METAMEMORY IN SUPERAGERS

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ABSTRACT

METAMEMORY IN SUPERAGERS

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Superagers are individuals who are above 60 years old and have similar cognitive abilities as well as episodic memory performances with individuals who are 20 or 30 years younger than them. As of today, researchers still do not have a satisfactory explanation for this unusual ageing process. This might be either due to the Superagers' resilience to the effects of ageing or they have superior cognitive ability performance when they were younger and as they age, they do not show the same amount of age-related cognitive decline compared to their same age peer group. Superagers show higher cortical thickness and volume compared to same age peer group and display similar thickness and volume when compared with young adults. The current study is the first study which assesses Superagers' metamemory performances rather than only evaluating their basic cognitive performance (e.g., executive function & episodic memory performances). Superagers' metamemory performances were assessed by applying Feeling of Knowing (FOK) and Judgment of Learning (JOL) metamemory monitoring tasks. According to the literature, FOK is age sensitive while JOL is intact as individual ages. Our aim was to find a relationship between metamemory accuracy results with being a Superager since we expected that both FOK and JOL metamemory monitoring ability of Superagers will stay intact. Therefore, we had 2 control groups for Superagers. The first control group was the elderly control group which included healthy elderly adults who were around the same age with Superagers and second control group was the young control group which included individuals who are 20 and 30 years younger than Superagers. We predicted that Superagers will achieve higher scores than their peer group on both cognitive and metacognitive tasks and have similar accomplishment with the young control group. The result of the study indicated that Superagers' both episodic FOK and delayed JOL judgments were more accurate and significantly different compared to both the elderly and young control groups. These results showed that Superagers also have intact metamemory abilities along with their cognitive abilities.

Keywords: Superagers, metacognition, neuropsychology, feeling of knowing, judgment of learning

ÖZ

SÜPERYAŞLILARDA ÜSTBİLİŞ SÜREÇLERİ

Onin, İrem Tuğçe

Yüksek Lisans, Bilişsel Nöropsikoloji

Tez Danışmanı: Dr. Oliver Anthony Wright

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Süperyaşlılar olarak tanımlanan 60 yaş ve üzerindeki bireyler, bilişsel yetenekleri ve epizodik hafıza performansları, kendilerinden 20 ile 30 yaş daha genç kişilerle eşleşen özel bir yaşlı grubudur. Araştırmacılar henüz bu özel yaşlı topluluğunun yaşlarına nazaran üstün yeteneklerini açıklamak için kesin bir sebep bulamamıştır. Süperyaşlıların normalden farklı yaşlanma sürecini açıklamak için iki farklı teori öne sürülmüştür. Bunlar; yaşlanmanın getirdiği etkilere karşı dirençli olduklarını veya genç iken yaşıtlarından daha üstün bilişsel performansları olduğu ve yaşlandıkça yaşıtlarıyla aynı oranda kayıp göstermedikleri düşünülmektedir. Beyin görüntüleme çalışmalarında Süperyaşlıların yaşıtlarına göre kortikal kalınlığın daha fazla görüldüğü ve beyin hacimlerinin genç yetişkinlerinkine daha yakın olduğu saptanmıştır.

Bu çalışma ile ilk kez Süperyaşlıların temel bilişsel süreçler performanslarının (epizodik hafıza, dikkat, yürütücü işlevler) yanı sıra üst bilişsel performanslarının Bilme Hissi ve Öğrenme Kararları tutarlılıklarının araştırılması hedeflenmiştir. Literatürden ispatlandığı üzere, Bilme Hissi yaşlanmaya bağlı kayıplar gösterirken, Öğrenme Kararları yaşlanma sürecinde bozulmamaktadır. Bu çalışmanın asıl amacı ise Süperyaşlıların üst biliş performanslarını incelemektir ve her iki üst biliş yargılarının korunduğunu desteklemektir. İlk kontrol grubu olarak Süperyaşlıların yaşıtları olan sağlıklı yaşlı bireylerden veriler toplanmıştır. İkinci kontrol grubu olarak ise genç yetişkinden veriler toplanmıştır. Genç yetişkin grubunun yaş ortalaması ise Süperyaşlılardan 20 ile 30 yaş daha gençtir. Bu çalışmanın ana varsayımı ise Süperyaşlıların kendi yaşıtlarından daha yüksek üst biliş performansı göstereceklerі ve bu performanslarının ise genç yetişkinler ile benzer sonuçlar açığa çıkartacağı beklenmektedir. Sonuçlar Süperyaşlıların hem Bilme hissinde hem de Öğrenme kararları testlerinde genç kontrol ve yaşlı kontrol gruplarından daha yüksek performans ve istatistiksel olarak anlamlı bir fark gösterdikleri saptanmıştır. Sonuç olarak Süperyaşlıların bilişsel yeteneklerinden ziyade üst bilişsel yeteneklerinin de korunduğunu gözlemlenmiştir.

Anahtar kelimeler: Süperyaşlı, üstbiliş, nöropsikoloji, bilme hissi, öğrenme kararları

“You don’t have to see the whole staircase, just take the first step.”

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CHAPTER 1

INTRODUCTION

Ageing is an inevitable biological process. Usually, this process leads to several major variations in elderly adults' life. Due to biological, genetic and environmental factors; distortion in cognitive abilities, physical health problems appear along with ageing. Considering the correlation between recessions in cognitive abilities, the metacognitive abilities also start to diminish with ageing. However, there is a special group of elderly people who seems to be immune to expected ageing process decrements and they are called "Superagers". The current study examines the Superagers' metacognitive judgments and compares these results with the same age peer group and the young adult control group.

1.1. Ageing and Cognitive Process Alterations

Every year, the population of elderly people is increasing due to life span extension made possible by the improvements in technology and healthcare all around the world. The ageing process brings with it a great number of advantages and disadvantages simultaneously.

Some of the disadvantages might affect elderly adults' daily social life. Deterioration of memory and cognitive abilities, degradation of information process speed, and degeneration of physical activities are main disadvantages of the ageing process (Gefen et al., 2012). According to National Institute of Mental Health Depression (2016), depending on an individual, depression is a common mood disorder among the elderly population. It is not an unavoidable process yet, elderly adults are at increased risks for experiencing geriatric depression.

Additionally, elderly people's use of medication for multiple physical diseases might lead to impairment in their cognitive functions as well (e.g., reduced heart rate correlates with dysfunction of cognitive abilities) (Hansen et al., 2004). Most of the time, the combination of the medicine they take might cause comorbidity (due to the undesired side effects of these medications). This comorbidity ultimately affects their psychological health.

Some advantages of the ageing process involve: less negativity and higher self-esteem, wiser perspective, self-appreciation and acceptance, more clear priorities and more positive well-being as well as greater emotional stability (Carstensen et al., 2000 and, Orth et al., 2010).

Curiosity regarding the ageing process, elderly adults' life span and their memory increases continuously. As the number of elderly people increases steadily due to advances in technology and health care, researchers become ever more interested in elderly people and age-related disorders which accompany the ageing process.

As people age and develop, their cognitive abilities change. Most people think that intelligence declines due to the ageing process during elderly adulthood (Murman, 2015). Murman's study claims that normal cognitive ageing process may be divided into two subgroups: (I) crystallized intelligence, which includes knowledge that arises from previous learning and prior experiences (e.g., historical information, general knowledge; math, science and vocabulary) and it stays intact while ageing, (II) fluid intelligence contains abstract reasoning and problem solving abilities (e.g., solving a puzzle). These abilities do not depend on experience or the level of education. For this type of intelligence degradation starts from age 20 and continues up to 80 years old.

Cognitive abilities can be divided into different cognitive domains: for example; attention, memory, visuospatial abilities, executive functioning and language (Smith & Kosslyn, 2013).

As people get older, simple attention tasks (e.g., digit span) are maintained (Salthouse, 2010). Normal ageing subjects' performances constantly decline for more complex attention tasks which elderly adults are already having trouble with. For example, divided attention (e.g., multitasking) and selective attention (e.g., focusing on a target item and ignoring the distracter) tasks become harder to complete.

Some features of memory are preserved during the normal ageing process (Cangöz, 2009). The previously mentioned study claims that semantic memory (e.g., capital of Turkey), procedural memories (e.g., riding a bike) are intact as individuals get older. However, learning new information (assess by delayed free recall) or retrieval of newly learned items (assess by delayed recognition) constantly decrease.

In addition, prospective memory (e.g., remembering not to drink coffee with medicine), also declines due to ageing (Salthouse, 2012). Additionally, short-term memory declines as well, but to a lesser extent compared to long-term memory. Also, episodic, source and flashbulb memory weaken as people age. According to Tulving (2002), episodic memory is the last memory form to develop and it is the most vulnerable to neural dysfunction due to ageing. Especially for the long-term memory; recall performance is the more vulnerable feature compared to recognition performance in cued-recall ability (Cangöz, 2009). Performing higher in recognition test rather than recall performance is the common result in most published studies (Alam et al., 2014; Bruce et al., 1978; Burke &Light, 1981; Fisher & Craik, 1977; Souchay, et al., 2007).There are two main hypotheses that account for this result: (I) the difference in the amount of alternatives to choose target item, (II) differences between the amounts of information during retrieval to identify the target item (Tulving et al., 1968). Usually, one of the reasons behind memory deterioration is the damages in synaptic connection instead of the critical loss in the amount of neurons (Karakaş, 2010).

According to Murman (2015), visuospatial abilities (e.g., recognition of an object, gestures, and shapes of an object) remain constant with ageing. However, visuospatial judgments decline related to ageing (e.g., copying a complex design is more difficult for elderly adults compared to young adults). Specifically, for mental flexibility requiring tasks, elderly adults find the task difficult due to the deteriorations in cognitive functioning that are associated with ageing.

According to Smith and Kosslyn (2013), executive functions include problem solving, decision making, multitasking, planning, cognitive flexibility, cognitive inhibitions and those abilities get poorer as people mature (Salthouse, 2012). The distinction between relevant and irrelevant information from contextual information (any information related to the target item in any way by not referring directly) also starts to decrease due to ageing process (Schwartz et al., 2014). Therefore, inhibition response and abstraction tasks become very difficult to complete for elderly people, especially for those aged 80 and above. Consequently, finding the target information is not an easy task due to poor inhibition ability.

Some aspects of speech and language functions (e.g., vocabulary and verbal reasoning) remain unharmed with advancing age. Nonetheless, lexical fluency, categorical fluency and naming an item start to decrease by ageing (Cangöz, 2009).

According to Park and Festini (2017), acquiring an average performance according to a specific age range normative value does not mean that cognitive abilities are undamaged. It only proves that the degradation over time has remained at an expected level for that average population. Also, age-related memory decline might be explained by non-cognitive domain theories such as test anxiety, poor health, low motivation, diverse performance aim as well as decreased memory self-efficacy.

Consequently, attention, memory (specifically episodic memory), executive function, language and processing speed are the main cognitive abilities that decline due to the ageing process.

1.2. Ageing, Brain Structure and Functional Changes

During the ageing progress, brain size decreases (Murman, 2015). Also, brain structures and functions change correlated to age related cognitive decrements including changes in neural structure, synapse loss and neural network dysfunction.

Healthy elderly adults demonstrate atrophy in various regions beyond the parietal, occipital, frontal lobe and lastly medial temporal region (Harrison et al., 2012). Neuroimaging studies indicate that both functions and volumes of temporal lobe (medial temporal lobe: hippocampus) and dorsolateral prefrontal cortex (working memory and executive functioning) start to decrease with ageing. These specific regions are essential for memory (binding different aspects of memory) and learning.

1.3. Superagers and Neurological Changes

Superagers are elderly adults who seem immune to age related memory decline and brain mass deteriorations. Different articles mention different age ranges for Superagers. According to Harrison (2012), Superagers are elderly adults, aged 80 years and above and show almost identical episodic memory performance with 50 to 65 year olds. They do not show similar episodic memory performance in comparison with their age matched peer groups. Sun (2016) and her colleagues, define Superagers as elderly people who are 60 to 80 years old and above, based on their performance in comparison with young adults who are around 18 to 32 years old on the California Verbal Learning Long Delay Free Recall test. They compared the Superagers' performance with age and education matched normative data. Researchers of the article expanded the age range to younger group of elderly adults and determined young adult control group according to their older adults' age range.

Previous studies state that, Superagers have explicit; anatomic, genetic, and histopathological markers in comparison with older adults who are age matched with Superager (Gefen et al., 2014). Superagers demonstrated deeply greater cortical volume and thickness than their cognitively normal age-matched cohorts and showed no significant cortical atrophy when compared to the young control group which comprised cognitively unharmed individuals who were 20–30 years younger than Superagers (Harrison et al., 2012). Another important finding from the same study is that Superagers' left anterior cingulate cortex is not significantly distinguishable from those in the healthy middle aged control group (50-65 years old). These differences might help Superagers to resist to the degeneration process of ageing. According to Mesulam (2009), cingulate cortex is critical for episodic memory, cognitive control and spatial attention.

According to Sun (2016), Superagers' cerebral cortex was thicker compared to same age peer group and substantially identical anatomically with the young adult control group. In addition, Superagers' hippocampus volume seems to remain the same as people age. Specifically, thickness in some of the essential parts for memory such as anterior cingulate cortex correlated with higher performances on memory tasks. There are several studies which support these results by showing significant correlation between bigger hippocampal volume and better delayed episodic memory performances (Convit et al., 1994; Golomb et al., 1994; Xu et al., 2008) on recall phase. However, Harrison's (2012), study did not find a direct correlation between cingulate thickness and episodic memory because cingulate is not known as the main component of episodic memory. Harrison and his colleagues assumed that cingulate might mediate resistance of memory to age related decline.

