_p^2 = .324, this is a large effect size as it is above 0.14 (Cohen, 1992). The main effect of handedness was not significant, F (1, 56) = 2.84, p = .100. The interaction was also not significant, F (1, 56) = 0.09, p = .767 (see Table 9).

Table 10 – Number of Teachers Names Recalled, with the Effect of Age and Handedness.

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
HG						
Strong	14.87	6.24	5.93	2.10	11.49	6.81
Mixed	17.59	6.76	8.17	3.37	15.13	7.33
Overall	16.03	6.53	6.60	3.20		

Note. HG = Handedness Group.

There was a significant main effect of age, *F* (1, 56) = 31.47, *p* = < .001, η_p^2 = .360, this is a large effect size as it is above 0.14 (Cohen, 1992). The main effect of handedness was not significant, *F* (1, 56) = 2.29, *p* = .136. The interaction was also not significant, *F* (1, 56) = 0.02, *p* = .884 (see Table 10).

Table 11 – Number of Vegetables Recalled, with the Effect of Age and Handedness.

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
HG						
Strong	17.22	4.74	14.93	5.59	16.35	5.13
Mixed	17.24	6.67	16.33	5.28	17.00	6.23
Overall	17.23	5.56	15.35	5.40		

Note. HG = Handedness Group.

There was no significant main effect of age, *F* (1, 56) = 0.96, *p* = .332. There was also no main effect of handedness, *F* (1, 56) = 0.190, *p* = .664. The interaction was again not significant, *F* (1, 56) = 0.18, *p* = .672 (see Table 11).

Table 12 – Number of Animals Recalled, with the Effect of Age and Handedness.

	Age					
	Young		Old			
	M	SD	M	SD	Overall	
	(*n*=40)		(*n*= 20)		M	SD
HG						
Strong	32.27	8.84	22.00	8.81	28.38	10.06
Mixed	32.18	7.46	23.00	5.73	29.78	8.06
Overall	32.23	8.18	22.30	7.87		

Note. HG = Handedness Group.

There was a significant main effect of age, F (1, 56) = 16.44, p = < .001, η_p^2 = .227, this is a large effect size as it is above 0.14 (Cohen 1992). There was no significant main effect of handedness, F (1, 56) = 0.04, p = .849. The interaction also was not significant, F (1, 56) = 0.05, p = .822 (see Table 12).

Discussion

Through analysis of the data, it has shown there is no significant interactions between eye movements and age, and no significant interactions between handedness and age for any of the conditions. However, the data shows significant main effects. Beginning with the ANOVA for the interactions of eye movements and age, there is a clear significant main effect of eye movements when recalling events from ages 5-11 years. There are also significant main effects of age for recall of events from ages 12-18, the number of friends' names, the number of teachers' names and the number of animals. Concerning the ANOVA looking into the interactions of handedness and age, there are significant main effects of age. This is apparent for the recall of events from 12-18 years, the recall of friends and teachers' names and for the recall of the number of animals.

Given the conclusions drawn from the data, not all hypotheses have been supported. Hypothesis one has been supported; this is because throughout there are clear significant main effects of age for each recall question. Hypothesis two however, has been disproved as for older participants there was no effect of eye movements on memory recall meaning the amount of memories recalled did not significantly differ from each group. It was also shown that handedness had no significant effect on memory recall which has disproved hypothesis three, but this finding has supported hypothesis four. This is because the lack of interaction showed that handedness did not influence the number of memories recalled for old and young participants. Due to the significant effects of age throughout the experiment, this can support hypothesis five as younger participants did remember more than older participants. However, due to only seeing a main effect of eye movements for the recall of events from 5-11 years this cannot support hypothesis six as the interaction is not seen throughout the results. One reason for this could be that 5-11 years is further in the past than 12-18 years, so these memories will be more recent. Meaning the effects of hemispheric communication are decreased in the recall from 12-18 years, but eye movements will have the desired effect on episodic recall (Propper et al., 2010).

