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IMPACT OF SMARTPHONE PHOTOGRAPHY ON MEMORY:

VISUAL RECOGNITION MEMORY AFTER EXPOSURE TO DIRECT IMAGE AND MEDIATED IMAGE OF ARTWORKS

by
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Abstract

Unprecedented access and frequent use of smartphone cameras is not only reconstructing the way we communicate and share, but also the way we remember. Previous work has shown that photographing a scene can have detrimental effects on memory. In a set of experiments, we investigated whether the act of taking photographs with a smartphone led to poorer memory. Participants were presented a mock museum tour. Differently from real life museum tours, this made it possible to control for confounding variables potentially undetected in previous research. Participants were directed to merely observe the artworks or to photograph them depending on the group they were assigned to. In the first two experiments we manipulated encoding condition. In Experiment 1, intentional encoding took place such that participants were informed before the tour of a later memory test. The procedure was identical in Experiment 2, except that that time participants underwent a surprise recognition test. The results of Experiment 1 revealed that taking many photos impaired participants' accuracy in remembering, whereas this impairment effect was eliminated in Experiment 2. This suggests that knowing in advance about a memory task creates itself the impairment by possibly affecting the retrieval strategies. Furthermore, photo groups in both experiments gave lower confidence ratings compared to no-photo groups, suggesting that photo taking makes people uncertain about what they remember. In Experiment 3, we aimed to replicate the photo-taking-impairment effect while testing for the effect of encoding by presenting for half of the retrieval cues only partial details of the original paintings. Overall, presenting only details impaired memory, and more importantly, the impairment effect was confirmed. However, no interaction was found with type of cues. Considered together, these results suggest that taking many photos does not impair encoding, while it seems to affect metacognitive variables at retrieval, such as confidence in memory and retrieval strategies. Further studies will examine this possibility directly.

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List of Abbreviations

ANOVA	Analysis of Variance
fMRI	Functional Magnetic Resonance Imaging
MTL	Medial Temporal Lobe
PA	Perceived Attachment to Phones Scale
PET	Positron Emission Tomography
PMPUQ	Problematic Mobile Phone Use Questionnaire
RT	Stimulus Reaction Time
SAS	The Smartphone Addiction Scale
SD	Standard Deviation
SMS	Self-Memory System
STAI	The State-Trait Anxiety Inventory

List of Symbols

F .... Statistic for the ANOVA

M .... Mean score of a sample

η_p^2 .... Partial Eta square

N, n .... Sample size

p .... Probability level

r .... Pearson correlation coefficient

t .... T test for two independent samples

Preface

Smartphones have become an indispensable part of our lives over the last two decades. Considering our tendency to develop pervasive cellphone-related habits, one of the widely used features of smartphones is without a doubt “smartphone camera”. Camera phones have developed so quickly that picture taking has globally become a daily and ubiquitous activity. The unprecedented access to smartphones has literally transformed most of us into amateur photographers.

Mnemonic effects of taking photos have received increased attention in recent years because of the extensive usage of smartphone cameras (e.g., Barasch et al., 2017; Henkel, 2014; Niforatos et al., 2017), yet still little is explored about how photographing a scene influences our personal memories. We do know that photographs can serve as powerful cues for facilitating memory retrieval in some cases (Deocampo & Hudson, 2003; Loveday & Conway, 2011; St Jacques & Schacter, 2013), and what makes them particularly effective in triggering memories lies in nature of episodic memory system (Tulving, 1984). As episodic memories can be rich in visual detail, visual cues (e.g., photographs) per se have been confirmed to be exceptionally successful in assisting the recall process (see Niforatos et al., 2014).

The aim of this dissertation is to further study the effects of today’s photo taking habits on memory encoding and retrieval. There is a considerable amount of evidence that revisiting photographs can help individuals with memory impairments (De Leo et al., 2011; Hodges et al., 2006; Lee & Day, 2007; Loveday & Conway, 2011). Despite the fact that revisiting photos serve as memory aids, people rarely review the pictures they had taken (Whittaker et al., 2010). Therefore, in this present study, we are interested in understanding how capturing photos affects people’s recognition of prior experiences when they do not revisit their photos.

Smartphones as memory repositories remain a facilitating device in our everyday lives, but the other side of the coin is that relying on external memories might be hindering our ability to remember. Studies have shown that manually taking photos during an experience can make us remember less of that experience (Henkel, 2014; Niforatos et al., 2017; Soares & Storm, 2018). Relying on photographs to remember might have a similar effect: what Henkel (2014) refers to as the “photo-taking-impairment effect” could be explained by people offloading their organic memory onto the camera’s prosthetic memory. Further, an alternative possibility is that this memory impairment might be arising from attentional disengagement (Soares & Storm, 2018) during the task of capturing photos of an object or experience, and thus leading people to encode it less elaborately than they would have otherwise. Hence, studies investigating photo-taking-impairment effect attempted to differentiate between two different explanations for the effect: (1) due to the attentional distraction caused by manual picture taking or (2) due to disruption at encoding as a result of relying on an external memory support.

The overall aim of this dissertation is to contribute to the understanding of how the act of manually taking photos during an experience influences memory encoding and/or retrieval. By using a controlled laboratory paradigm, this study examines an understudied area, whether frequent photo taking with cellphones impairs memory.

The first chapter addresses the concept of autobiographical memory as an umbrella term, since we consider the mock museum tour a personal episodic experience, rather than a pure episodic memory task. This first chapter aims to provide a general framework about this overarching topic in memory research. It primarily focuses on episodic components of autobiographical remembering by describing theoretical, functional, and neural perspectives of episodic memory system.

The second chapter is dedicated to visual memory including its episodic, working, and attentional components. Subsequent sections of this chapter aim to present a review on the use of photographs as visual retrieval cues and the use of lifelogging devices to foster episodic memory recall.

The third chapter aims to be a snapshot of the current literature regarding the association between smartphone technology and its influence on human cognition. It introduces important issues regarding today’s increasing problematic smartphone use.

The fourth chapter, as an inspiration for this dissertation, addresses the concept of photography in the age of smartphones and its link with human memory. It introduces the photo-taking-impairment effect along with a detailed literature review on the effects of photography on memory.

The three chapters that than follow review a series of laboratory experiments that I conducted in order to understand how the act of taking photos by using smartphone cameras during an experience influences the way people encode and/or retrieve that experience.

In the final chapter we discuss the results which were obtained from these experiments. Additionally, we conclude by discussing this study’s implications for future research.