According to Harrison (2012), postmortem studies on two Superagers' brains demonstrated that Superagers had four times more Von Economo neurons (VEN) or spindle neurons in comparison with age matched cohort adults. This density might have helped them perform better at complicated cognitive and social tasks by increasing their performance in information processing which can get slower as people get older (Gefen et al., 2017). According to Cauda and Geminiani (2014), spindle neuron provides social cognitive abilities, executive control and self-awareness. Most of frontotemporal dementia patients suffer from a lack of social awareness and self-control due to the declining number of spindle neurons.

According to Salat (2004), atrophy in older cohorts in numerous regions such as frontal, occipital, parietal and medial temporal region which play key roles in memory performances might be expected. However, Superagers have higher density and thicker volume in those areas compared to those in healthy age peer groups (Rogalski et al, 2013). To summarize, Superagers do not manifest expected age-related decrement in specific brain regions which might eventually provide more accurate and stable cognitive abilities as they age.

One of the recent longitudinal studies demonstrates that Superagers do not show any significant deterioration in neuropsychological assessments that measure attention, executive function, memory and language from baseline up to 18 months (Gefen et al., 2014).

According to Harrison (2012), there are two main theoretical explanations for Superagers' surpassing cognitive and episodic memory performances: (I) Superagers had superior cognitive ability performance when they were younger and as they age, they do not show the same amount of age-related cognitive decline compared to their same age peer groups even though age-related decrement affects their cognitive abilities (II) They can be resistant to age-related cognitive performance decline. Specifically, the longitudinal study about Superagers might support the second hypothesis by providing 18 months study results which indicates Superagers' intact cognitive abilities and those results might support the idea of that they might be resistant to age related cognitive reduction (Gefen et al., 2014). It's unclear which of the explanations is better due to lack of longitudinal studies.

1.4. Metacognition and Metamemory

The basic definition of metacognition would be thinking about thinking (Flavell, 1979). Metacognition is the knowledge about what you know and what you don't know, it's an awareness of our own cognition (Nelson & Narens, 1990). Metacognition is thus one's ability to control their thinking process by monitoring, strategizing and adapting. There are a few major categories of metacognition: (I) metamemory, (II) memory comprehension (III), critical thinking and problem solving (Martinez, 2006).

Metamemory is about understanding one's own knowledge and circumstances. Individuals can evaluate their memory either retrospectively or prospectively and make judgments according to that information (Metcalfe & Dunlosky, 2008).

Joseph Hart is the first scientist who stressed the importance of assessing the accuracy of metacognition objectively in 1965. He observed: "When people feel like they know something, most probably they really do, and when people feel like they do not know something, presumably they really do not know" (Hart, 1976b, 1976). Metacognition intrigued interest by creating a mystery for people: people can feel whether they know the target item or not and can also make decisions about whether they have access to that specific information or not.

According to Hart (1965), subjects' introspective judgments can be evaluated by conducting an objective test. He evaluated the accuracy of judgment by creating Recall/Judgment/Recognition (RJR) tasks. However this technique started to evolve in the following years.

According to Nelson and Narens (1990), the metacognitive process consists of both (I) monitoring the information (knowledge) and (II) controlling the behavior (control of the cognitive activities). This model is also called "Procedural metamemory" (Mazzoni & Nelson, 2014). Both aspects perform together as a circuit. In the monitoring stage, we gather information from our performances, our own knowledge, our strategies as well as beliefs about ourselves and our general cognition. However, in the controlling stage; we regulate our own behavior consciously or unconsciously according to the output of our monitoring procedure. For example, a student wants to decide whether she studied enough so she can go to sleep. Employing the monitoring process; she might feel that she has understood the text she has just read. Employing the controlling process, she decides whether the items are encoded sufficiently. If they are not, she may choose to continue studying those items based on total time availability, difficulty levels of the information and judgments of importance (Souchay et al., 2004). Also this (monitoring/controlling) structure includes two correspondent levels: (I) a meta-level, (II) an object-level.

Meta-level adjusts the object-level. This process will affect object-level and create an action. (See the figure 1 for the model).

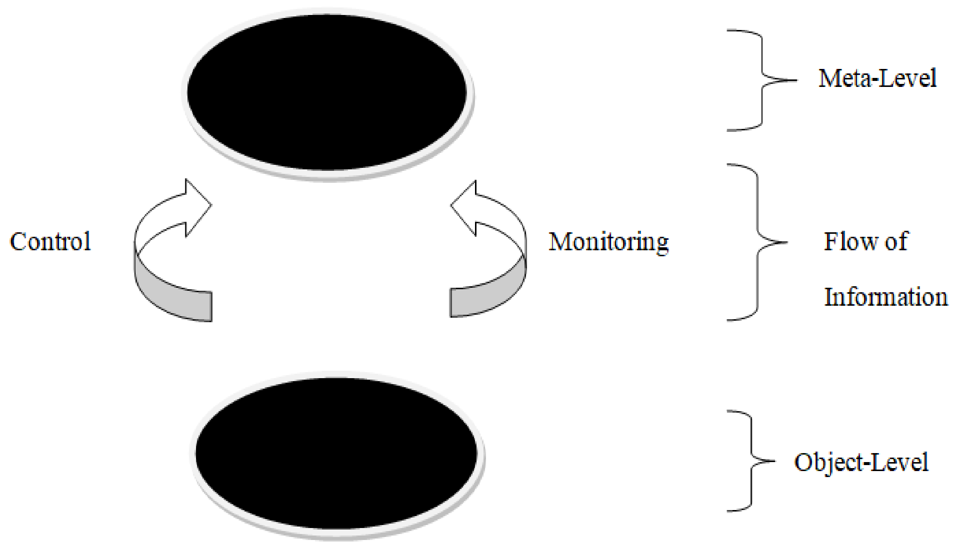

Figure 1 Nelson and Narens (1990) originally published Theoretical Model of Memory and Metamemory.

According to Irak (2005), monitoring judgment has two aspects: (I) retrospective judgment which is made during knowledge obtaining, and (II) prospective judgment which is made during the retrieval time. The comparison between judgments and the actual performance will provide the accuracy (Hart, 1965).

The most common assessment of monitoring ability can be divided into three as (I) Ease of Learning (EOL): difficulty judgments before the learning phase, (II) Judgment of Learning (JOL): judgment helps them to assess how well the subject learned something and make assumptions for their future recall performance, and (III) Feeling of Knowing (FOK): judgment about subjective experience of feeling regarding the current unrecalled items and predict the future retrievability (Nelson & Naren, 1990).

Monitoring our memory is one of the most essential abilities in everyday life since we control our behaviors according to monitoring outputs (Souchay & Isingrini, 2012).

According to Schwartz and Metcalfe (1994), there are different sources of information underlying metacognitive judgments which help individuals understand how they can make reasonably accurate judgments. Schwartz refers to these views as: (I) direct access and (II) inferential views. Direct access mentions that people make judgments depending on features of the target that they can retrieve or access. This access is essential for an accurate or strong metacognitive judgment. The Inferential view states that strong metacognitive judgment depends on the level of recognition at the time the cue was given and judgment was made. This view guides people to make judgments by familiarity even though they were not able to access the actual information about the target item. Dunlosky and Tauber (2016) state that, subjects do not usually have direct access to the target in their memory and instead they make judgments based on the derived cue and how strongly the cue relates to criterion performance. Direct access is not usually a favored source of information for scientists to explain the theoretical bases of metacognitive judgments.

Additionally, people determine their metacognitive judgments not only based on correct retrieved information, they also use incorrectly retrieved information as clues (Nelson, Gerler & Narens, 1984). Subjects might be able to recall the first letter of the target item or amount of syllables, the meaning of the item and the partially related information may be crucial at metamnemonic judgments (Koriat, 1993).

Since FOK and JOL are not highly correlated these judgments might be monitoring the different aspects of the memory and structure of those judgments might include different brain regions (Krinsky & Nelson, 1985).

1.4.1. Feeling of Knowing (FOK)

Feeling of Knowing paradigm was developed by Hart (1965), and it is an assessment process of one’s own memory and it envisions the subjects’ future memory performances on items they cannot recall at the given moment. Basically, FOK is a subjective experience one has when she fails to recall information; the subject makes a prediction of recognition for those non-recalled items, and should be confident about that information to be retrieved in the future (Flavell, 1979; Nelson, 1996).

Dichotomous FOK judgment (FOKs) was originally developed by Hart in 1967. If the subject believed that they would recognize the currently unrecalled item in the future they responded “Yes”. If the subject believed that they would not recognize the target item in the future they responded “No”.

FOKs is based on the monitoring of the memory retrieval process, and has an important duty in coordinating memory functioning (Sacher, 2015). FOK judgment is about whether information is potentially available in the subjects’ memory or not. Also FOK is a judgment about one's confidence in the accuracy of retrieved answers.

There are three major FOK judgments: (I) speeded retrieval decisions which take place immediately before an attempted retrieval, (II) tip of the tongue which occurs shortly following a retrieval attempt and (III) FOK judgments which are made right after retrieval (Schwartz ,1994). In the present study only the FOK judgments which come right after retrieval were examined.

For the judgments made at the retrieval stage, subjects were asked to evaluate whether they would be able to recall or recognize the target item at the given time, or in the future, often with additional cues (Nelson & Narens, 1990).

FOK judgments might be based on two different sources of information: experience-based judgments and information-based judgments (Koriat et al., 2007). Semantic FOK is based on information-based judgments which depend on people's belief about their cognitive skills and strategies. Episodic FOK is based on experience and evaluates the studied items in the encoding, retention and retrieval stages. Usually, greater accuracy of memory predictions is observed in semantic FOK rather than episodic FOK (Dunlosky and Tauber, 2016).

According to Schwartz's (1994) review article, there are two different types of cue theories that individuals use when they make FOK judgments: (I) Cue familiarity (e.g., higher cue familiarity lead to greater FOKs), which will lead to making higher judgments (II) partial target accessibility (e.g., attempt to retrieve the first letter of the target item or the number of syllables, even if it is not successful), recalling the meaning of the target items or the last letter of the item. Cue familiarity in episodic FOK judgments does not distort the accuracy of target retrievability (Koriat, 1993). In fact, they influence the accuracy in a more precise way. A more recent study claims that cue familiarity and partial target accessibility are probably employed consecutively (Koriat & Levy-Sadot, 2001). Both of the cue theories facilitate individuals to make more accurate FOK judgments. However, FOK usually depends on accessibility account whereas JOL usually depends on cue familiarity (Hertzog, Dunlosky & Sinclair, 2010).

Several studies show that ageing has little or no effect on the resolution of semantic FOKs while it has a significant effect on episodic FOKs (Hart, 1967; Souchay et al., 2004; Souchay et al., 2012). Thus, differences between semantic and episodic memory might be explained by a lack of recollection during recognition test in old age group (Yonelinas, 2002). In addition, the older adults' failure to use the contextual information related to the target to make their judgments might cause deficits in FOK resolution (Hertzog, 2010).

Usually, FOK judgments are related to fronto-temporal and fronto-parietal networks (Dunlosky and Tauber, 2016). Also, medial prefrontal cortex (mPFC) gets active while people make FOK judgments or metacognitive awareness of memory (Schnyer et al., 2004). mPFC density was also found intact in Superagers (Sun et al., 2016). In addition, Elman (2012) states that during the FOK judgments, anterior cingulate cortex gets active. Both brain regions are very active and intact in Superagers therefore, there is a high expectation for more accurate FOK judgments.

Frontal lobe plays an important role for metamnemonic judgments (Janowsky, Shimamura & Squire, 1989). Patients with frontal lobe damage could not accurately judge their memory performances. Even in an unimpaired brain, deformation of metacognition in subjects can rarely occur due to bias effect. The monitoring ability stays intact, controlling of behavior might be distorted (Dunlosky et al., 2008).

1.4.2. Judgment of Learning (JOL)

Arbuckle and Cuddy (1969) are the first researchers who mentioned JOL and worked on the prediction about subjects' future memory performance during the encoding phase. They wanted to distinguish the difference between what is and what is not remembered in a given moment. Monitoring of learning is assessed by asking subjects to make JOL judgments (JOLs). According to Nelson and Dunlosky (1991), JOL is people's own evaluation of how great they learned something and their prediction about how well they are going to remember in the future. JOL is very important because it contributes to the information of JOL underline mechanism which will eventually help subjects control their own behavior better by monitoring accurately (Son et al., 2005).

JOL is one of the prospective monitoring judgments and it helps to predict future recall memory performances (Nelson & Narens, 1990). JOL is the only prospective monitoring judgment that occurs during encoding or during storage, rest of the prospective monitoring judgments take place either before encoding (e.g., EOLs) or after failed retrieval (FOKs). Using JOL, researchers believed that only short term memory can be monitored by applying immediate recall tasks. Nevertheless, with JOLs, long term memory can also be monitored by applying delayed recall tasks (Son et al., 2002). To summarize, while delayed JOLs depends on retrieval fluency, immediate JOLs depend on encoding fluency (Koriat et al, 2005). Researchers also discovered that JOL response was extremely accurate when JOL was delayed rather than take place immediately after study (Nelson & Dunlosky, 1991). According to Son (2005), there are three hypothesis that explain differences between delayed JOL and immediate JOL; first the monitoring dual memory hypothesis; in immediate JOLs, subjects make judgments based on retrieved information from their short term memory, their predictions concerning the future performance based on long term memory is more beneficial and accurate in comparison to short term memory. Second hypothesis is transfer appropriate processing view, the difference between matching the JOL condition with the contextual information at a given time. The third hypothesis maintains that delayed JOL is more accurate compared to immediate JOL. Immediate JOLS might affect the accuracy of JOLs so, only delayed JOLs are included in this study.