The significant main effects of age that have been found are in line with the HAROLD model (Cabeza, 2002); this is because the older adults remembered less, which indicates prefrontal activity is less lateralised. It is clear to suggest that episodic memory does display the largest degree of age-related decline as significant main effects of age were seen for most of the questions (Manenti et al, 2016). Given that age related differences are more prominent for tasks that require spontaneous recall (Tromp et al., 2015), this will explain why age had a significant main effect as the tasks used in this experiment were not spontaneous recall. The tasks in this experiment involved recall of specific events from time periods with regards to episodic memory. Had this experiment involved spontaneous recall of event specific memories instead of splitting it up into two different age ranges, the interactions between age and eye movements, and age and handedness may have been seen. If future research is going to use an experimental design like this, they should look to broaden the range of memories to recall to 5-18 years. This may allow for more spontaneous recall and therefore be able to look more closely to see if age does interact with eye movements and handedness, given that this is the suggestion from previous research (Parker and Dagnall, 2010; Parker et al., 2013; Propper et al., 2005).

One possible reason for the age-related differences seen in the results is the reminiscence bump (Steiner et al., 2014). This is the tendency for older adults to have increased recollection for events that have occurred during their adolescence (Steiner et al., 2014). The effects of this are stronger when they are prompted to recall specific memories, which can give explanation to why age did not have a significant effect on the recall of events from 5-11 years. Steiner et al. (2014) also suggested it is more prominent for positive than negative life events, which could be why older participants do not remember as much overall as they may have associated earlier life as negative. Studies investigating the reminiscence bump and autobiographical memories do not use specific time periods and participants are free to recall memories throughout the life span (Kirk and Berntsen, 2018). Although, previous research cannot be certain of the stability of the reminiscence bump throughout different experimental designs (Kirk and Berntsen, 2018; Steiner et al., 2014). However, the research by Kirk and Berntsen (2018) shows the temporal location of the reminiscence bump varies, and the mean range is usually 8.7 to 22.5 years for word cued memories, which is what the current experiment used.

Conversely, the recall period that showed no significant effect of age was 5-11 years, suggesting that the mean age range of recall relating to the reminiscence bump should be lower as it is apparent older participants can remember memories from earlier than 8.7 years old. The current experiment failed to consider the explanations of the reminiscence bump in relation to age related effects on episodic memory recall (Kirk and Berntsen, 2018). Research by Tromp et al. (2015) showed that age related changes lead to increases in time required to retrieve stored information, which does not consider the reminiscence bump as older adults can retrieve the information. The reminiscence bump raises conflict to the theory of cognitive slowdown as it argues older adults may in fact remember earlier memories. However, these two effects were not investigated through the current experiment. Future research needs to consider the mean age of the reminiscence bump and the links to cognitive slowdown to see if less effective coding does exist, as this experiment shows that is does not.

Contrary to prior research, handedness did not produce any significant main effects on memory recall regardless of participants' age; despite mixed handed individuals previously being shown to have superior recall for real world memories (Christman and Butler, 2011). In line with the research by Luders et al. (2010) it is possible to assume that lateralisation is the reason for handedness having no significant effects on memory recall. The size of the corpus callosum appears to not influence memory recall, as mixed handed participants did not remember more than strong handed participants. This then offers support to the research by Luders et al. (2010) as the left and the right prefrontal cortex may not need to communicate to retrieve memories, it is simply due to the functional capability of each hemisphere of the brain. With regards to the fMRI studies by Habib et al. (2003) they found decreases in hemispheric interaction for strong handed individuals, however the current experiment did not find these effects as episodic memory recall was not affected by handedness. Furthermore, this raises questions as to whether the impacts of handedness on recall do exist, as research is contradictory and does not provide a clear explanation. More knowledge and understanding needs to be developed through future experiments around the concept of handedness lateralisation (Luders et al., 2010).

As eye movements did not produce any significant effects on memory recall, the results produced in the experiment also disproved the SIRE model (Lyle and Martin, 2010). Bilateral saccades showed no effect on memory recall and they do not assist in the retrieval of event-specific information. The current findings showed no significance, therefore disproving the claim from Christman et al. (2003) as eye movements did not influence explicit (episodic) recall, suggesting also the predictions of the HERA and the SIRE model need to be adapted to suit the current findings (Parker et al., 2018). Lyle and Martin, (2010) also assume the SIRE effects could be explained by top-down processing of the recall task. Even though there is research to show that bilateral saccades do increase access to childhood memories (Parker et al., 2009), it has been disproved by this research. As age also did not interact with eye movements to produce significant differences for memories recalled by both young and old participants.