CHAPTER 1

EPISODIC COMPONENTS OF AUTOBIOGRAPHICAL MEMORY

1.1 Introduction

Autobiographical memories help us assemble pieces and transform them into meaningful life narratives. Despite substantial research over the past few decades, a consensus on a common definition of the concept of autobiographical memory has yet to be reached (see Rubin, 1992, for his related conference talk). The amorphous and highly complex nature of autobiographical memories possibly causes this divergence and the concept itself presents different issues for interdisciplinary memory research. According to Baddeley (1992), for instance, the field of autobiographical memory moves towards two parallel but related strings; one deals with the cognitive mechanisms and processes by which we recollect the events of our lives, and the other deals with the social and emotional factors that contribute to the construction of the self.

What then is autobiographical memory? Autobiographical memories are recollections that belong to an individual's past (Pillemer, 1992; Rubin, 1986, 2005). They are of fundamental significance for the self, for emotions, and for the experience of personhood, that is, providing us the experience of enduring as an individual (Conway & Pleydell-Pearce, 2000). The term autobiographical memory is also used to refer to one's ability to maintain a constantly updated record of public and private events (McCarthy & Warrington, 1990). Since our personal awareness requires us to be capable of associating those events, autobiographical experience and memory comprise a central feature of human memory (Baddeley, 1992).

According to some theorists, autobiographical memory and the self are intrinsically related so that autobiographical memory should be considered as a part of the self (Brewer, 1986; Conway & Tacchi, 1996; Howe & Courage, 1997). Knowing the fact that multiple systems are involved in construction of autobiographical memories, brings us to the conclusion that the self is not a single entity (Conway & Pleydell-Pearce, 2000); rather, it is distributed among the individual systems (Rubin, 2005).

Further, Tulving's (1972) proposal of an episodic-semantic memory distinction has made a profound contribution to the direction of memory research. He suggested that episodic and semantic memory (these two concepts will be explained in more detail in the following section) represent two functionally separable memory systems (Baddeley, 1992; Tulving, 1983), and it is now widely accepted that also in autobiographical memory both episodic and semantic components are present, and are intimately interacting with each other (Conway, 2005).

This chapter will start addressing the concept of episodic memory, and then will examine how autobiographical memories are organized and retrieved. A subsequent section will go deeper into the encoding and retrieval characteristics of episodic memory from a neural perspective.

1.2 The concept of episodic memory

Today the episodic memory system is recognized as one of the major memory systems. Tulving (2002), in one of his most comprehensive scholarly work on episodic memory, noted that episodic memory may have emerged as an embellishment of the semantic memory at some point in human evolution. But let us now turn backwards for a moment:

In 1966, the term semantic memory was introduced into the literature by Quillian. At that time, this type of memory was described as an organized internal lexicon (Kintsch, 1970) that is the memory necessary for the use of language. Inspired by this topic, Tulving (1972) proposed a new form of a dichotomy of the two distinct memory systems that constitute memory; with semantic memory referring to one's general knowledge of the world and of language, and episodic memory referring to the capacity to recollect experienced events characterized by spatial and temporal tags (Baddeley, 1992; Sarp & Tosun, 2011, Tulving, 1972). He defined a fundamental part of the representation of a remembered experience in the episodic memory system with its link to the knowledge of personal identity. The semantic memory system, instead, does not register perceptible properties of inputs, but rather cognitive referents of input signals (Tulving, 1972).

More precisely, semantic memory reflects our knowledge of the world by storing generic information acquired across many different contexts and situations, whereas episodic memory stores the episodes concerning particular individuals at particular times and places (Bayles & Kaszniak, & Tomoeda, 1987; Collins & Quillian, 1969; Prasada, 2000). Most importantly, the basic feature of episodic memory is its specificity, more than that, its capacity to represent a unique event and to locate it in time and space (Baddeley, 2001).

On the other hand, Conway (2009) states that the content of episodic information should be more summarized and generic, meaning that it is rather just representative of an experience than a literal record. Despite the importance of the preservation of temporal order in episodic memories (Drosopoulos et al., 2007; Griessenberger et al., 2012), these memories tend not to endure for lengthy periods of time in the long-term memory (see also Sato, 2002). For instance, in many situations, episodic memories are stored only to the extent that temporal-order information is also available (e.g., remembering today's vs. yesterday's parking spot) (Jacques et al., 2008). It is further explained that although many episodic memories from a single day can be recalled at the end of the day, as the retention interval increases, access to many of these memories would be rapidly lost other than those with an enduring association with current goals (Conway, 2005, 2009). In addition, when it comes to conceptual autobiographical knowledge, people can retain and accurately recall certain events without accessing associated episodic memories (without many or any further details). To illustrate this, consider a person who has an academic profession. This person can easily access his/her career related lifetime periods such as “studying at University X” as it represents a personal conceptual knowledge about work, without necessarily accessing to associated episodic memories such as “taking part in some word test experiment”. In short, this seems to be one way the memory system reduces the potential information overload of retaining very detailed and extensive records of experience (Conway, 2005).

Episodic memories inherently include information about conceptual and contextual components of personal experiences in varying degrees of amount and quality, or about object (what), spatial (where), and temporal (when) information (e.g., Cheke, 2016; Nairne, 2015; Tulving, 1983). Recollection of such memories requires a rich re-experiencing of the past event; in other words, what Tulving called the ability to *mentally travel back* in our past and use it to predict our future (Baddeley, 2001; Tulving, 1985). This hypothesis was also supported by evidence coming from observations of amnesic patients with severe episodic memory impairments, as they appeared to be unable to anticipate the future (e.g., Andelman et al., 2010; Klein, Loftus, & Kihlstrom, 2002; Verfaellie et al., 2012). Episodic memory then might be considered as a system in which both remembering the past and imaging the future take place (Conway, 2009).

Later Tulving (2002) expanded his work and held that the essence of episodic memory lies in the conjunction of three concepts: self, autonoetic awareness, and subjectively sensed time. What he refers here as the "autonoetic" character of episodic memory is that of a special kind of consciousness that allows humans to be aware of subjective time in which events occur. In this sense, autonoetic consciousness indeed appears as a critical component of episodic remembering which is strongly associated with imagery, a type of mental reliving of an experience (see e.g., Conway & Pleydell-Pearce, 2000; Wheeler, 2000). Tulving wrote: "Episodic memory is oriented to the past in a way in which no other kind of memory, or memory system, is. It is the only memory system that allows people to consciously re-experience past experiences" (Tulving, 2002, p. 6).