JOL judgments can be made in two different ways; one includes all items on the list and the other item by item (Dunlosky et al., 2008). In the current study, the usage of item based judgment was preferred. For paired-associated JOLs there are two types of judgments: one involves cue-target JOLs which includes stimulus and response at the same time (e.g. çerçeve-çiçek) and the other involves cue-only JOLS (e.g. çerçeve - ?). In this study only cue-only JOLs were included to increase the delayed JOLs prediction accuracy (Dunlosky & Nelson, 1994).

Both FOK judgment and delayed JOL judgment reflect participants' ability to predict the retrieval of information after a delay. Nevertheless, there is a difference between FOK and JOL responses. JOL judgment are made at the acquisition stage and made on all items whereas FOK judgments are made at the retrieval stage and usually only includes unrecalled items (Dunlosky & Nelson, 1992). Subjects usually overestimate their calibration scores for JOL while underestimating their FOK calibration scores in the published articles (Koriat, 2006; Souchay et al, 2012). According to Arbuckle and Cuddy (1969), JOL in older adults are more accurate rather than FOK. Moreover, JOL resolution is not age sensitive unlike episodic FOK (Connor, Dunlosky & Hertzog, 1997).

1.4.3. Metacognition in Elderly Adults

Healthy adults are usually aware of their declining memory functions and this might cause them to feel anxiety (Hess, 2005). Young adults tend to overestimate their self-efficacy while older adults underestimate theirs (Perfect et al., 2002). According to Hertzog (2002), many elderly adults believe in the stereotype of age related memory degradation, even though these assumptions are not always accurate. In addition, poor expectations might lead elderly adults to feel anxiety and also have other negative effects. Elderly adults believe that; as they age, their memory starts to decline and this belief affects their actual performance as well as their metacognitive accuracy. However, most of the time their assumptions about their own memory decline reflects their actual memory performance.

According to Murman (2015), retention of newly learned information usually stays intact with the ageing process; however, the retrieval of information might require more cues or a recognition format to keep the ability stable among on all age groups. Most of the time, elderly adults retrieve some information but they cannot separate the irrelevant information from the essential ones due to age-related decrement of inhibition ability in executive functioning (Souchay et al., 2012). Hasher and Zacks (1988) created a model for inhibition decrement in elderly adults to explain how it affects the working memory by accessing to irrelevant information which interferes with the retention and retrieval of relevant information (target item). Furthermore, previous studies point out to the relation between executive functioning and metacognition (Irak, 2005; Souchay et al., 2004; Zhou, Lu & Dong, 2017). Retrieval failure is caused by three possible reasons: (I) cues can be too weak or irrelevant for the target, (II) interference problem (same cue might be associated with more than one memory), and (III) either information has decayed or was never encoded (Hertzog, 2010).

Elderly adults may suffer impairments' in their memory and metamemory. Even though older adults recall fewer words compared with young adults, still their JOLs are similar to young adults (Dunlosky & Tauber, 2016). JOL judgments usually stay intact with age. This might be due to their use of metacognitive strategies or awareness in order to compensate age-associated decrement in their memory performances.

Episodic FOK is age sensitive and this might be due to lack of memory awareness, recollection deficits or context retrieval difficulties in elderly adults (Souchay et al., 2007). This episodic memory dysfunction is mediated by deficits in metamemory because older adults cannot monitor their own memory efficiently and as a result, they cannot deal with memory difficulties. Nevertheless, when subjects employ semantic FOK, there are no FOK resolution differences between young and elderly adults (Souchay et al., 2012). The reason behind successful semantic FOK judgement is the successful retrieval of semantic memories which is essential for FOK accuracy. despite the fact that episodic memory retrieval diminishes with age (Dunlosky & Tauber, 2016).

There are two different theories which explain the difference between semantic FOK and episodic FOK: (I) inferential-deficit hypothesis and (II) memory constrain hypothesis. Inferential-deficit hypothesis which is the successful recognition of unrecalled items depends on the accessibility of contextual information. Memory constrain hypothesis is about encoding strength rather than retrieval (Hertzog et al., 2010).

According to Hertzog (2002) longitudinal findings indicate that actual changes in memory performance level are not strongly correlated with perception of memory which changes over time. However, this information does not mean that elderly adults cannot make an accurate assessment of their own memory functions. Researchers rely more on implicit theories about ageing; age related decrement and memory rather than accurate monitoring of memory. They examine representation in memory, explicit retrieval cues, priming manipulations and other factors (Wyer and Srull, 1986).

1.5. Aim of the Study and Hypotheses

The aim of this study was to work with Superagers with the assumption that understanding the intact mechanism of Superager brains will provide a better understanding of this unusually successful ageing process. By including metacognition in the present study, it might provide detailed evidence about Superagers' higher cognitive function performance along with their metamemory performance. Previous studies only mention neuroimaging techniques however; with the current study, we might be able to go deeper by providing behavioral data. Understanding this unusual process might provide more information for health ageing process. Another reason why the current study focuses on metamemory process in Superagers is that proficient metamemory functioning could lead to more effective memory performance. As proven by the previously published literature, there is a correlation between memory and metamemory monitoring performances and consequently, this study might find the relation between Superagers outstanding memory performances and their metamemory levels (Dunlosky & Tauber, 2016). Another aim of this study was to assess the levels of change in episodic memory along with their metamemory level in Superagers. The current study predicts that the Superager group would perform better in both episodic FOK and delayed JOL judgments in comparison with elderly control group. In addition, the present study predicted that Superagers will perform similarly with the young control group possibly due to their intact cortical volume in their brain structure (Sun, 2016). It is predicted that Superagers metamemory monitoring ability process will still intact.

In addition, the present study predicted that the elderly control group would be receiving similar delayed JOL performance with the young control and Superager groups. For episodic FOK, elderly adults were expected to show deteriorated FOK judgments in comparison to both young control and Superager control groups due to fact that FOK is age sensitive while JOL is not (Souchay et al, 2012).

The main aim of the current study was to conduct research about metamemory monitoring of different age groups (as young adults, elderly adults and Superagers) and compare their performance within the groups. For monitoring there are several different types of judgment measurement but this study only includes the most studied judgments which are FOK and JOL.

This study aims to evaluate following hypotheses:

1. There will be significant differences between Superagers' basic memory performance (recall and recognition) and elderly adults'.
2. It is also predicted that two metacognitive judgments will not correlate with each other because they both measure different aspects of metamemory monitoring (Souchay et al., 2012).
3. For JOL accuracy results, we expect all of our groups overestimate the accuracy of their JOL judgments (Koriat et al., 2006) while for FOK we expect them to underestimate the accuracy of their judgments (Souchay et al., 2012).
4. There will be significant differences between Superagers metamemory performance on episodic FOK compared to elderly adults but similar FOK performance is expected for Superagers and young adults.
5. Delayed JOL accuracy is expected to stay intact for all groups while episodic FOK is expected to stay intact only for the Superager group.
6. All young adults, elderly adults and Superagers will receive higher JOL resolution scores than FOK resolution scores (Souchay et al., 2012).

CHAPTER 2

METHOD

2.1. Participants

A total of 89 participants are assessed for the study. However, due to group inclusion criteria and expected performance levels, 39 elder adults and 5 young adult candidates were not included in the study. 45 participants were recruited (25 females, 20 males) from 18-35 and 60-83 age range and we divided them into three different groups: (I) The Superager group included 15 participants (8 females, 7 males) who were 60 years old and older (mean age = 68.86 years, *SD* = 8.19) (Sun et al., 2017). (II) Young control group included 15 healthy young adults (9 females, 6 males) between 18-35 year olds (mean age = 22.53 years, *SD* = 4.18). (III) Elderly control group consisted of 15 age-matched to our Superager participants (8 females, 7 males) (mean age = 70.26 years, *SD* = 7.22). All participants lived in Istanbul. All participants reported to be in good physical health as well as not using any SSRI, SNRI, and psychoactive medication which could most likely affect their central nervous system functions, which will eventually affect their day-to-day cognitive performances (Souchay et al., 2012).

All participants reported having an active life style by continuing day-to-day duties and were free from any neurological and psychiatric diseases based on their self-report and family member reports (Rogalski et al., 2013). All elderly participants were scored at least the cut off 27 and higher (M = 29.73, SD = 0.52) on Mini Mental State Examination in order to demonstrate the absence of possible dysfunctions in basic cognitive skills (Güngen et al., 2002).

In addition, we applied the Geriatric Depression Scale (GDS) to the elderly control group and the Superager group in order to test for memory impairments that may result from depression. Both groups scored under the cut-off of 12 (M = 3.7, SD = 1.36). In this study, our inclusion criteria for elderly adults included completing at least primary school education, literacy, and absence of health problems including also ophthalmological disease which could affect their performances. Young participants spent more years studying (M = 15.86, SD = 1.80) than both the Superager (M = 10.73, SD = 4.75) and the elderly control group (M = 8.8, SD = 3.54). Even though the Superager group was somewhat higher in education years (M = 10.73, SD = 4.75) compared to the elderly control (M = 8.8, SD = 3.54), there was no statistically significant difference between the groups t (28) =1.26, $p < 0.05$.

Eligible participants received a written informed consent along with a demographic history survey form to complete their age and health information (see appendix for demographic information and inform consent forms). Due to the physical conditions of both groups, the assessments were made at participants' residence. For the young control group, the assessments were made at Bahcesehir University Brain and Cognition laboratory as well as their residence.

Our study was approved by the Ethical Committee of Psychology Department (11/2017) (Bahcesehir University, Istanbul).

2.2. Materials

The diagnostic tests included basic neuropsychological assessments: episodic memory, visuospatial abilities, attention, working memory and language which took approximately 45 minutes to complete.

Experimental testing measured 2 separate metacognitive judgments: (I) Feeling of Knowing and (II) Judgment of Learning. Experimental tests took approximately 60 minutes depending on participants' performances.

2.2.1. Diagnostic Tests

Usually, older adults expose to age-related memory impairments and we were able to discover this vulnerability during our diagnostic test procedure. According to Harrison and his colleagues (2012), they applied basic neuropsychological assessments to health elderly adults in order to find Superagers.

The diagnostic test section included a Turkish version Gungen (2002) of Mini-Mental State Examination which was published by Folstein (1975) to quantitatively assess signs of cognitive impairment and dementia.

In order to assess short term auditory verbal memory, episodic memory and delayed free recall and recognition, modified Turkish version memory assessment Öktem Sözel Bellek Süreçleri Testi (SBST) was used due to the normative data availability (Öktem, 2011).

To measure word retrieval and semantic memory, we administered Turkish standardized “Boston Adlandırma Testi” (Tumaç, 2015). The 31-item Boston Naming Test originally published by Kaplan (1983).

Trail Making Test Part A & B (TMT) published by Raitan (1958) measures visual scanning together with attention and executive functioning (specifically task switching). In the study Turkish standardized version of TMT “İz Sürme Testi A formu ve B formu” was applied (Cangoz, 2013).

We applied the Category Fluency Test published by Newcombe (1969) to assess executive function, language and semantic memory. In the study, Turkish version “Hayvan Sayma Testi” was used (Tumaç, 2015) (see table 1 for order of the test and diagnostic test list).

Table 1

List of Diagnostic Tests

Diagnostic Tests
I. Mini Mental State Examination (Mini)
II. Geriatric Depression Scale (GDS)
III. Sözel Bellek Süreçleri Testi (SBST)
IV. Boston Naming Test (BNT)
V. Category Fluency Test (CFT)
VI. Trail Making Test Part – A (TMT- A)
VII. Trail Making Test Part – B (TMT- B)

2.2.2. Experimental Tests

For metamemory assessment, a total of 80 cue-target pairs of words were used. 40 cue-target word pairs were used in the FOK task and the other 40 cue-target word pairs were used in the JOL task. The list was selected randomly from the most commonly used Turkish words dictionary (Yazılı Türkçenin Kelime Sıklığı Sözlüğü) (Göz, 2003) to assess the levels of Feeling of Knowing and Judgment of Learning. The criteria for word pairs included a minimum of 4 and a maximum of 7 letters (additionally they should not evoke any emotion). In the study, Irak's (2015) FOK research word pair list was used. The list was already applied and passed validity and reliability studies in both young and elder adults groups. In addition, there were 80 distracter words on the list for the recognition phase in both metacognitive tests. Distracter words were given with the target words which were previously seen in the tasks. Distracter words did not have any connection to the target words by semantically or phonemically (Irak et al., 2015). Distracter words were also chosen randomly from the same source (see table 2 for task stages).

Table 2

List of Experimental Tests and Their Stages

Experimental Tests	
Feeling of Knowing (FOK)	Judgment of Learning (JOL)
I. Study Phase	**I.** Study Phase
II. Recall Phase	**II.** JOL Judgment Phase
III. FOK Judgment Phase	**III.** Recall Phase
IV. Recognition Phase	**IV.** Recognition Phase

2.3. Design and Procedure

In order to prevent exhaustion due to the duration of the test, data was collected in 2 sessions for each participant: (I) Diagnostic tests and (II) Experimental tests.

2.3.1. Diagnostic Tests

Mini Mental State Examination and Geriatric Depression Scale were applied first. After those two basic assessments, Sözel Bellek Süreçleri Test was applied in order to measure their memory performances. Furthermore, the rest of the neuropsychological batteries were tested: Boston Naming test, Category Fluency test and Trail Making Part A & B. According to those test results, our participants were placed in groups by comparing their performance with their age and education matched normative values and applied experimental test phases afterwards. All of our diagnostic tests were paper-based tests.

2.3.1.1. Neuropsychological Profile Criteria for the Superager Group

All control group participants received scores within 1.5 SD of the average range for their age on each of the diagnostic tests according to published age and education matched normative values (Öktem, 2001; Cangöz, 2013; Tumaç, 2015). Superagers had to perform at or above the mean adapted value for young adults (18-35) normative values on SBST memory test (long delay free recall evaluation). Particularly, in Trail Making part B, Superagers were expected to perform no lower than 1 SD below the mean for particular age matched control group (Sun et al., 2016). However in the rest of the non-memory tests, they should be within one standard deviation according to published age and education normative data (Rogalski et al., 2013). Elderly adults who did not attain those criteria were put in the elderly control group. (See table 3 for list of neuropsychological test results).