Furthermore, it is often assumed that recall of autobiographical memories may start with the most accessible information first (Conway et al., 2001). This could explain why eye movements did not produce a significant effect on memory recall for both young and old participants within the experiment. Therefore, supporting the notion that top-down processing is involved in autobiographical memory recall as it begins with accessible memories then focuses on generative recall which is associated in the frontal areas linked with encoding and retrieval (Parker et al., 2013; Jacques et al., 2012). Suggesting that autobiographical memory is a hierarchical process (Parker et al., 2013).

Through the implementation of these methods into future research, we may be able to further enhance our knowledge into the interaction handedness has on memory recall. It is apparent it has some effects given previous research (Luders et al., 2010; Sahu and Christman, 2014; Parker and Dagnall, 2010), although this experiment did not show these effects. This could be due to the type of memory questions asked as hemispheres are differently specialised for positive or negative valence, which may explain why handedness had no significant effect. If a significant effect of handedness is to be seen through this experiment, then recall of memories needs to be specific to a certain emotional valence for each question (Propper et al., 2010). Creating a different emotional valence each time will allow observation as to whether the amount of memories recalled is affected by handedness as you would expect mixed handers to recall more as communication between the hemispheres is greater. Consequently, mixed handers should be more adapted to the changes in emotional valence (Propper et al., 2010).

By having 60 participants in the current experiment this accounted for an effect power of 80 and having an overall medium effect size (Cohen, 1992; Cohen, 1988). To enhance the insights into the interactions a larger sample size of 112 participants, plus the pilot study and in case of drop out, could have been used, as this would account for 14 participants per cell. Which will yield the desired power of 80% and an effect size of .50 (Wilson and Morgan, 2007; Parker et al., 2013). If there was a larger sample size, this would have split the data up even further as a three-way ANOVA would have been used. This would have meant the data having three levels of handedness, eye movements and age. If the statistical testing involved more than two groups then the sample size would have to be the same for each group (handedness, eye movements and age) which would not have been possible given the time period for the current experiment (Cohen, 1992).

With a smaller data set for each variable, this would mean the 80% chance of detecting the effect size would be decreased and the effect of power would not exist. Therefore, the sample size for this experiment was appropriate for the research conducted due to the power of the data being significant to see an effect size of .50 and to use the two-way ANOVA with an appropriate 56 participants. The handedness group within the experiment was a quasi-design, as it was not possible to control the handedness group an individual identified with. Consequently, this affected group size as everyone uses different hands for different activities meaning if we were to ask participants if they were left or right handed this still would not be able to control for whether they were strong or mixed handed.

If further research is carried out within this area, experimenters should look to use an eye tracker when participants follow the eye movement clip on the screen. Due to the range of environments the experiment was conducted in it cannot be certain that participants were completely focussed and following the eye movement. By implementing an eye tracker this will allow the researcher to ensure the experiment is being followed through by the participants. Additionally, the results may in fact show a significant interaction between eye movements and age, which would then help to further the understanding of why bilateral saccades improve memory recall (Manenti et al., 2011). The experiment has shown that handedness does not have the predicted impact on memory as research may suggest (Christman and Butler, 2011; Propper et al., 2005). This gives an understanding and potential to look at the impact lateralisation has on memory recall. By manipulating age and lateralisation instead of age and handedness, potentially significant interactions may be found as lateralisation is seen to decrease the demands on interhemispheric communication, and in turn could increase episodic memory recall (Luders et al., 2010).

To conclude, even though the experiment did not produce significant interactions for age, handedness and eye movements it did produce significant suggestions for future research. By incorporating the importance of the reminiscence bump (Steiner et al., 2014), handedness lateralisation instead of dominance (Luders et al., 2010), and emotional valence (Propper et al., 2010) it will allow further research into the interaction between these effects that have yet to be investigated. Consequently, this will give way to more understanding and insight into what the links between handedness, age and eye movements are. And subsequently questioning if these do all interact with each other or if they are still all independent components.

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