Even if we see the terms episodic memory and autobiographical memory as often used interchangeably, however it is best to avoid equating these two concepts (Feinberg & Keenan, 2005; Raes et al., 2006; Tulving, 2001). Autobiographical memory cannot be described as a memory system in itself as it represents not only event-specific details of unique events (episodic component), but also contains knowledge-based information (semantic component) (Baddeley, 2001). Conway (2009), therefore, made another distinction between the term episodic memory which he limited to relatively recent recollective experience, and the term accumulation of personal knowledge that he refers to as autobiographical memory.

1.3 The content and organization of autobiographical memory

Several studies have established that autobiographical memories are organized hierarchically as they always contain knowledge at different levels of specificity (Conway & Bekerian, 1987; Haque et al., 2014; Linton, 1986). Based on this view, three broad levels of autobiographical knowledge have been identified: lifetime periods, general events, and event-specific knowledge (see e.g., Brewer, 1996; Conway, 1992). The top level of this hierarchy contains representations of lifetime periods (e.g., "college years"), whereas general events (can be repeated events, e.g., "Sunday morning walks" or extended events, e.g., "my trip to Miami") constitute the second level of the memory organization hierarchy, and event-specific knowledge (e.g., my first time in Colosseum) forms the lowest level of this hierarchy (Burt et al., 1995).

The self-memory system (SMS), a well-known model of autobiographical memory developed by Conway and Pleydell-Pearce (2000), refers to the conjunction of the working self with the autobiographical knowledge base. The SMS is postulated as a superordinate memory system in which three sub-ordinate systems (working self, retrieval models, and autobiographical knowledge base) work coordinately to construct a memory (see also Haque et al., 2014). A central principle of the SMS model is that autobiographical memory should be a product of a trade-off between competing demands of coherence and correspondence (Conway, 2005). While coherence shapes both the accessibility of memories and their content, memory should also correspond to experience (see Figure 1 below).

The SMS suggests that the goal structure of the working self is critical for both encoding and retrieval of autobiographical knowledge and these goals are assumed to be grounded in autobiographical memories (Conway & Pleydell-Pearce, 2000). That is to say, the SMS determines what knowledge will or will not be combined into an autobiographical memory, based on the relevant goal's compatibility, and thereby a person's goal could not be maintained if it would contradict autobiographical knowledge (see Conway & Tacchi, 1996).

Goal change can be costly in cognitive-affective terms because even a single change of a goal in a positive or negative way would have consequences for many other goals (Conway, 2005). In this respect, the purpose of the basis of conservatism of this goal structure is indeed to resist goal change (Conway et al., 2004, 2006). Retrieval models might also function in a similar manner:

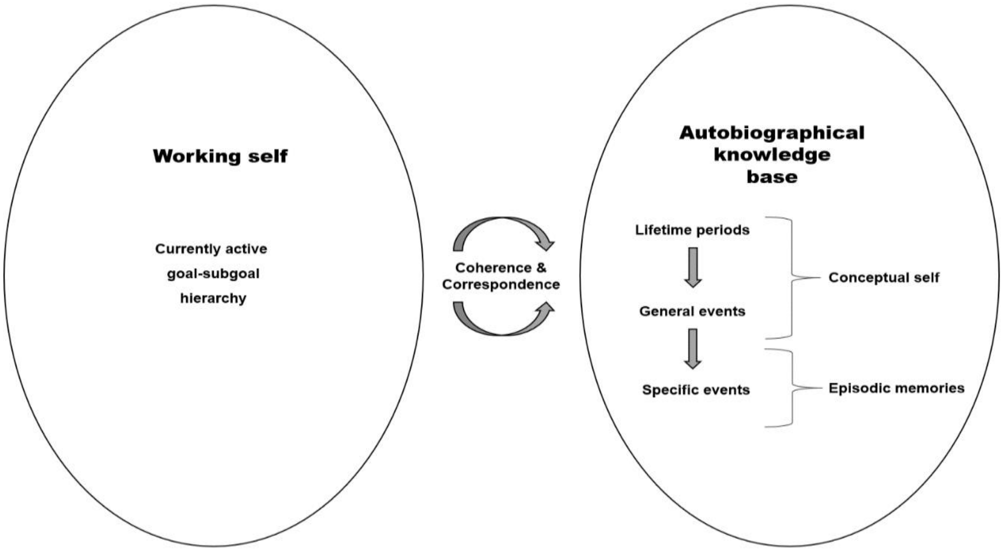

Figure 1. Reconstruction of autobiographical memory in the self-memory system (The illustration and the description are adapted from Conway and Pleydell-Pearce, 2000; Conway, 2005). The term working self implies the currently active goal hierarchy, and the purpose of the goal-subgoal hierarchy is to decrease discrepancies between the current state of the self and the desired goal states and in turn, regulate behavior. The working self moderates between the demands of coherence and correspondence in the formation and construction of memories. The conceptual self, on the other hand, is directly connected to autobiographical knowledge and episodic memory system and aims to activate specific events.

for instance, they are able to attenuate or prevent the access to recall of highly emotional materials which would increase self-discrepancies (Conway & Pleydell-Pearce, 2000).

Conway and Pleydell-Pearce (2000) further suggest in the SMS model that judgments of the temporal order of events tagged as occurring in different lifetime periods should be recalled more accurately and faster compared to judgments of temporal order of events tagged as occurring in the same period. Based on this view, Skowronski et al. (2007) explored in their study whether people tag an autobiographical event with labels reflecting the life era in which the event happened. Their latency data from order judgment of events consistently showed that between-era judgments were faster than within-era judgments (see also Hurst & Volpe, 1982; Skowronski et al., 2003).

Similarly, Sato (2002) examined the temporal organization of autobiographical memories through the event-cueing technique. It is a technique in which participants are first presented a cue-word and then asked to recall an autobiographical event. This recalled event is used as a cue (cueing event) and the participants are asked to recall a second related event (cued event) (see Bluck & Habermas, 2000, for a review). Sato’s findings suggested that recent autobiographical memories are organized temporally within a lifetime period; cueing events frequently evoke cued events belonging to the same lifetime period. Contrary to former evidence, this study indicated that temporal organization becomes ambiguous as time passes; remote autobiographical memories tend to evoke temporally distant events sharing the same period, activity, location, or other distinctive features.