Table 3

Demographic Information and Neuropsychological Data

	YOUNG CONTROL Mean (SD)	SUPERAGERS Mean (SD)	ELDER CONTROL Mean (SD)
AGE (years)	22.53 (4.19)	68.8 (8.19)	70.27 (7.23)
SEX (% female)	59.9%	53.4%	53.3%
EDUCATION (years)	15.86 (1.80)	10.73 (4.75)	8.8 (3.54)
SBST TOTAL LEARNING (150)	138 (3.46)	128.86 (4.62)	113.86 (7.90)
SBST RECALL (15)	14 (0.92)	12.93 (1.16)	12.6 (1.40)
SBST RECOGNITION (15)	1 (0.92)	2.06 (1.16)	2.4 (1.40)
BNT (31)	29.73 (1.43)	30.7 (0.77)	29.33 (1.34)
CFT	27 (5.52)	25.53 (6.33)	19.06 (3.03)
TMT-A (s)	20.93 (4.80)	43.6 (8.57)	53.13 (18.47)
TMT-B (s)	46.33 (14.52)	79.4 (19.55)	100.8 (31.98)
GDS (30)	-	2.73 (1.79)	4.66 (2.94)
MINI MENTAL (30)	30	29.86 (0.35)	29.33 (0.81)

2.3.2. Experimental Tests

Two separate tasks were used: delayed episodic JOL and episodic FOK. Both tasks were created through psychopy programming. Test application was completed through a 13 inch laptop. In experimental tests word pairs appeared by 2.54 cm tall letters and with a gray background. In order to prevent any list effects, the lists were counterbalanced across the JOL and FOK conditions by changing the word list (e.g., 21 participants received list A as FOK task and list B as JOL task and 24 participants received List B as FOK task and List A as JOL task). In addition, orders of the tests were also balanced among the participants (e.g., 22 participants completed FOK test first instead JOL test). Every participant received 4 cue target word pairs as practice items for each condition before the application of experimental tests.

For elderly control and Superager groups, some of the participants responded to tasks verbally during the entire study instead of pressing a key due to their lack of computer skills.

2.3.2.1. Judgment of Learning Task

The structure of the procedure was similar to Nelson & Dunlosky (1991). JOL procedure had 4 different stages which included a study phase, judgment phase, a cue-recall phase and a recognition phase. JOL condition included 40 cue-target word pairs from the list of Irak (2015), the metacognitive research.

During the study phase, participants were asked to memorize the randomized 40 word pairs (e.g., Çerçeve – Çiçek) each within 15 seconds. The first word is the cue word while the second word is the target word in every trial. Participants were told that they were going to test later on the shown word pairs.

After the study phase which took approximately 10 minutes, JOL ratings were taken for 40 trials in random order by only presenting the cue words. Participants had to rate their JOL judgments as “Yes/No” responses by pressing the left key as “Yes” and right key as “No” within 10 seconds for each pair (e.g., if Çerçeve – Çiçek) was showed earlier in the study phase, (Çerçeve - ?) was the cue for the JOL judgment). If participants believed that they learned the words as pairs and could recall the target word in the future, they responded “Yes”. If participants believed that they did not learn the words as a pair and could not recall the target word later, they responded “No”.

After participants studied and judged the word pairs on the list, they continued with the recall phase. In the recall phase, participants only received the cue words in each of the 40 trials in random order (e.g., Çerçeve - ?) then recalled the target word in the pair by typing them within 20 seconds for every pair.

For the recognition phase, participants were shown 40 target words and 40 distracter words one by one as a word pair in random order without presenting the cue words from the 40 trial word pairs. Participants were instructed to choose the target word (e.g. Çiçek – Dolap) which was on the word list earlier among distracter word by pressing key “R” to select the first word which appeared on the screen and key “O” to choose the second word which appeared on the computer screen within 10 seconds per pair.

2.3.2.2. Feeling of Knowing Task

The format of the procedure was similar to the JOL experimental task. The only difference was judgment phase order. The episodic FOK task included 4 stages including the study phase, cued recall phase, FOK judgments and recognition phase (see table 2 for task stages).

In the study phase participants were instructed to create their own method to memorize the word pair list (e.g., Yemek – Deniz). The duration of each word pair was 15 seconds.

In the recall phase, participants were presented 40 trials by only receiving the cue word (e.g., Yemek - ?) in random order and they had to recall the target word and write them down within 20 seconds per pair.

After the cued recall phase, participants completed FOK judgments for each randomized 40 cue words which appeared on the list earlier by choosing “Yes/No” responses within 10 seconds for each pair. If the participants believed that they could recognize the target word in the pair later they responded “Yes” by pressing the left key. If they believed that they could not recognize the target word in the pair later, they responded “No” by clicking the left key. For the FOK judgment phase, we included all 40 items even though the participants could not recall some of the words in the previous cued-recall phase.

For the recognition phase, participants were shown 40 novel words with 40 target words one by one as pair without the cue word and were asked to find the target word of 40 trials within 10 second per pair. In order to choose the target word they had to press the “R” key and the “O” key as the 1st word or the 2nd word which showed on the screen.

CHAPTER 3

RESULTS

For the data analysis, the main aim was to test the group differences on basic memory performances and their metamemory abilities. Therefore, two separate analyses were conducted. For both of the analyses, there were no univariate or multivariate outliers. Also, there was no violation of required assumptions.

3.1. List Effect

Experimental tests were counterbalanced by changing the orders of the test and the lists within participants in order to prevent the list effect. To examine the potential list effect, repeated measure of ANOVA was performed on 2 (word list) x 2 (conditions: FOK and JOL). The results demonstrated that there was no interaction effect between conditions and word lists F (2, 43) = 3.96, p > .05. For FOK condition: List A (*M* = 27.52, *SD* = 4.61) and List B (*M* = 28.45, *SD* = 4.06). For JOL condition: List A (*M* = 28.16, *SD* = 4.70) and List B (*M* = 27.22, *SD* = 3.86).

3.2. Memory Performances

To examine potential age differences on memory performance 3 (group: Superagers, young and elderly adults) x 2 (memory type: recall and recognition) x 2 (conditions: FOK and JOL) mixed ANOVA analysis of variance were applied on the memory test score. (Table 4 summarizes the mean and standard deviations for memory type). The variables had to be transformed by using log10 in order to meet the homogeneity assumption.

The results of analyses showed that there was a significant main effect of memory type, F (1, 42) = 845.59, $p < .01$. Recognition scores were higher (M = .91, SD = .02) compared to recall scores (M = .48, SD = .05).

Table 4

Memory Performance tests (means and standard deviations) results. For memory tests, means indicate proportion of correct responses.

Memory	Young participants	Elderly participants	Superager
Cued recall - FOK task	.61 (.14)	.33 (.09)	.52 (.14)
Cued recall - JOL task	.55 (.18)	.36 (.07)	.53 (.17)
Recognition - FOK task	.94 (.06)	.87 (.05)	.93 (.17)
Recognition - JOL task	.92 (.07)	.88 (.07)	.91 (.08)

The analysis showed that there was a significant effect of conditions F (1, 42) = .579, $p > 0.05$. FOK scores (M = .70, SD = .11) slightly higher than JOL scores (M = .69, SD = .11).

There was a significant main effect of group types on memory performance, F (2, 42) = 12.44, $p < .01$. For post doc, three separate independent sample t-test were applied to compare means in each group. The young control group (M = .75, *SD* = .08); performed higher compared to the Superager group (*M* = .72, *SD* = .09); and the elder control group performed poorer (*M* = .61, *SD* = .05). Results showed that the elder control group performed worse than the other two groups (max t = 3.87, min p = .01). There was no significant difference between the Superager and the young control groups.

There was an interaction effect between memory type and groups F (2, 42) = 13.31, $p < .01$ as reported previously in the literature (Souchay et al., 2012). (Figure 2. shows the data of both correct recall and recognition results).

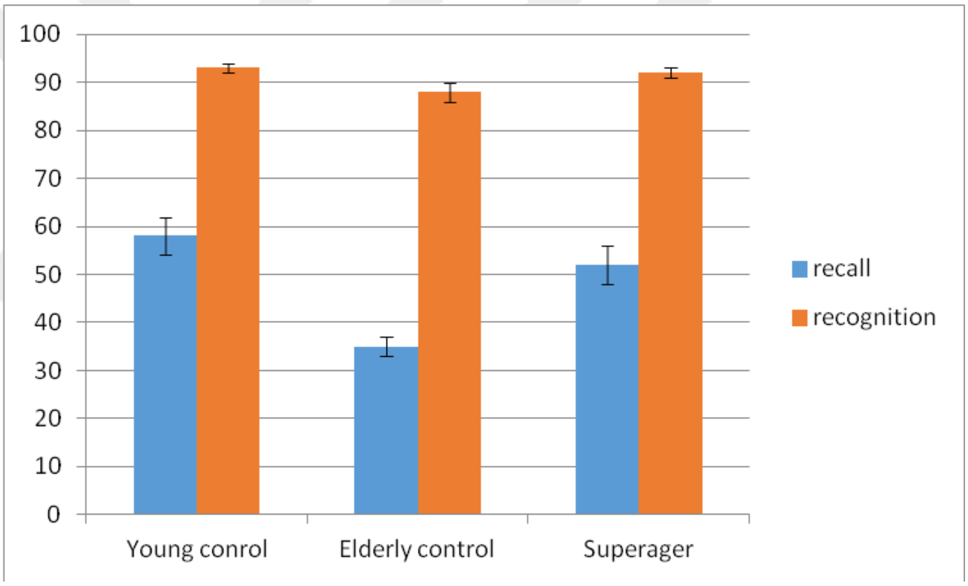

Figure 2. Proportion of Correct Recall and Recognition Performance for All Groups.

For post hoc analysis two different one way ANOVA's were applied, one to the recall data and one to the recognition data. 3 (group type: young, elderly and Superager) x (memory type: recall), one way ANOVA applied along with 3 (group type: young, elderly and Superager) x (memory type: recognition). However, the patterns of the results were the same in both analysis and thus inconclusive. To explain the differences, a new variable was created by subtracting recall scores from recognition scores. 3 (group type: young, elderly and Superager) x (recognition-recall), one way ANOVA was applied. There were statistically significant differences between the groups on their memory type performances F (2, 42) = 13.36, $p < .01$. Post hoc results revealed that (max $t = 4.87$, min $p = 0.01$), Superager ($M = 15.96$, $SD = 3.68$) and the young control group ($M = 13.90$, $SD = 4.91$) had no significant differences and both of the groups showed significantly higher performance in comparison with the elder control group ($M = 21.06$, $SD = 2.88$). The more the difference increases between recognition and recall score the more performance decreases, and according to the results, elderly control group performed poorer than both the young control and Superager groups.

There was an interaction effect between condition and groups F (2, 42) = 3.35, $p < .05$. For post hoc analysis two separate one way ANOVA were applied; one for FOK condition and for JOL condition. FOK condition result revealed that the elderly control group significantly differed from both the Superager and the young control group while the Superager and the young control group did not significantly differ from each other F (2, 42) = 18.09, $p < .01$. For the JOL condition, the elderly control group significantly differed from both the Superager and the young control group while the Superager and the young control group did not significantly differ from each other F (2, 42) = 5.34, $p < .01$. There was no significant interaction effect between memory performances and condition F (1, 42) = .113, $p > .05$. The results also demonstrated that there was no significant 3-way interaction between memory performance, judgment type and groups F (2, 42) = 1.60, $p > .05$.

3.3. FOK and JOL Calibrations

Calculating the calibration score (absolute accuracy) provides more information about participants' bias scores notwithstanding whether subjects overestimated or underestimated their performance. Absolute accuracy is the measurement which calculates the magnitude of the subject's judgments and matches the subject's magnitude of their performances (Dunlosky & Tauber, 2016). However; for the calculation of FOK calibration, the current study included both FOK unrecalled item calibration and FOK all item calibration in order to compare the calibration results of the current study with published literature.

For FOK calibration regular method results were not in accord with the literature therefore, the application of FOK all item calibration was also calculated.The FOK (all item and unrecalled items) and JOL judgments data summarized in Table 5.

Table 5

Mean Proportion of Yes and No Predictions for both FOK and JOL judgments

	Young Control		Elderly Control		Superagers	
	Yes %	No %	Yes %	No %	Yes %	No %
FOK (all)	.86	.14	.81	.19	.92	.08
FOK(unrecalled)	.26	.74	.48	.52	.42	.58
JOL	.55	.45	.40	.60	.54	.46

The first analysis included FOK and JOL predictions in each groups. The calibration for both FOK and JOL judgments summarized in Table 6. For FOK judgment, the current study included both all items and unrecalled items calculations.

Table 6

FOK and JOL judgments Means and Calibrations

	Young control	Elderly control	Superager
JOL Calibration	16 % overestimated	32 % overestimated	26 % overestimated
FOK Calibration (unrecalled)	58 % underestimated	56 % underestimated	39 % underestimated
FOK Calibration (all)	8 % underestimation	6 % underestimation	1 % underestimation

The JOL condition, the mean proportion of "Yes" predictions in JOL tasks was .71 (.17) for young control group, for Superager group .80 (.13) and .71 (.12) for the elderly control group. For JOL analysis, one way ANOVA was conducted to JOL judgments (% yes responses). Results showed that there was no significant difference between all 3 groups on JOL judgments $F(2, 42) = 1.81$, $p > 0.05$.