Another intriguing study established that depressed people appeared to organize their autobiographical memories in an opposite manner compared to the nondepressed ones, as suggested in Tomkins's (1978) script theory of personality. Their findings showed that the depressed subjects tended to organize positive life events in terms of their thematic similarities and negative life events in terms of their thematic differences, whereas nondepressed people showed the opposite pattern (McAdams et al., 1988).

So far, in this section, we briefly considered the theoretical framework of construction of autobiographical memories as well as the findings coming from related studies. Although the investigation of memory construction processes remains a challenge, in the next section we introduce the underlying neural mechanisms of episodic memories, even if the experiments reported in this dissertation are purely behavioral and will not examine the brain areas that might be involved in the task.

1.4 Neural correlates of episodic memory system

1.4.1 Episodic memory network

A brain network can be defined as a pattern of spatially remote brain regions whose activity levels are correlated, or functionally connected where patterns of dynamic interactions among regions are statistically observed (Habib et al., 2003; Sporns, 2013). Much of the data from neuropsychological and neuroimaging experiments investigating the neural basis of episodic memories have revealed a consistent network of associated brain regions (Hassabis et al., 2007; Svoboda et al., 2006). Here, we review the results of a series of neuroimaging studies that have examined neural correlates of episodic remembering**.**

There are mainly two opposing approaches in the debate over the episodic memory network. The first one is the *multiple memory systems* view which postulates that a widely distributed network of cortical and subcortical brain areas subserves the episodic memory system (Cabeza & Nyberg, 2000; Gabrieli, 1998; Tulving, 1987, 2002). Consistent with this notion, most of the functional magnetic resonance imaging (fMRI) studies investigating the neural basis of episodic remembering (Cabeza & St Jacques, 2007; Maguire, 2001), future thinking (Addis et al., 2007; Szpunar et al., 2007) and solely imagining fictitious experiences (Hassabis et al., 2007), have reported a distributed network of brain regions. Nevertheless, specific contributions of individual brain regions to the overall recollective experience are yet to be fully known (Hassabis & Maguire, 2009). Proponents that stress the role of a *unitary memory system* posit the idea of a single declarative memory system, in which memory retrieval would not be localized in discrete brain regions, but rather would be mediated by the interaction between functionally related neural areas (Baddley, 1984; Burianova et al., 2010; Friston, 2002; Rajah & McIntosh, 2005). For instance, neuropsychological case studies demonstrated that patients with hippocampal amnesia exhibit impairments in semantic retrieval in addition to profound deficits in episodic and autobiographical retrieval, compared to healthy controls (Kopelman & Kapur, 2001; Manns et al., 2003; Squire & Zola, 1998).

Our knowledge of the critical neuroanatomical sites which have a role in mediation of episodic remembering derives mainly from numerous positron emission tomography (PET) and fMRI studies. Certainly, the common episodic memory network in the brain includes medial temporal and prefrontal regions (Allan et al., 2000; Wheeler, Stuss, & Tulving, 1997).

One of the pioneer PET study by Kapur et al. (1994) was explicitly designed to explore the neuroanatomical basis of encoding processes in episodic memory. What they found was that, when subjects carried out deeper as compared to shallow processing operations on the same verbal stimuli, the deeper encoding operations were accompanied by increased neural activity in the left inferior prefrontal cortex. Another PET study (Wiggs et al., 1998) explored that retrieving semantic information activates the left temporal and left frontal regions whereas retrieving episodic memories activates medial parietal cortex, retrosplenial cortex, and thalamus. More interesting results for the current study have come from an fMRI study in which Vaidya, Zhao, Desmond and Gabrieli (2002) examined whether neural pathways used during memory encoding would be re-activated during episodic retrieval. They reported a neural overlap in which a subset of the brain regions in left ventral extrastriate cortex and right middle occipital gyrus involved specifically in encoding of pictures were also engaged during their recognition (See also Schacter et al.'s, 1999 results for a pinpoint overlap in medial temporal regions).

As we pointed out earlier, a critical component of episodic remembering seems to be the ability to have autonoetic consciousness. It is suggested that this type of autonoetic experience in remembering involves a dynamic interaction of networks located in frontal lobes (Conway & Pleydell-Pearce, 2000; Wheeler, 2000). This is in line with the results of several patient and neuroimaging studies that have pointed out the important role of the prefrontal cortex in episodic memory network (Simons & Spiers, 2003; Wheeler et al., 1997) with assumptions ranging from self-awareness to autonoetic consciousness to metacognitive and control processes (Rugg & Wilding, 2000; Wheeler et al., 1997). A very relevant topic which is worthwhile to mention at this point is our capacity of reality monitoring. The evidence from cognitive neuroscience research suggests that the anterior prefrontal cortex region of the brain is central to reality monitoring ability. This capacity allows us to determine the sources of mental experiences and to distinguish internally and externally generated information that, for instance, happens to be disrupted in symptoms of mental illness such as hallucinations. On that sense, reality monitoring is vital for attributing memories to real experiences, maintaining confidence in our memories and perceiving ourselves in the world with a past and future which is also implied in autonoetic consciousness (see Simons et al., 2017).

1.4.2 The medial temporal lobe structures in the context of episodic memory

The importance of medial temporal lobe (MTL) for memory processing is well known based on studies of individuals with amnesia, animal models and neuroimaging research (Eichenbaum et al., 2012; Squire et al., 2004). The regions in the MTL exhibit a crucial role in supporting episodic memory, and these include subdivisions of the parahippocampal region and hippocampus (Diana et al., 2007; Eichenbaum et al., 1992). Besides that, MTL activation can be reliably observed during both episodic encoding and retrieval (Lepage et al., 1998; Schacter et al., 1999).

Existing neuroimaging literature have shown the prominent role of the hippocampus, a medial temporal lobe structure, for episodic memory (Conway, 2005; Gilboa et al., 2004; O'Keefe & Nadel, 1978). Although hippocampus is supposedly involved in forming, storing, and retrieving episodic memories, the neural mechanism by which it accomplishes this has been widely debated (Leal, 2016). One view explained the role of the MTL in memory in terms of recollection (recognizing an item on the basis of its specific contextual details) and familiarity (recognizing an item on the basis of its perceived memory strength without any specific details) (Diana et al., 2007; Wixted et al., 2010; Yonelinas et al., 2010). According to this view, recollection is associated with the activity in the hippocampus and posterior parahippocampal gyrus, familiarity instead is associated with the activity in the anterior parahippocampal gyrus (Diana et al., 2007).

Another point is that the ability to retrieve "context" from item information appears as a classic prototype of episodic memory (Eichenbaum et al., 2012). In this regard, the hippocampus may be critical for remembering contexts of episodic events such as spatial locations, background voices or even emotional physical states (Polyn & Kahana, 2008; Ranganath, 2010).

Hirstein (2009) states that the hippocampus is not a region where the content of an episode is stored, but rather it contains a set of neural links to that content which is distributed widely throughout the cortex. For example, even though the amygdala and hippocampal complex are two independent memory systems, they interact when emotional content meets memory (Phelps, 2004).

Overall, there is a consensus that the human hippocampus is involved in episodic memory (Burgess et al., 2002; Eichenbaum & Cohen, 2001) as it is explicitly seen in patient studies where a damage to the hippocampus leads to severe deficits in episodic memory (Eichenbaum et al., 2012). Nevertheless, the mystery of how hippocampal and neocortical regions interact and to what extent these interactions support memory functions remain to some extent unsolved (Wagner et al., 2007).

CHAPTER 2

EPISODIC MEMORY FOR VISUAL INFORMATION

2.1 Introduction

Visual imagery plays a fundamental role in episodic remembering (Brewer, 1986; Vannucci et al., 2016). Although sensory–perceptual data can enter the system in any one of several modalities, visual imagery appears to be very powerful (Brewer & Pani, 1996; Greenberg & Knowlton, 2014). The strength of recollection of an experience, therefore, can be anticipated more by the vividness of its visual imagery in comparison with its auditory imagery, emotion, or narrative coherence (Rubin, 2005).

The remarkable nature of human visual episodic memory is salient in our everyday lives. In an earlier behavioral study, Brewer (1988) reported that more than 80% of randomly sampled memories consisted of visual images. This finding itself may give us an idea of how crucial the visual components are in episodic remembering (See also Standing, 1973; Whitten & Leonard, 1981 for similar results).

Schurgin and Flombaum (2018) recently noted that visual episodic memory can be described as massive, invariant, and explicit. It is massive because of its large storage capacity for images, it is invariant in a way that we are able to recognize the objects despite some alterations in appearance or viewing conditions, and it is explicit as it lets us discriminate between objects that are different but share visual properties (DiCarlo & Cox 2007; Rust & Stocker 2010).

It seems that visual episodic memories are recalled with an “own-eyes” or an “observer” perspective (McIsaac & Eich, 2002; Nigro & Neisser, 1983), in the same manner as storytelling. A visual episodic memory with an own-eyes perspective is considered to preserve a person’s original perspective, whereas with an observer perspective, the rememberer looks into the memory and sees oneself in the memory as an external observer (Conway, 2009; Sutin & Robins, 2008). It is also possible to shift visual perspective during memory retrieval; for example, shifting perspective from an own-eyes to an observer perspective during retrieval has found to be reducing subjective ratings of vividness as well as the number of episodic details people reported in their narratives (see St. Jacques, 2019).

This chapter will begin with describing the characteristics of visual memory. This will be followed with the episodic, working, and attentional components of visual memory. Subsequent sections specifically aim to present a review on the use of photographs as visual retrieval cues and the use of lifelogging devices to foster episodic memory recall.

2.2 Visual memory

2.2.1 Characteristics and power of visual memory

Given the fact that vision is the most dominant and complex modality of our perception, one might expect it to be the richest modality in remembering (Robinson & Swanson, 1990). Indeed, human visual memory is one of the core areas of human cognition that artificial intelligence systems have not yet been successful in replicating (Andreopoulos & Tsotsos, 2013; Schurgin, 2018). For example, the clearest, most salient, and almost lifelike autobiographical memories appear in the form of "flashbulb" memories. As consequentiality and surprise are known to be prerequisites for a flashbulb memory, what makes these memories particularly fascinating is that they are remembered as if the brain takes a picture of the event. People tend to recall their surroundings in exceptional detail even long after these events occur (Greenberg & Rubin, 2003; Rubin & Kozin, 1984).

Why does creating a visual representation in memory lead us to better remember things than the rest of the modalities such as verbal representations? Indeed, a memory advantage for picture over word stimuli, the so-called picture superiority effect, has been empirically well supported (see Baadte & Meinhardt-Injac, 2011). Haber (1983) explained this phenomenon with the evolution of the human visual system which allows us to organize all the disparate elements in a scene, a photograph or even an imagined scene as if a coherent chunk. Unlike verbal or more abstract inputs, chunking occurs automatically for visual inputs, because it organizes all light stimulation coming to the eyes in a way that none of the patterns of the light need to be encoded or remembered separately.

In a behavioral experiment, Brewer (1988) reported that subjective certainty about memory recall is highly related to the level of experienced visual imagery. This result suggests that visual re-experiencing in memory is indeed more extensive than other modalities such as auditory or tactile. Since visual imagery predominates in the episodic memory system, the loss of visual memory may cause a general amnesia as a secondary consequence (Conway, 2005; see Greenberg & Rubin's, 2003 review including neuropsychological data of 11 interesting cases). After such a loss, conceptual autobiographical knowledge appears to remain intact, and new autobiographical memories could still be encoded and retrieved, but without any visual component (Rubin, 2005).

The storage capacity of visual long-term memory remains unclear (Brady et al., 2008). Despite the general view that visual episodic memories represent short time slices of experience (Anderson & Conway, 1993; Conway, 2009), there are studies suggesting that visual episodic memory for objects in scenes can be more detailed than previously believed. Those representations can actually contain more information than only the gist of the object (Brady et al., 2008; Castelhano & Henderson, 2005; Hollingworth, 2004). This might provide another possible explanation for the superiority of visual memory over memories for other modalities.

2.2.2 Visual working memory versus visual episodic long-term memory

Visual memories can be distinguished as belonging to either visual working memory or visual episodic long-term memory (Schurgin, 2018). The former provides a link between perception and higher cognitive functions, especially by allowing the active maintenance of information about stimuli no longer in view (Baddeley & Hitch, 1974; Chun, 2011; Vogel et al., 2001). Therefore, it has the function of supporting complex cognitive behaviors that require temporary retention and manipulation of information in order to produce actions. The latter, on the other hand, is defined as a passive storage of visual information over longer periods of time (Cowan, 2008; Squire, 2004) and its goal is to identify an object based on some previous input, just like any object recognition system does (Schurgin, 2018). Furthermore, on a cerebral level, visual working memory tends to be associated with activation in the occipital and parietal cortex (Harrison & Tong, 2009; Todd & Marois, 2004), whereas visual episodic memory appears to activate the medial temporal lobe and hippocampus (Squire, 2004; Yonelinas et al., 2010).