For JOL calibration calculation, the proportion of correct recall was subtracted from (% yes) JOL judgments (see Table 6 for correct proportion of the metamemory judgment responses). The young control group overestimated their performance 16%, the Superager group overestimated their performance by 26% and elder control group overestimated their performance by 32%. For the JOL calibration score, one way ANOVA was conducted and results showed that there was significant difference between groups on JOL calibration $F(2, 42) = 3.39$, $p < .05$ and Post hoc results revealed that there was a difference between the young control group (M = .16, SD = .20) and the elder control group (M = .31, SD = .15). Young people tend to overestimate their JOLs less in comparison to the elderly control group. Nonetheless, there was no significant difference between the Superager group (M = .26, SD = .14) and the young control group.

For the FOK condition, we included both different FOK conditions as unrecalled item analysis was conducted for only on the judgments made on unrecalled items and all items whether they failed to recall them or not. By analyzing both all items FOK and unrecalled item FOK calibration, we might provide more information about the differences between the use of unrecalled item for the calculation of FOK which provides more cue by giving feedback whether they recalled the target item or not. However, by applying all items FOK we do not provide extra cue.

For FOK unrecalled condition, the mean proportion of “Yes” predictions was .27 (.11) for the young control group, .42 (.11) for the Superager group and .48 (.14) for the elder control group. For FOK analysis, one way ANOVA was applied to FOK judgments and results showed that there were significant differences between groups F (2, 42) = 12.91, $p < .01$. Post hoc analysis revealed that the scores of young control group (M = .27, SD = .11) were significantly lower compared with both Superager (M = .42, SD = .11) and elder control groups (M = .48, SD = .14).

For the FOK unrecalled calibration calculation, unrecalled items for FOK judgments were subtracted from proportion FOK recognition yes responses. The young control group underestimated their metacognitive ability by 58% compared to Superager group which underestimated their metacognitive ability by 39% and the elder control group by 56%. For FOK calibrations, one way ANOVA was conducted but there was homogeneity violation therefore Welch test was applied. The results demonstrated that there were significant differences between groups F (2, 42) = 5.31, $p < .05$. Post hoc results revealed there was a significant difference between the Superager (M = .38, SD = .26) and both the elder control (M = .56, SD = .09) and the young control groups (*M* = .58, *SD* = .13); however, there was no statistically significant difference between the elderly and young control groups. The Superager group was the most accurate predictor group in comparison with both the elderly and young control groups.

For FOK all item condition, the mean proportion of "Yes" predictions was .86 (.10) for young control group, .92 (.08) for the Superager group and .81 (.12) for the elder control group. For FOK analysis, one way ANOVA was applied to FOK judgments and results showed that there were significant differences between groups F (2, 42) = 4.87, p < .05. Post hoc analysis revealed that for young control group (*M* = .86, *SD* = .10) there were no differences with both the Superager (*M* = .92, *SD* = .08) and the elder control groups (*M* = .81, *SD* = .12). However, the results indicated that there was a significant difference between the Superager and the elderly control groups.

For FOK all item calibration calculation, the proportion of correct recognition was subtracted from (% yes) FOK judgments. The young control group underestimated their performance by 8%, the Superager group underestimated their performance by 1% and the elder control group underestimated their performance by 6%. For FOK all item calibration, one way ANOVA was conducted but results showed that there was a homogeneity violation. Therefore, Welch test was applied instead of one way ANOVA. The results showed that there was no significant difference amongst all the groups on FOK calibration F (2, 42) = 3.39, p > .05. Most accurate results were provided once again by Superager groups. They predicted that they will recognize 92% but in reality they recognized 93%.

3.4. JOL & FOK Resolutions

To explore the age-related differences between Superagers, young and elderly adults, the current study measured the metamemory calibrations and resolution of all groups.

FOK and JOL relative accuracy was measured with the same procedure for both types of judgments (see Table 7 for means and standard deviations for metamemory judgments). Relative accuracy is the degree to which a subject can accurately distinguish between remembered and not remembered items.

Goodman and Kruskal's gamma is a continue variable which provides measure for a degree of association between FOK judgments and recognition performances by comparing the differences between the joint probability of concordant and discordant responses (Schraw, 1995). The gamma correlation ranges from -1 to + 1. As the correlation number gets close to large positive value it indicates a high level of judgment accuracy. If correlation number is a zero, it means that chance level judgment accuracy appeared. If the number is a negative value, it corresponds to poor judgment accuracy. If the calculation of gamma includes (A: correct recognition of "Yes" prediction; B: incorrect recognition of "Yes" prediction; C: correct recognition of "No" prediction; D: incorrect recognition of "No" prediction) more than two of the four possible outcomes as "0", predictions should be computed. According to Snodgrass and Corwin's (1988) article, we revised the raw data by adding 0.5 to each prediction's frequency and divide those with judgment numbers + 1 (See appendix J for Gamma correlation formulation).

Hamann coefficient is a continue variable which measures the accuracy by evaluating the differences between proportion of correct and incorrect responses by including four mutual exclusive conditional probabilities (Schraw, 1995). The Hamann coefficient extends from -1 to + 1. The correlation shows the differences between proportion of correct and incorrect predictions. A large positive coefficient number means a higher degree of judgment accuracy, zero value means chance level judgment accuracy and negative value means less than chance level judgment accuracy. (See appendix K for Hamann correlation formulation).

FOK and JOL conditions, for three groups' correlation coefficients were all reliably above the chance level. One sample t-test indicated that Gamma results were reliably non-zero ($p < .001$). Accuracy calculation was computed by both Gamma and Hamann correlations between each participant's FOK and recognition and each participants' JOL and recall performances (Nelson, 1984). Most of the metacognitive studies calculated FOK and JOL accuracy by using Gamma correlation (Hertzog et al., 2010; Nelson et al., 1984; Souchay et al., 2002; Souchay et al., 2007; Zhou et al., 2017). However, in the current study judgment phase in metamemory tasks included force choice response as "Yes" or "No", therefore, including Hamann correlation calculation also provided more information about dichotomous selection results. Schraw (1995) emphasized the importance of using both Gamma correlation and Hamann coefficient because they both provide different types of information about FOK and JOL judgments. For FOK accuracy, the calculation of both Gamma correlation and Hamann only included unrecalled items on recall phase (omission errors), whereas for JOL accuracy, the computation included all items whether they are recalled or unrecalled.

Table 7

Metamemory judgments resolution results by numbers indicate mean correlation coefficients and standard deviation.

Metamemory judgments	Young Control	Elderly Control	Superagers
FOK Gamma Scores	.18(.34)	.28 (.29)	.60 (.34)
FOK Hamann Scores	.29 (.34)	.36 (.20)	.36 (.20)
JOL Gamma Scores	.81(.15)	.63 (.32)	.69 (.26)
JOL Hamann Scores	.45 (.26)	.16 (.29)	.35 (.29)

For FOK and JOL conditions, all three groups' correlation coefficients were all reliably above the chance level (max t = 9.40, min p = 0.00). Accuracy calculation was measured by using Gamma and Hamann correlations between each participant's FOKs and recognition and each participant's JOL and recall performances (Nelson et al., 1984).

In order to examine group differences on FOK and JOL resolutions, a 3 (group type: young, elderly and Superager) x 2 (judgment type: JOL and FOK) mixed ANOVA was applied on Gamma scores. The results demonstrated that there was main effect of judgment type F (2, 42) = 33.78, p < .01; JOLs (M = .71, SD = .26) and FOKs (M = .36, SD = .36) and JOLs were more accurate in comparison to FOKs.

There was a significant main effect of group F (2, 42) = 7.63, p < .05. For post hoc, 3 separate independent sample t-test were applied to compare means in each group. The results showed that the young control group (M = .55, SD = .30) did not differ from Superager groups (M = .52, SD = .23) but the elderly control group

(*M* = .26, *SD* = .23) was significantly different from both the young control group and the Superager group, (max t = 3.44, min p = 0.00).

There was an interaction effect between groups and judgment type F (2, 42) = 6.46, $p < .05$ showing that the difference between FOK and JOL accuracy was more frequently observed in the group of young control group. For Post hoc analysis, two separate one way ANOVAs were applied to each metamemory measures. FOK judgment type Gamma results indicated that there was no statistical difference between the young control group (*M* = .29, *SD* = .34) and the elderly control group (*M* = .36, *SD* = .21), F (2, 42) = 6.88, $p < .05$. However, the Superager group (*M* = .68, *SD* = .25) was different from both the elderly and the young control groups and received a higher score in comparison with both control groups. One way ANOVA was applied for JOL judgment type Gamma correlation and revealed that there were no significant differences F (2, 42) = 1.81, $p > .05$ between groups.

For Hamann correlation, in order to examine group differences on FOK (unrecalled) and JOL resolutions, a 3 (group type: young, elderly and Superager) x 2 (judgment type: JOL and FOK) mixed ANOVA was applied on Hamann scores. The results demonstrated that there was one tailed level significant effect of judgment type F (2, 42) = 3.82, $p > .05$; JOLs (*M* = .32, *SD* = .25) and FOKs (*M* = .44, *SD* = .36) and FOKs were more accurate in comparison to JOLs.

There was a significant main effect of group F (2, 42) = 7.63, $p < .05$. For post hoc, 3 separate independent sample t-tests were applied to compare means in each group. The results revealed that the young control group (*M* = .55, *SD* = .30) did not differ from the other two Superager groups (*M* = .52, *SD* = .23) and the elderly control group (M = .26, SD = .23), (max t = 3.48, min p = 0.02). However, the elderly group was also statistically different from the Superager group.

There was an interaction effect between groups and judgment type F (2, 42) = 5.82, p < .05 showing that the difference between FOK and JOL accuracy was more frequently observed in the young control group. For Post hoc analysis, two separate one way ANOVAs were applied for each metamemory measures. FOK judgment type Hamann results indicated that there was no statistical difference between the young control group (M = .29, SD = .34) and the elderly control group (M = .36, SD = .21), F (2, 42) = 9.28, p < .05. However, the Superager group (M = .68, SD = .25) was different from both the elderly control and young control groups and received a higher score in comparison to both control groups. One way ANOVA applied for JOL judgment type Hamann correlation F (2, 42) = 4.12, p < .05. The result showed that there was a significant difference between young control (M = .45, SD = .26) and elderly control groups (M = .16, SD = .29). Superager group (M = .35, SD = .29) was not different from both of the control groups. Young group accuracy scores were higher than those of the elderly control group. Interestingly, there was no statistically significant difference between the Superager group and the elderly control group. They both performed quite similarly.

3.5. Correlations between FOKs and JOLs

The relationship between the two metamemory judgments which were FOK and JOL was checked with partial correlation controlling for groups. The results showed that no significant correlation was found between the two judgments (r = - .251, p = 0.97) and (r = - .244, p = .106).

To summarize, the Superagers showed similar episodic memory performance with the young control group while the elderly control group performed lesser compared to both the Superager and young control groups. For metamemory Gamma accuracy, the Superager showed superior FOK performance compared to both the elderly and young control groups while performed similar results on JOL task with both young and elderly control groups. For metamemory Hamann accuracy results were different than Gamma accuracy results. For Hamann coefficient correlation, the young control group performed higher than both the elderly control and Superager groups. Again, the Superager showed superior FOK performance compared to both theyoung and elderly control groups.

CHAPTER 4

DISCUSSION

In the present study, Superagers' metacognitive processes were examined by comparing their performance with the same age peer group and young adults. To assess their metacognitive performances, JOL and FOK judgments were used to provide information about the participants' metamemory abilities. Usually, metamemory literature includes only the comparison of young adults and elderly adults when it comes to the ageing process. However, for the first time with the existing study, the assessment of the unusual healthy ageing process (Superagers) via metamemory judgments was conducted to supply more information about this unusual ageing route. The current study shed lights on two main findings: (I) low levels of memory performances were observed for the healthy elderly adults while for the Superagers, intact memory ability performances were monitored and (II) for the Superagers, higher metacognitive abilities were observed in the accuracy of episodic FOK in comparison to the elderly control group and for the delayed-JOLs Superagers were shown to be intact JOL ability. The results of the present study were discussed in light of the findings from the literature on both metamemory and the ageing process.

4.1. Summary of the Current Results

The next parts of the discussion sections include the previously mentioned hypotheses and their theoretical backgrounds. Age-related episodic and metamemory differences between Superagers, elderly, and young adults were tested by using metamemory judgments and episodic memory tasks. We explain the previously proven relation between memory and metamemory performance.

4.1.1. Summary of Memory Performance Results

The analyses of the results indicate that there were main effects of both memory type and group (3 levels: young, elderly control and Superagers). Recognition performances were higher than recall performance. Elderly control group performed poorer than both the Superager and young control groups on both memory type tests. For conditions and group interaction effect, significant differences were found between all groups and FOK, JOL conditions. Elderly control group received poorer scores in both FOK and JOL conditions.

4.1.2. Summary of Absolute and Relative Accuracy Results

For absolute accuracy assessment, calibration scores showed that the Superager group, elderly control and young control groups overestimated their performance on the JOL task while they underestimated their performance on the FOK task.

For relative accuracy assessment, Gamma correlation results demonstrated that there were significant main effects for the judgment types and the groups (3 levels: young, elderly control and Superager group). JOL judgments were more accurate compared to FOK judgments. The interaction effect of the judgment type and groups were significant. In addition, FOK results showed that FOKs was not age sensitive due to the fact that elderly control and young control groups did not show any significant differences and also Superagers performed better compared to both the elderly control and young control groups. For the JOL task, all group performances indicated intact JOLs ability by showing non-significant differences between the results of all groups.

Also, the present study suggests contradictory results for the young control and elderly control groups, because they do not show any significant differences on the FOK task.