Contrary to our rich phenomenological visual experience, our visual working memory has a limited storage capacity that people can retain up to about 3-4 things at any given moment (Schurgin, 2018; Vogel et al., 2001). However, the capacity of visual working memory should be understood in terms of integrated objects rather than individual features, which is a form of visual chunking that maintains the binding of features into integrated objects (Luck & Vogel, 1997). Furthermore, Vogel and Machizawa (2004) provided electrophysiological evidence for lateralized activity in humans which reflects the encoding and maintenance of items in visual memory. Their results suggest that the amplitude of this activity continues increasing as the number of visual items increases and reaches a limit once visual working memory capacity is exhausted.

Despite working memory and long-term memory are two distinct memory systems, they must be interacting and running in synchrony (Axmacher et al., 2008; Nyberg & Eriksson, 2016). Baddeley’s (2000) concept of an “episodic buffer”, for instance, is originally defined as a component of working memory system, however it is also episodic in a sense that it holds the episodes from our lives and plays an important role in feeding information into and retrieving information from episodic long-term memory.

2.2.3 The role of visual attention in visual processing

When it comes to identify the relationship between working memory and selective attention, the traditional view suggests that selective attention filters incoming information and allows only relevant information into short-term processing stores, thereby reduces the load on limited-capacity cognitive systems (Downing, 2000). Likewise, during visual search, target representations are maintained in visual working memory to control perceptual attention on the task-relevant items in our visual field (Bundesen et al., 2005; Carlisle et al., 2011).

Existing studies have established that visual attention improves the quality of visual encoding (Posner & Peterson, 1990) by boosting contrast sensitivity (Carrasco et al., 2004), decreasing distractor’s influence (Shiu & Pashler, 1995), and improving acuity (Carrasco et al., 2006). Moreover, it was suggested that visual working memory might share a common capacity limit with visual attention (Chun, 2011; Franconeri et al., 2013; Olivers, 2008). Consistent with this notion, the findings from few studies showed that asking people to make eye movements away from locations they try to maintain in working memory or preventing people from freely moving their eyes can inhibit their visual working memory performances (see Souza & Oberauer, 2017 for a recent review).

Overall, visual working memory and visual attention are considered to be separate but intimately related constructs (Awh et al., 2006; van Moorselaar et al., 2015). What we know is that visual attention processes are widely distributed over the human cortex, and some brain networks located in frontal and parietal areas appear to be responsible of controlling these processes (Bressler et al., 2008, Nenert et al., 2014).

2.3 Photographs as memory cues

Given that the importance of the visual component, and visual images, in memory functioning, it is not surprising that photographs act as memory stimulants (Hodges et al., 2006). Indeed, photographs are usually regarded as the most potent triggers for personal memories (Whittaker et al., 2010). It is not very likely to imagine a special occasion such as a birthday, wedding, or graduation without associated photographs. In fact, in today's era of mobile camera phones, even everyday activities and casual social meetings are accompanied by obligatory visual recording (Cohen, 2005).

People often report photo taking as a strategy for remembering information and life events (Harrison, 2002; Henkel, 2014). Several studies have established that photographs provide valuable retrieval cues that help people reactivate and retrieve their real or false personal memories (see Aschermann et al.'s, 1998 study with children; see Deocampo & Hudson's, 2003 study with toddlers; Garry & Gerrie, 2005; Henkel, 2011; Koutstaal et al., 1999; Wade et al., 2002).

Most of us have an extensive collection of photographs depicting our past. Interestingly, Burt (1995) claimed that an individual's personal photo albums may map quite closely onto the nature of autobiographical memory organization, a topic that we had previously discussed here. The way we sort out and organize photo albums can depict this hierarchy (e.g., lifetime periods - photos of university years - are kept in a separate album, whereas extended events - a group of photos from a camping holiday - are kept in the same album). Furthermore, we tend to use personal photographs as external repositories of memory since photographs have the capacity to trigger one's memory for forgotten information (Salter et al., 2017). This issue will be explained in more detail in following chapters.

2.4 Use of lifelogging technologies to trigger episodic remembering

Autobiographical memory is thought to be rich in visual imagery (Brewer, 1986, 1988; Conway, 2001). This emphasis on visual memory, and the role of photographs in memory recall, inspired scientists to use cameras as aids for autobiographical remembering. Particularly, wearable cameras such as WearCam (Mann, 1998), StartleCam (Healey & Picard,1998), and more recently SenseCam (Hodges et al., 2006), have an established role in ubiquitous and wearable computing research.

Recent technological developments have caused huge interest in ‘digital memories’ that are able to capture important digital information (‘lifelogs’) about multiple aspects of our lives (Whittaker et al., 2010). Lifelogging devices can capture personal experiences in an automated and continuous fashion and vary from small digital cameras to positioning technology and physiological sensors (Niforatos et al., 2014). The SenseCam, for example, is a small wearable digital camera which consists of multiple electronic sensors which are able to detect changes in light levels, motion, temperature and so forth (Hodges et al., 2006). This specialized camera is worn around the neck and automatically captures a picture every 30 seconds, so that it can trigger thousands of photographs in a single day (De Leo et al., 2011). The SenseCam functions without any user interaction, and therefore does not disrupt the ongoing experience through the act of taking photographs (St. Jacques et al., 2011).

The use of digital memories is also used to help people to compensate for their memory deficits (see Kapur et al., 2004 for a review). Some recent research making use of lifelogging systems has shown much promise in providing good autobiographical memory aids (Hodges et al., 2006; Lee & Dey, 2007). These studies have established that reviewing the day’s photos benefits memory and cognitive performance in patients with amnesia and other severe memory impairments, and this effect is found to be preserved in the long run (Hodges et al., 2006; Loveday & Conway, 2011; Milton et al., 2011).

Unlike wearable cameras, smartphones are a flexible and relatively low-cost technology that can be used for the same purpose. Moreover, what makes it superior to those lifelogging systems is that the images can be easily transferred through the Internet (De Leo et al., 2011). For example, Leo et al. (2011) conducted a single case study to use smartphone camera as a memory aid for a patient with Alzheimer’s disease and observed a clear increase in the number of events remembered after reviewing photos. Thus, much like with the lifelogging technologies, smartphones may indeed be used as an assistive device in the recall of recent events.

CHAPTER 3

SMARTPHONES AND COGNITIVE FUNCTIONING

3.1 Introduction

Smartphones have become an omnipresent part of our everyday lives. There are many benefits of smartphone technology, including accessibility of information, ability to contact others immediately, increased feelings of connectedness and social interaction. Besides, these devices are generally considered as repositories for memory (Ibrahim, 2017; Mazzoni, 2019). Indeed, they are capable of performing numerous cognitive activities for us (e.g., phonebooks, appointment calendars, internet portals, tip calculators, maps etc.) and of satisfying our affective urges (Wilmer et al., 2017). But what are the consequences of relying more on smartphones than on our memory?

The available evidence suggests that frequent use of mobile technologies has negative effects on our attentional, memory and learning skills (see Wilmer et al., 2017 for a recent review). For example, Jamal et al. (2012) showed that a sample of medical students reported experiencing memory impairment (56.8%), sleep disturbances (61.7%), chronic headache (22.5%) and concentration problems (22.5%) due to mobile phone use. Furthermore, cell phone use has obvious negative consequences such as delayed reaction times, inattentional blindness, increased traffic accidents due to distracted driving (see Caird et al., 2008 for a meta-analysis). More surprisingly, navigation system use - which is also a commonly used functionality of smartphones - while driving was found to impair “cognitive map building”, which is the acquisition of environmental spatial knowledge (Burnett & Lee, 2005).

Excessive involvement of smartphones in our daily activities caused a dramatic increase in multitasking (Cauwenberge et al., 2014). Much of the current correlational research on media multitasking have found that heavy media multitaskers perform worse in several cognitive domains including attention and working memory tests (see Uncapher & Wagner, 2018 for a recent review). Similarly, frequent media multitaskers seem to exhibit greater impulsivity and sensation seeking along with poorer working memory performances (Sanbonmatsu et al., 2013).

This entire chapter aims to be a snapshot of the current literature regarding the association between smartphone technology and its influence on human cognition. We will start by introducing important points regarding problematic smartphone use such as smartphone separation anxiety, nomophobia, or fear of missing out. The sections that then will follow will focus on the observed effects of mobile technologies on cognitive functioning.

3.2 Smartphone separation anxiety

Smartphone owners seem inseparable from their phones. Previous research showed that 91% of users report that they never leave home without their phones (Deutsche Telekom, 2012), and one-half of owners describe their device as something that they could not live without (Perrin, 2017). This type of attachment allows cellphone users to hold on to the impression that they are constantly connected to the world and therefore feel themselves less lonely (Srivastava, 2005). According to a very recent study, smartphones can serve as a source of psychological comfort for owners. In a sense, one’s smartphone functions like an “adult pacifier” (Melumad & Pham, 2020).

Even if smartphone addiction has been considered to have much in common with Internet addiction, unlike computers or laptops the portability and ubiquitous nature of smartphones allow users to stay connected to the Internet regardless of time and space (Jin Jeong et al., 2020). This constant connectivity afforded by mobile technology induces itself a preoccupation; an overwhelming majority of users are continuously checking their phones for calls and texts, and report they could not go without their phone for one day (Poll, 2012; Thornton et al., 2014).

But why does smartphone separation cause discomfort, anxiety, and potential cognitive impairment? A theory postulates that smartphone separation anxiety arises from “fear of missing out”, which is described as concerns in relation to being out of touch with an interesting event, experience, or conversation within one’s social circle (Przybylski et al., 2013).

Another theoretical explanation for the anxiety caused by smartphone separation is the “extended self theory” which proposes an individual’s possessions can become an extension of one’s self (Belk, 2013). In line with this notion, smartphones can be perceived as an extension of the physical self, and thus separation from one’s phone is likely to trigger perceived loss of self, which in turn causes anxiety (Clayton et al., 2015).

In addition to these theories, a new psychiatric condition related to smartphone dependency was defined and termed “nomophobia”. This contemporary pathology is closely associated with mental health, internet addiction, and behavior modification (see Rodriguez-Garcia et al., 2020 for a systematic review). It is characterized by pathological fear, anxiety, or discomfort related to being out of contact with one’s smartphone (King et al., 2013). Not surprisingly, in a survey (SecurEnvoy, 2012) carried out in the United Kingdom, 66% of smartphone users reported experiencing nomophobia.

Smartphone separation appears to have not only emotional but also cognitive consequences. Recent studies have shown that simply asking participants to put their smartphones out of sight is associated with heightened anxiety levels (Cheever et al., 2014). For instance, Clayton et al. (2015) observed in a group of college students that being unable to respond to one’s ringing smartphone activated the aversive motivational system which led to an increase in heart rate, blood pressure and feelings of unpleasantness, as well as a decline in the performance during a cognitive task. Similarly, Hartanto and Yang’s (2016) study showed that smartphone separation significantly increased state anxiety and impaired higher-order cognitive processes, such as executive functions in college students.

3.3 Cognitive impairments associated with mobile phone use

Aside from psychological and behavioral impacts of mobile technologies including smartphones, the use of these devices appears to have deleterious effects on cognitive functioning. In this section we will present an overview of the empirical research concerning this topic.

Research in the educational sphere has shown that the use of cell phones can disrupt learning processes and as a result can impair academic performance. For instance, results of a study indicated that participants’ academic performance was impaired by cell phone rings (End et al., 2009). Another research identified a negative relationship between the use of electronic media, including cell phones, and academic performance among first year university students in the United States (Jacobsen & Forste, 2011).

Because working memory is considered a limited resource, the distraction from mobile phones would make it difficult to encode learning material properly or take notes accurately during classes (Peverly et al., 2012). In accordance with this view, using cell phones and social media while learning new material was found to impair academic performance by reducing comprehension (Froese et al. 2012). Recently, Aharony and Zion (2018) tested the distractions of WhatsApp (which is a main mobile instant messaging app that enables smartphone users to send real time, cost-free messages) text messages on working memory performance in adolescents. The results of this controlled study showed that WhatsApp distractions decreased participants’ performance in the working memory tests used.

Stothart, Mitchum, and Yehnert (2015) found evidence that cellular notifications can damage performance on an attention demanding task even if one does not directly interact with the device during the task. The authors stated that although the cellular notifications are generally short in duration, they can prompt task-irrelevant thoughts or mind wandering which may persist beyond the duration of the notifications themselves. More surprisingly, Thornton et al.