4.2. Memory Performance and Cognitive Reformation: Theoretical Implications

As previously mentioned in the current study, there a lot of changes take place in the cognitive functions as people get older, for example; complex attention, executive function, episodic memory and so on (Murman, 2015). Age-related cognitive decrements have correlations with specific brain regions such as; frontal lobe (involved in working memory, executive functioning), temporal lobe (including medial temporal lobe: hippocampus) (Harrison et al., 2012). In our study, the first hypothesis is supported by the basic memory results which indicate that elderly adults showed poorer episodic memory performance compared to both the Superager and young control groups. Again, as expected from the Superager group, they received similar scores with the young control group and this might be due to their intact episodic memory abilities (Rogalski et al., 2013).

According to Sun (2016), Superagers' density of frontal lobe and temporal lobe is especifically (medial prefrontal cortex, medial temporal lobe: hippocampus and dorsalateral prefrontal cortex) correlated with their memory abilities. The intact size of those specific lobes might have an impact on the Superagers' superior episodic (recall and recognition) memory performances.

As expected, all participants' recognition scores were much higher in comparison to their recall performances because, receiving higher recognition performance than recall performance is a common result in most published studies (Alam et al., 2014; Botwinick, 1978; Burke &Light, 1981; Fisher & Craik, 1977; Souchay, et al. 2007). As mentioned earlier, recall performance is the most vulnerable feature compared to recognition and cued-recall ability (Cangöz, 2009). According to Sun (2016), the difference between the Superager and elderly control groups on recognition might demonstrate that the Superagers' mnemonic storage methods are more adequate than healthy elderly adults. This might be one of the reasons why the Superager group performed better at both recall and recognition tasks compared to same age peer group and also received similar scores with the young control group in the current study. To summarize, age decrement can be seen in both recognition and recall tasks however, age-related decrement is smaller in recognition tasks than in the recall task (Craik & McDown, 1987).

Elderly adults, whose education levels are lower compared to both the young control and Superagers groups, usually tend to be skeptical while responding to a task or test (Cangöz, 2009). That's why for the elderly adults, we usually expect them to receive scores within given normative values. In the current study, Superagers' education level was barely higher than the elderly adults however no statistical difference was found between the Superager and elderly control groups.

4.3. Metacognitive Judgments and Theoretical Implications

The ageing process corrupts the metacognition abilities because monitoring ability requires some cognitive sources which have already been proven to deteriorate with age (Perlmutter, 1978).

For the metamemory judgments both monitoring and controlling abilities are essential. In order to regulate one's own memory functions, subjects need to monitor their memory which will eventually lead to more appropriate controlling of their behavior on a daily basis. Understanding the metacognitive processes in ageing might lead elderly adults to compensate for their age-related cognitive performance decrement (Hertzog & Dunlosky, 2011). The link between memory performance and procedural metamemory (monitoring and controlling) is not very strong. In fact, Schneider and colleagues' (2013) study reveals a reliable but an overall moderate correlation. But still, that link provides information about one's own memory and abilities that comes along with that memory. Even though metamemory accuracy results are not 100% accurate, subjects still get benefits by assessing their learning (monitoring) and making self-regulation of learning which depends on the information acquired from monitoring (control) (Dunlosky & Tauber, 2016).

According to Souchay and Isingrini (2012), the common ground of both the FOK and JOL judgments is that they both assess the ability of a subject's retrieval prediction after a delay which means that both of the judgments are prospective judgments. The main differences between FOK and delayed JOL judgments: (I) JOL occurs during the encoding phase which helps to envision future recall performance while (II) FOK occurs during the retrieval phase and helps to predict the subject's future recognition of the currently unrecalled item. This might indicates that both metamemory judgments measure different aspects of the monitoring ability.

The relation between JOL and FOK judgments were controlled by partial correlation in order to provide more information whether both judgments were relied on the same source or different processes. The second hypothesis of the existing study is supported with the current study correlation results which showed that there was no significant correlation between both judgment types (Souchay et al., 2004). Both FOK and JOL do not rely on same source; and both of the judgments might be functionally different. According to Modirrousta (2008), FOK and JOL judgments' neural basis might not be the same. For the FOK judgments usually medial prefrontal cortex plays a major role but for the JOL judgment, this region does not play crucial role. Sensitivity of accuracy was only observed in FOK judgments, but not in JOL judgments. This result might demonstrate that among the metacognitive processes only retrieval is affected by ageing, unlike encoding (Hertzog & Dunlosky, 2011).

As previously mentioned in the present study executive function decreases with ageing. This might be one of the reasons why the elderly control group received a lower score in comparison to the Superager group in the present study. Memory retrieval depends on the provided cue during the given time and this cue might be an environmental or self-generated cue (Smith et al., 2013). For the elderly adults usually retrieval failure appears due to inability to separate (inhibit) the insignificant information from the significant information. Among retrieved contextual information, older adults might not select the useful coded information to find the target item (which supports the memory constrain hypothesis by Hertzog) (2010).

The present study expected all of our groups to perform overestimated calibration score in their JOL judgments according to Koriat and his colleagues (2006). For our participants' episodic FOK judgment calibrations, the expectation was for them to make underestimated responses (Souchay et al., 2012). The third hypothesis of the current study supports both judgments calibration results by showing overestimation during JOL judgments in all groups (young control, elderly control and Superagers) while showing underestimation for FOK judgments in all of the groups. The bias differences occurs in all groups due to the differences in criterion performance (finding the target item), rather than the differences in monitoring ability, because bias score includes both judgment (monitoring) and criterion performance (recognize or recall and task ability) (Dunlosky & Tauber, 2016).

4.3.1. Feeling of Knowing

Age-related episodic memory dysfunction is associated with metamemory deficits (Souchay et al., 2007). Decrement in monitoring metamemory ability might cause elderly adults not to compensate with memory difficulties and also create hard times for them to plan cognitive resources conveniently. However, this was not the case with the Superagers metamemory performances in the present study.

The existing study results indicate that the difference between FOK and JOL accuracy was observed more frequently in the young control group. The post hoc result indicated that for the FOK judgments, Superagers have the most accurate FOK judgments in comparison to both the young and elderly control groups while both control groups did not significantly differ from each other.

As previously mentioned in the introduction section, this age-deficit of episodic FOK judgment resolution might be caused by age-related changes in the episodic memory performance. Numbers of the studies showed that the resolution of episodic FOK is impaired as people age (Dunlosky & Tauber, 2016; Son & Schwartz, 2002; Souchay et al., 2000; Souchay et al., 2007; Souchay et al., 2012). According to Souchay (2012), this difference of episodic FOK might be explained by the memory constrain hypothesis which indicates that insufficient encoding stage might lead to a weak partial and contextual information, which will eventually affect the episodic FOK resolution during the retrieval stage. The fourth hypothesis of the current study was partially supported by the Superager group, because they received the highest FOK accuracy and they did have significant differences with the both elderly and young control groups. This indicates that Superagers' metamemory abilities are still intact and even better in comparison to the young adults. In addition, when you compare the present study FOK accuracy results of the elderly control group with the Superager group, the results indicate that the Superagers showed superior performance on both episodic memory and metamemory while the elderly control group performed poorer compared to the Superagers in both tests. However, the current study results did not show any FOK deficits in the elderly adults but the results might still indicate that the elderly adults' estimation of their ability to recognize recently studied items are less accurate in comparison to the Superager group.

Age related FOK deficits might be caused by lower level of deep encoding process which creates retrieving difficulty for the target-related contextual information for participants. This process also mediates participants to make an accurate prediction in the recognition phase (Sacher et al., 2013). Participants use retrieved partial information about the unrecalled item during the FOK judgment to determine their FOK (Koriat, 1993). In the recent study, Superagers did not illustrate any deterioration in the quality of encoding by receiving higher recognition performance and more accurate FOK resolution compared to the elderly control group. In addition, elderly control group did not demonstrate any age-related FOK deficits by receiving similar accuracy results with the young control group.

As previously mentioned in the introduction section, FOK judgments usually depend on a heuristic-based account which is based on either cue familiarity or target access ability. Having better contextual information leads to more accurate judgments during the prediction of recognition (Schwartz et al., 2014). Recollection is expected to decrease due to hippocampal damage brought about by the ageing process (Yonelinas, 2002). This might support the explanation of Superagers' superior performance in episodic FOK. As previously mentioned in the present study, the volume of hippocampus starts to decline as people age, and the loss of hippocampus volume might have a connection with the lack of recollection. However for the Superager group, the loss of hippocampal volume does not appear therefore, having accurate metacognitive judgment ability is what we already expected from them. In order to support this theory, the present study results indicate that the Superagers' FOK accuracy was especially higher compared to the elderly control group.

Also, familiarity decreases as temporal lobe gets corrupted (Yonelinas, 2002). This might be one of the reasons why elderly adults had a hard time making accurate metacognitive judgments in comparison to the Superagers' due temporal lobe deterioration caused by ageing. However, one of the main differences between recollection and familiarity is that they both start to decrease due to age-related changes but familiarity gets affected more in comparison to recollection (Yonelinas, 2002).

Neuroimaging studies indicate that prefrontal lobe and medial temporal lobe correlates with the metamemory process during the remembering process (Chua et al., 2009; Schnyer et al., 2004; Schnyer et al., 2005). These regions usually get activated in all self-referential processes or subjective experiences (Schnyer et al., 2005). However especially frontal lobe structures change due to age-related volume decrement (Harrison et al., 2012). Damage to those specific networks of brain regions eventually lead elderly adults to a false memory performance (e.g., remembering stimulus that is actually a novel stimuli). Specifically, left hippocampal activation of medial temporal lobe increases during the encoding of words (Smith et al., 2013). The present study results support that even though Superagers age, their hippocampal volumes do not decrease (Sun et al., 2016) and this mediates the accuracy of their metamemory judgments. Also frontal lobe plays a major role for the FOK judgments (Sun et al. 2016). As previously mentioned, Superagers do not show any sign of frontal lobe decrement as they age. In addition, the results of the recent study might support that by showing Superagers' FOK accuracy results. They received a higher accuracy score in comparison to the both elderly adults and young adults. Future research on this subject should include brain imaging techniques to provide more information about those brain regions and their correlation with Superagers' superior metamemory performance in the future.

According to Sacher and her colleagues (2015), age-related differences in subjects' episodic memory might be derived from differences between the subject metamemory performances. Superagers still have intact episodic memory performance despite their biological age. This might be one of the reasons why their FOK judgments were more accurate in comparison to the elderly and young control groups in the existing study.

According to Park (2016), due to diminished executive function and attention, older adults tend to struggle with inhibition and therefore, they can easily get distracted and lose their focus on the contextual information which is essential for finding the target information. This dysfunction can interfere with the distinction between relevant and irrelevant contextual information and this situation eventually leads elderly adults to perform poorly on both recall and recognition phases. According to Zhou (2017), deprived inhibition can interrupt the working memory performance which might limit their capacity to encode new relevant information. In the end, this process interferes with the retrieval phase. According to Schwartz (2014), FOK judgments were positively correlated with the retrieval process of the contextual information. The current study previously mentioned that the Superagers did have intact cognitive abilities (e.g., executive function). This might be one of the reasons why Superagers did show superior FOK accuracy. Moreover, having four times more spindle neurons in the Superagers brains might also help them make accurate metacognitive judgments. Previous studies mention that spindle neurons play a role in executive functioning and self-awareness (Gefen et al., 2015). This might be one of the reasons why Superagers achieved more accurate scores in comparison to the elderly control group. As a result, Superagers were more aware of how to use different strategies to receive higher scores. Again, further examination should apply for brain imaging techniques to support the results of the present study.

Relative accuracy results of the current study demonstrate that there was no significant difference between the elderly and young control groups on the FOK task which is an unusual outcome compared to the previous published studies (Souchay et al. 2007; Souchay et al., 2012). However, there is a published study which supports the results of the present study by showing the absence of any significant FOK task results between the older adults and young adults (Alam et al., 2014).

As mentioned earlier in the introduction of the current study, several studies observe resolution of episodic FOK impairment due to the ageing process. That's why in the literature, usually FOK accuracy is higher for young adults in comparison to elderly adults. However in the present study, the young control group did not have any significant differences with the elderly control group in the FOK accuracy task. According to Till (1980), age-related difference in memory can be cancelled out when older adults encode deeper level of processing which will ultimately change the trend of their retrieval stage. The inconsistent result of the current study might be explained with reference to deeper levels of encoding in elderly adults.

One of the possible mediators for the results is that our elderly control group did not know that they received the average neuropsychological assessment results in the diagnostic test section. Instead, they only knew that the current study concentrated on Superagers and was focused on their memory and metamemory performances. This might have decreased the possibility of poor expectation on the part of elderly adults at the beginning of the test application. Poor expectation may lead participants to experience negative affect and anxiety while completing the judgment tasks (Son et al., 2002). The older adults who believe that age decrement is inevitable and their memory ability decrease as they aged, had worse results compared to the results which were obtained from elderly adults who believe that their memory is still intact even though they aged (Hertzog et al., 2002). On the contrary, elderly adults who believe in inevitable decrement are usually aware of their memory abilities whether it’s good or bad and by being aware of their memory ability, they can create new effective strategies to learn and remember new items (Devolder and Pressley, 1992; Lachman, Steinberg, and Trotter, 1987).

Souchay and her colleagues (2007) use Yes/No in the target recognition task. However in the present study, recognition phase included forced choice item recognition task. One main disadvantage of using Yes/No target in the recognition task is that, it creates more sensitivity for the misleading familiarity effect. It can also lead participants to create different strategies at retrieval which might create age differences in the FOK accuracy and memory performances (Alam et al., 2014). In addition, one of the unpublished studies of Hertzog and Stephanie claimed that by using forced choice item in the recognition task, they did not find any age differences in the accuracy of episodic FOK (Maclaverty & Hertzog, 2009). This might be one of the reasons why the present study did not show any significant difference in FOK accuracy scores between the young and elderly control groups.

Age-related deficiency in memory might bring encoding problems along with bias at the encoding stage (e.g., if elderly participants believed that age-related memory decline is inevitable, they would not have succeeded in these tests). On the other hand, bias at the retrieval stage can deceive subjects when people reconstruct the past experience (Smith et al., 2013). However, by using effective strategies for deeper level processing while acquiring new information might help subjects to improve their encoding ability and thus helping them in retrieval stage in the future (Dunlosky & Tauber, 2016). The cued recall phase of the FOK task usually provides information about the FOK reliance on the recollection process. For elderly adults receiving higher recognition performance assures the acceleration in the quality of encoding stage (Souchay et a., 2007). In the present study, the elderly control group received higher recognition and recall scores in the FOK task compared to previous studies in the literature. This might show that our elderly control group participants' quality of encoding were higher than expected (Souchay et al., 2012).

The correlation between memory performance and metamemory judgments makes it hard to evaluate the actual age differences when it comes to the resolution. Hertzog and Dunlosky (2011) suggested that, older and younger adults should be chosen equally according to their performance of memory in monitoring retrieval phase to discriminate certain judgment performance. In the current study, the Superager and young control groups performed similarly in episodic memory tasks, which supports the theory that, if both groups are equated based on their episodic memory performance results, there would not be significant differences between groups on the episodic FOKs. Yet, the present study still showed that there was a significant difference between the FOK resolutions of young adults and Superagers.

According to Park (2016), there are also non-cognitive theories which might provide more information to explain the age-related memory impairment. For example; lower motivation, greater test anxiety, different performance goals, lower formal education and reduced memory self-efficacy. This might explain why the elderly control group's memory performances the current study were somewhat higher than those in previous studies in the literature (Souchay et al., 2007; Souchay et al., 2012).

Some researchers have found that unrecalled FOK judgments might be inadequate specifically when it comes to examining the underline FOK mechanism (Schwartz et al., 2016). In order to solve this problem, they included all items in FOK judgments whether it was recalled or unrecalled (Souchay et al., 2007; Souchay et al., 2012; Koriat, 1993. Using all item FOK judgments might lead participants to higher FOK resolution compared to unrecalled item FOKs. By applying all item FOK judgment, participants use another source to make accurate retrieval by including recall-based strategy (Schwartz et al., 2016). Successful recall phase might be a better predictor of future recognition performance than the cue familiarity. In addition, retrieval of partial information also influences the FOK judgments (Schwartz et al., 2014). The current study includes only all item FOK judgments whether participant recalled the target or not in the earlier recall phase. By applying all item FOK judgment, prevention of bigger potential source of information was acquired which may be the unrecalled FOK judgment feedback whether or not participant just recalled the target (Schwartz et al., 2016).

To summarize; according to previously mentioned literature, episodic FOK judgment is age sensitive and as people age, it deteriorates. Superagers are a special group of elderly adults who do not show any decrement in their episodic FOK judgments as hypothesized in the current study. Also, both the elderly and young control groups performed poorer than Superagers. However, in the current study no significant difference was found between the elderly and young control groups which conflicts with the published literature. This might indicate that, the encoding ability of our elderly adults were not as poor as expected by looking through the unusual recall and recognition performance of our elderly adults. These higher memory performances might mediate their episodic FOK performance which is different from published literature.

4.3.2. Judgment of Learning

The interference of recollection process in ageing provides more information why elderly adults demonstrate greater impairments for the FOK (monitoring of retrieval) rather than for JOL (monitoring of learning). Since, JOL judgments would be essentially based on automatic process, the disruption of recollection would not impact the JOL accuracy in the same way it affects the episodic FOK accuracy (Zhou et al., 2017).

The fifth and sixth hypotheses of the present study are supported by the resolution results which revealed that, the JOL resolution scores were higher than the FOK resolution scores and the JOL judgments were not significantly differ in all young control, elderly control and Superager groups. These results support the current study hypothesis about the JOL judgment, which is not age sensitive unlike published episodic FOK studies as formerly mentioned (Connor, Dunlosky & Hertzog, 1997). Also, there is a recall effect while completing the JOL task. In the JOLs, metacognitive resolution improves when a subject has a chance to attempt retrieval before the JOL responses which boost the resolution results of the JOL (Schwartz et al., 2016). This might be the reason why the JOL resolution scores are higher than the FOK resolutions.

Delayed-JOL judgments are largely based on the retrieval fluency from long-term memory, while immediate-JOL judgments are largely based on working memory and both of them considered as encoding fluency judgments due to the relatedness to how well target items have been learned during the encoding phase (Hertzog & Dunlosky, 2011). Delayed-JOL judgments resolution should be higher for both young and elderly adults and should indicate no age differences between both groups due to fact that JOL resolution is age insensitive (Connor, Dunlosky & Hertzog, 1997; Hertzog & Dunlosky, 2011; Souchay et al., 2012). In the current study, there was no significant resolution difference between all of the mentioned groups. This corresponding JOL resolution result might indicate that the accuracy of monitoring encoding stays intact across the adult life time.

In the current study, JOL gamma accuracy scores are higher than what was published in the literature (Souchay et al., 2012; Rhodes & Tauber, 2011). JOL judgments assess the encoding fluency. This might provide information about elderly adults not so deteriorated encoding ability. This might be one of the reasons why our elderly control group received higher accuracy score in the FOK tasks than the young control group. The Superagers already showed intact metamemory ability in both FOK and JOL judgments.

For JOL judgments, related pairs of items increase the magnitude of JOL. However, Caroll, Nelson and Kirwan (1997), had subjects whose over learned the given unrelated pairs of items and compared their performance with related pairs of items within 3 weeks. The results showed that unrelated paired items were recalled more frequently in comparison to the related pairs of items. In the current study, the pairs of items were not related in order to ensure reliability and validity violation.

While creating the experimental tasks list of words, the lists were chosen cautiously in order to prevent any manipulation. For example, for JOL judgments, subjects can provide higher JOLs for concrete items (e.g., car) in comparison to abstract items (e.g., truth) which are more constant for memory performance (Hertzog, Dunlosky, Robinson & Kidder, 2003).

Successful retrieval phase can boost subjects' memory therefore; applying more successful JOL judgment assessment will enhance delayed-JOL judgments and the memory performance as a result this leads to higher JOL accuracy (Dunlosky & Tauber, 2016). The results of the current study might also indicate that ageing leaves monitoring of encoding phase intact while it hardly dustups the monitoring of retrieval because significant differences between groups and judgment type was only found with the episodic FOK rather than the delayed JOL.

Also, number of items to be learned in the JOL task is sensitive for the JOL judgment magnitude (Dunlosky & Tauber, 2016). In this study, working with elderly adults already created sensitivity in the tasks, being cautious for the number of items in study phase was important.

The current study results support that all of the mentioned hypotheses except for the significant episodic FOK differences between the young and elderly adults. The analyses showed that the episodic FOK is not age sensitive for elderly adults. In the FOK task, the superager group received higher scores than even the young adults in the present study. Delayed-JOL results were still intact in all of the groups. Superagers, young adults and oddly elderly adults did not show any impairment for either episodic FOK or delayed JOL.

For the Hamann correlation accuracy results, Hertzog and Dunlosky (2011) mentioned that JOL judgment and ageing studies usually includes extreme-age-group designs which usually compares elderly adults with young adults (university students). This method may create limitation due to fact that (I) not including any middle age group in order to provide more information about the developmental function, (II) using well educated high functioning university students as reference group might create biased evaluation of age effect. This might be one of the reasons why delayed-JOL judgments Hamann accuracy scores had significant difference between both young and elderly control groups. According to Zhou (2017), the tasks that the current study included might necessitate too many cognitive sources to allow elderly adults to dedicate sufficient cognitive effort to complete the JOL task.

The present study provides very valuable information about Superagers and their metamemory abilities by investigating their episodic FOK and delayed JOL performances. Previous studies about the Superagers only included neuroimaging techniques and basic neuropsychological assessments. This study provides more information about the correlation between their intact episodic memory and their metamemory abilities. In addition, most of the metamemory in older adults' studies only include the comparison of the young and elderly adults. With this study, we were able to compare the Superagers metamemory performance with same age peer group and young adults to find the similarities and differences in their performance.

4.4. Limitations and Implications of the Study

According to Blake (1973), judgments do not provide 100% accuracy about one's own memory performance. The accuracy results usually appear reliably above chance level, but still far from perfect prediction results. For example, Souchay

(2012) results were different from Alam (2014) metamemory study. Alam and friends did not find any FOK accuracy differences between young and elderly adults while Souchay and her colleagues did find a significant episodic FOK accuracy differences between young and elderly adults.

Firstly, using dichotomous judgment “Yes” and “No” responses limited the subject’s judgment about their metamemory ability. Using likert scale would provide more information and more accurate judgment results. Giving likert scale will encourage subjects to evaluate their real FOK judgments rather than probability of guessing (Schwartz et al. 2014). In the present study, most of the Superagers chose “Yes” response for all 40 items in the judgment phase.

The current study did not include any vocabulary knowledge test, however the word lists were already chosen from the most frequently used words dictionary.

In the recognition phase, there should be more distracter word with the target word in order to provide more information about subjects’ recognition ability rather than the probability of guessing.

4.5. Future Study Suggestions

Future study for the Superagers should more focus on essential components for undamaged cognitive abilities such as social activities, diet, exercise and genetic factors (Sun et al., 2016).

For metacognitive judgments assessment, if you would like to work with elderly adults, including how beliefs about memory change can affect their performance and their predictions might be a good next step for this study (Dunlosky

& Tauber, 2016). Self-assessment memory questionnaire might be applied to especially elderly adults and to Superagers in order to provide more information about their memory beliefs (Vander, Linden, Coyette, & von Frenckell, 1989). Also metamemory assessment can combine with neuroimaging techniques in order to provide more information about the process and locations that get activated.

In addition, social context of elderly adults might be an important factor affecting their metamemory judgments. Comparison with different cultures might provide more information about their metamemory.

In addition, while calculating the relative accuracy for both FOK and JOL judgments with Gamma and Hamann correlation, signal detection theory measurement should also be included in order to receive more precise relative accuracy results (Masson & Rotello, 2009).

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APPENDICES

APPENDIX A

(DEMOGRAFİK BİLGİLER)

Yaş:		
Eğitim durumu:		
Cinsiyet:		
Aile geçmişi:		
Kullandığı ilaçlar:		
	Evet	Hayır
Uyku probleminiz mevcut mudur ?		
Uyku düzeniniz nasıldır:		
Yabancı dil bilginiz var mı ?		
Eğer cevabınız evet ise hang diller ve süresi :		
Görme bozukluğu varmı?		
Eğer cevap evet ise detaylar:		
Nörolojik rahatsızlık varmı ?		
Eğer cevaplar evet ise:		
Psikolojik/Psikiyatrik rahatsızlık varmı ?		
Eğer cevaplar evet ise:		
Şeker veya tansiyon hastalığınız varmı ?		
Günlük veya haftalık yürüyüşler yaparmısınız?		
Kahve çok tüketirmisiniz ?		
Eğer cevap evet ise günlük kaç bardak kahve içiyorsunuz:		
Bol sebze tüketimine dikkat edermisiniz ?		
El işi yaparmısınız ?		
Hobileriniz mevcut mudur ?		
Eğer cevabınız evet ise nelerdir:		
Günlük hayatınız çok aluminyum ürünleri kullanırmısınız ?		
Ailenizde hiç Alzeimer veya Demans hastalığı olan biri varmı ?		
Eğer cevap evetse hangi yakınınız:		

APPENDIX B

(Inform Consent)

Süper Yaşlılarda Üst-biliş Çalışma Farkları

Bahçeşehir Üniversitesi

BİLGİLENDİRİLMİŞ OLUR FORMU

Değerli Katılımcı,

Bu çalışmada Süper yaşlılar diye adlandırdığımız bilişsel fonksiyonları yüksek seviyelere olan yaşlı katılımcılarımızdaki üst-biliş fonksiyon farklarını araştırmayı hedefliyoruz. Bu çalışma yüksek lisans öğrencisi Irem Tuğçe Onin tarafından yürütülmektedir.

Çalışma toplamda iki farklı oturumdan oluşmaktadır ve her oturum 1 ile 1:30 arasında sürmektedir. İlk oturumumuzda farklı bilişsel aktiviteleri ölçmek için 4 farklı diyagnoz testi uygulanmaktadır. İkinci oturumumuzda bilme hissi ve öğrenme kararlarının ölçümü için 2 farklı test uygulanmaktadır. Verdiğiniz kişisel bilgiler veri tabanımızda gizli tutulacaktır. Bununla birlikte kayıtlarınız kurumun yerel etik komitesine ve Sağlık Bakanlığına açık olacaktır. Çalışma verileri herhangi bir yayın ve raporda kullanılırken isminiz kullanılmayacak ve veriler izlenerek size ulaşılmayacaktır.

Bu çalışma bilimsel bir çalışma olup, size doğrudan bir fayda sağlamamaktadır. Ama katılımcı istediği takdirde 4 diyagnostik test sonuçları rapor halinde verilebilir. Katılımcı istediği takdirde bu çalışmayı ret etme ya da çekim başladıktan sonra devam etmeme hakkına sahiptir.

Katılımcı olarak davet edildiğiniz bu çalışma tamamen gönüllülük esasına dayanmaktadır. Gönüllülük kriterlerine göre çalışmaya katılım şartları:

- Nörolojik ve psikiyatrik rahatsızlıkların olmaması
- SSRI ve SNRI ilaçlarını kullanmaması
- Okuma yazma bilmesi

- Görme yeteneğini etkileyen etkenlerin olmaması

Araştırma hakkında sorularınız veya almak istediğiniz ek bilgiler olduğu takdirde lütfen İrem Tuğçe Onin ile, iremonin@gmail.com adresinden veya 0530 580 1118 numaralı telefondan iletişime geçiniz.

*Bu proje Bahçeşehir Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından onaylanacaktır.

Bilgilendirilmiş Gönüllü Olur Formundaki tüm açıklamaları okudum. Bu çalışma ile ilgili yapılan tüm açıklamaları ayrıntılarıyla anlamış bulunmaktayım. Yukarıda bütün şartları okudum kabul ediyorum. Sorduğum sorulara açıklayıcı cevaplar verildi. Bu araştırmaya katılmayı kabul ediyorum. Araştırmaya gönüllü olarak katıldığımı, istediğim zaman gerekçeli veya gerekçesiz olarak araştırmadan ayrılabileceğimi ve kendi isteğime bakılmaksızın araştırmacı tarafından araştırma dışı bırakılabileceğimi biliyorum.

İsim: e-mail:

İmza: Telefon numarası:

APPENDIX C

Mini Mental State Examination

Standardize Mini Mental Test

Ad/Soyad : ______ Tarih : ______
Yaş : ______ Eğitim (yıl) : ______ Meslek : ______
Aktif El: ______ Toplam puan : ______

YÖNELİM
(Toplam puan 10)

Hangi yıl içindeyiz ☐
Hangi mevsimdeyiz ☐
Hangi aydayız ☐
Bugün ayın kaçı ☐
Hangi gündeyiz ☐

Hangi ülkede yaşıyoruz ☐
Şu an hangi şehirde bulunmaktasınız ☐
Şü an bulunduğunuz semt neresidir ☐
Şu an bulunduğunuz bina neresidir ☐
Şu an bu binada kaçıncı kattasınız ☐

KAYIT HAFIZASI
(Toplam puan 3)

Size birazdan söyleyeceğim üç ismi dikkatlice dinleyip ben bitirdikten sonra tekrarlayın (Masa, Bayrak, Elbise) (20 sn süre tanınır) Her doğru isim 1 puan ☐

DİKKAT ve HESAP YAPMA
(Toplam puan 5)

100'den geriye doğru 7 çıkartarak gidin. Dur deyinceye kadar devam edin. Her doğru işlem 1 puan. (100, 93, 86, 79, 72, 65) ☐

HATIRLAMA
(Toplam puan 3)

Yukarda tekrar ettiğiniz kelimeleri hatırlıyor musunuz? Hatırladıklarınızı söyleyin. (Masa, Bayrak, Elbise) ☐

LİSAN
(Toplam puan 9)

a) Bu gördüğünüz nesnelerin isimleri nedir? (saat, kalem) 2 puan (20 sn tut) ☐

b) Şimdi size söyleyeceğim cümleyi dikkatle dinleyin ve ben bitirdikten sonra tekrar edin. "Eğer ve fakat istemiyorum" (10 sn tut) 1 puan ☐

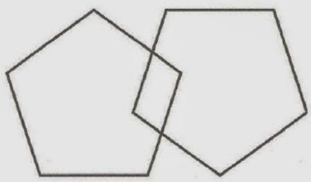
c) Şimdi sizden bir şey yapmanızı isteyeceğim, beni dikkatle dinleyin ve söylediğimi yapın. "Masada duran kağıdı sağ/sol elinizle alın, iki elinizle ikiye katlayın ve yere bırakın lütfen" Toplam puan 3, süre 30 sn, her bir doğru işlem 1 puan. ☐

d) Şimdi size bir cümle vereceğim. Okuyun ve yazıda söylenen şeyi yapın. (1 puan) "GÖZLERİNİZİ KAPATIN" (aşağıda) ☐

e) Şimdi vereceğim kağıda aklınıza gelen anlamlı bir cümleyi yazın (1 puan) ☐

f) Size göstereceğim şeklin aynısını çizin (aşağıda) (1 puan) ☐

GÖZLERİNİZİ KAPATIN



APPENDIX D

Hastanın Adı, Soyadı:	Tarih:
Hastanın Yaşı ve Cinsiyeti:	Değerlendirici:

GERİATRİK DEPRESYON ÖLÇEĞİ (GDS)

Lütfen yaşamınızın son bir haftasında kendinizi nasıl hissettiğinize ilişkin aşağıdaki soruları kendiniz için uygun olan yanıtı işaretleyerek yanıtlayınız.

	Evet	Hayır
1) Yaşamınızdan temelde memnun musunuz?	☐	☐
2) Kişisel etkinlik ve ilgi alanlarınızın çoğunu halen sürdürüyor musunuz?	☐	☐
3) Yaşamınızın bomboş olduğunu hissediyor musunuz?	☐	☐
4) Sık sık canınız sıkılır mı?	☐	☐
5) Gelecekten umutsuz musunuz?	☐	☐
6) Kafanızdan atamadığınız düşünceler nedeniyle rahatsızlık duyduğunuz olur mu?	☐	☐
7) Genellikle keyfiniz yerinde midir?	☐	☐
8) Başınıza kötü bir şey geleceğinden korkuyor musunuz?	☐	☐
9) Çoğunlukla kendinizi mutlu hissediyor musunuz?	☐	☐
10) Sık sık kendinizi çaresiz hissediyor musunuz?	☐	☐
11) Sık sık huzursuz ve yerinde duramayan biri olur musunuz?	☐	☐
12) Dışarıya çıkıp yeni bir şeyler yapmaktansa, evde kalmayı tercih eder misiniz?	☐	☐
13) Sıklıkla gelecekten endişe duyuyor musunuz?	☐	☐
14) Hafızanızın çoğu kişiden daha zayıf olduğunu hissediyor musunuz?	☐	☐
15) Sizce şu anda yaşıyor olmak çok güzel bir şey midir?	☐	☐
16) Kendinizi sıklıkla kederli ve hüzünlü hissediyor musunuz?	☐	☐
17) Kendinizi şu andaki halinizle değersiz hissediyor musunuz?	☐	☐
18) Geçmişle ilgili olarak çokça üzülüyor musunuz?	☐	☐
19) Yaşamı zevk ve heyecan verici buluyor musunuz?	☐	☐
20) Yeni projelere başlamak sizin için zor mudur?	☐	☐
21) Kendinizi enerji dolu hissediyor musunuz?	☐	☐
22) Çözümsüz bir durum içinde bulunduğunuzu düşünüyor musunuz?	☐	☐
23) Çoğu kişinin sizden daha iyi durumda olduğunu düşünüyor musunuz?	☐	☐
24) Sık sık küçük şeylerden dolayı üzülür müsünüz?	☐	☐
25) Sık sık kendinizi ağlayacakmış gibi hisseder misiniz?	☐	☐
26) Dikkatinizi toplamakta güçlük çekiyor musunuz?	☐	☐
27) Sabahları güne başlamak hoşunuza gidiyor mu?	☐	☐
28) Sosyal toplantılara katılmaktan kaçınır mısınız?	☐	☐
29) Karar vermek sizin için kolay oluyor mu?	☐	☐
30) Zihniniz eskiden olduğu kadar berrak mıdır?	☐	☐

APPENDIX E

Sözel Bellek Süreçleri Testi (SBST)

OKTEM SÖZEL BELLEK SÜREÇLERİ TESTİ (OKTEM-SBST)

(A LISTESİ)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	SKOR
	Davul	Perde	Zil	Kahve	Okul	Anne	Bahçe	Şapka	Ay	Çiftçi	Burun	Hindi	Renk	Ev	Nehir	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
U S B																
T																
															Top.Hat:	
																Y.T:

APPENDIX F

Boston Naming Test (BNT)

BOSTON ADLANDIRMA TESTİ

	İtem	Kendiliğinden	Semantik İpucuyla	Fonemik İpucuyla	Hiç Adlandıramadı
1	Makas				
2	Kalem				
3	Tarak				
4	Diş fırçası				
5	Ev/Bina/Okul				
6	Deve				
7	Çiçek				
8	Testere/Hızar				
9	Ağaç				
10	Karyola/Yatak				
11	Süpürge				
12	Askı				
13	Düdük				
14	Huni				
15	Helikopter				
16	Kayık/Sandal/Kano				
17	Dünya/Küre				
18	Pergel				
19	Mantar				
20	Akordeon				
21	Mızıka				
22	Salyangoz/Sü.böcek				
23	Yanardağ/Volkan				
24	Raket				
25	Maske				
26	Palet				
27	Maşa				
28	Kaktüs				
29	Bank/Sıra				
30	Hamak/Salıncak				
31	İletki/Minkale				

Toplam İtem Sayısı:
Kendiliğinden:
Semantik İpucuyla:
Fonemik İpucuyla:
Hiç Adlandıramadı:

2

APPENDIX G

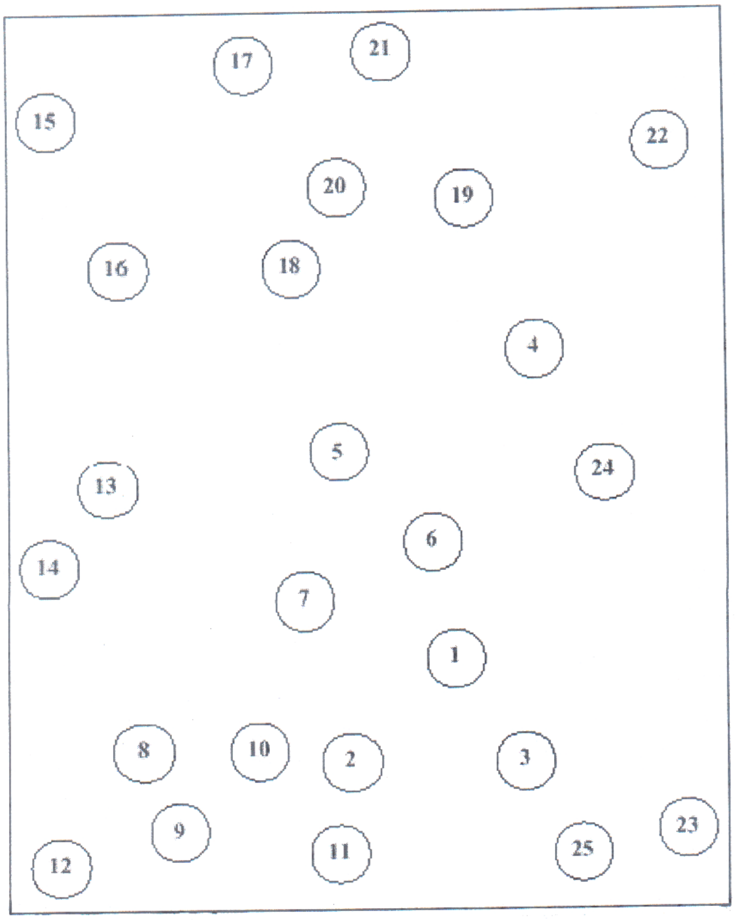
Category Fluency Test (CFT)

	HAYVAN
0-15 Saniye	
16-30 Saniye	
31-45 Saniye	
46-60 Saniye	
	Puan: Perseverasyon: Kategori Dışı:

1

APPENDIX H

Trail Making Part A


Trail Making Test Part A

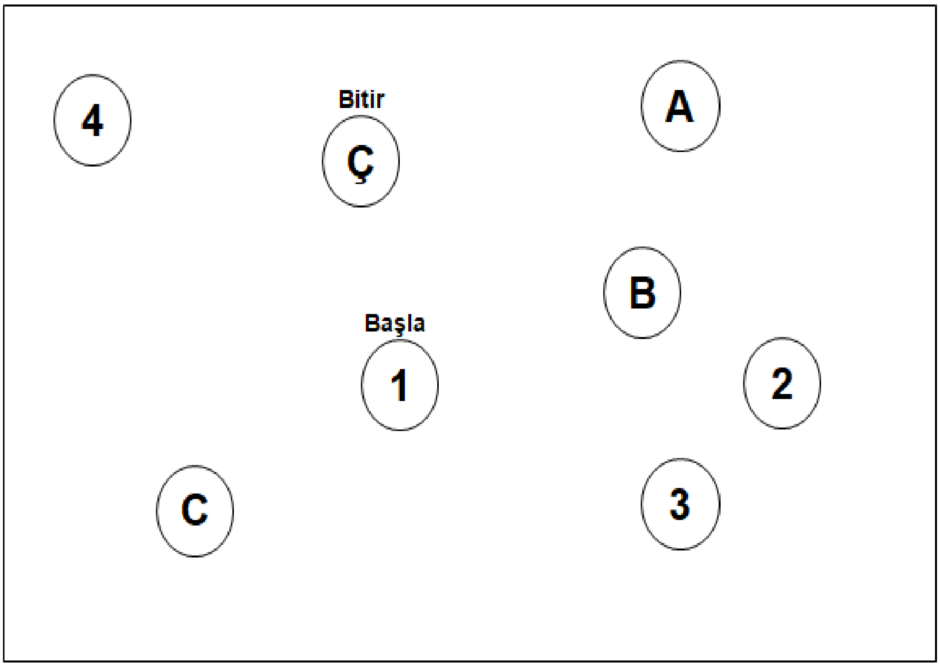
Patient's Name: ______________________ Date: ______________

APPENDIX I

Trail Making Part B

İZ SÜRME TESTİ- Bölüm B

ÖRNEK



APPENDIX J

Gamma Coefficient Formulation

(A.D- B.C) / (A.B + B.C)

- A: correct recognition of “Yes” prediction
- B: incorrect recognition of “Yes” prediction
- C: correct recognition of “No” prediction
- D: incorrect recognition of “No” prediction

APPENDIX K

Hamann Correlation Formulation

- A: correct recognition of “Yes” prediction
- B: incorrect recognition of “Yes” prediction
- C: correct recognition of “No” prediction
- D: incorrect recognition of “No” prediction

$$\frac{(a+d)-(b+c)}{a+b+c+d}$$