(2014) showed that the mere presence of the cell phone itself, even if not being used, could serve as a distractor. This resulted in diminished attention and deficits in task-performance, especially for tasks with greater attentional and cognitive demands.

According to Ward, Duke, Gneezy and Bos (2017), cognitive impairments associated with cell phone use may simply occur due to the diversion of conscious attention away from a focal task. However, what may be special about smartphones is the frequency of these diversions. The authors proposed that smartphones might occupy part of the limited capacity cognitive resources for purposes of attentional control. Across two studies, they established that the mere presence of smartphones was enough to impair the participants' cognitive performance. Note that waiting to respond or to check calls, text messages or notifications from smartphone apps may itself disrupt attention performance (Stothart et al., 2015). Thus, the omnipresence and personal relevance of smartphones seem to create a potent shift on the orientation of attention.

3.4 Do we rely on external memories?

The idea of humans as "cognitive misers" has been a long tradition of reasoning research (Tversky & Kahneman, 1974; Stanovich, 2009). Since information does not necessarily need to be stored within the neural structures of the human brain to be recalled (Storm, 2019), the concept of "cognitive offloading" particularly can form a basis for this idea of miserliness in human cognition. Cognitive offloading refers to the use of physical action to change the information processing requirements of a task in order to reduce cognitive demand (Risko & Gilbert, 2016). We rely on the external environment to do this; noting an upcoming event to a paper, or - in recent times – to smartphone calendars as reminders is a common way of engaging in cognitive offloading.

As it is well-known, our unaided mental abilities do have limits. For instance, we fail to notice visual changes to scenes or objects (Simons & Levin, 1997), or can actively hold a limited amount of information in working memory system (Cowan, 2010). Offloading cognition, in this sense, reduces cognitive demand on memory because it reduces demands on internal storage (Hu et al., 2019). Further, it helps us to overcome such capacity limitations while minimizing computational effort to achieve our cognitive goals (Risko & Gilbert, 2016).

Another important aspect to address is cognitive miserliness in the age of the Internet. Arguably, no recent technology has had a more profound effect on human memory than the Internet (Storm & Soares, in press). The Internet has become an external memory system, where information is stored collectively outside of ourselves (Sparrow et al., 2011).

As in all types of transactive memory systems including the Internet, individuals do not need to remember the information that is saved, rather they merely need to know who knows it or where to find it (Storm & Soares, in press). In a very influential publication by Sparrow et al. (2011), the effects of "Google search" on memory was tested. A series of experiments showed that when the participants were told that the information would be saved on a computer, they remembered it less well than when they believed it would not be saved on a computer. More importantly, Sparrow et al.'s results suggested that once information has been accessed, our internal encoding is increased for where the information is to be found rather than for the information itself. Finally, the authors concluded that this effect occurs as the brain is adapting to new technologies and with greater use of transactive memory through these technologies.

More recently, Barr, Pennycook, Stolz, and Fugelsang (2015) predicted that individuals who are relatively less willing or able to engage in effortful reasoning processes may compensate by relying on the Internet through their smartphones. Across three studies, it was confirmed that those who were less analytical and more intuitive reasoners, were more likely to rely on their smartphones to access information. Hence, this pattern of results suggested that the use of smartphones can be considered as a modern form of cognitive miserliness.

Overall, today, individuals seem to allow their smartphones to do their thinking for them. The technological properties of smartphones provide an exciting and interesting new means of externalization of memory (Barr et al., 2015). The Internet which is an integral function of the smartphones as well, remains a potent external memory source.

CHAPTER 4

SMARTPHONE PHOTOGRAPHY

4.1 Introduction

The appearance of smartphones with digital cameras has led to an explosion in photography such that the vast majority of photos are now taken using smartphones (Storm & Soares, in press). While the amount of digital photos taken worldwide continue increasing exponentially, one previous data forecasting revealed that over 1.3 trillion photos would have been taken worldwide by 2017, 79% of which were captured via camera phones and smartphones (Heyman, 2015). Therefore, personal photo collections rapidly grow out of control, even curating such photo collections has become a challenge (Van House, 2011).

One of the earliest studies on the use of camera phones was by Ito and Okabe (2003). The authors conducted detailed case studies with camera phone users to understand how those cameras are being used in everyday life. The authors noted this: “Unlike the traditional camera, the camera phone is an intimate and ubiquitous presence that invites a new kind of personal awareness, a persistent alertness to the visually newsworthy that makes amateur photojournalists out of its users.”. In line with this view, in Zhang’s (2017) study, narratives from semi-structured interviews with a Chinese sample suggested that the enthusiasm for photography is associated with the adoption of the smartphone, particularly for those who have no expertise in photography.

With the proliferation of picture taking by using smartphone cameras, personal photography has become an integral part of modern life (Murray, 2008). People have the desire of capturing every memorable moment in their lives and sharing these photographs through social networks. Therefore, smartphone photography has been used as a memory aid, as a tool to document life events and as media to communicate with the social environment (see Chen et al., 2016).

The considerations reported in this chapter, which represent an inspiration for this dissertation project, aim to address the concept of photography in the age of smartphones and its relation with human memory. The first section will start with the timely, controversial topic of the intentions behind captured images by using smartphone cameras. Why do millions of people constantly share their photos online via social media platforms? The next section will consider this topic from a historical perspective by explaining what has changed in the transformation era of digital photography. Finally, the last section will introduce the photo-taking-impairment effect, with a detailed literature review on the effects of photo taking on memory.

Figure 2. Tourists at the Louvre in Paris (Czapsky, n.d.).

Figure 3. People take photos on smartphones as Pope Francis greets the crowd (Haring, 2016).

4.2 Intentions behind photo capturing and sharing practices

With the growth of social media, online photo sharing has become an increasingly popular phenomenon (Oeldorf-Hirsch & Sundar, 2016). More than half of all Internet users share photos and videos online, and a considerable number of smartphone owners use specific photo sharing applications such as Instagram or Snapchat (Duggan, 2013). The most popular genres of smartphone photography include (Zhang, 2017): (i) food pictures; it is fashionable to take pictures of food with a smartphone and share them on the general social network, (ii) selfies, which is a digital version of a self-portrait and (iii) screenshots; they are non-photographic images that typically provide information in the form of texts and screenshots of operations, notes, or text messages.

Not surprisingly, photo taking appears to increase enjoyment of experiences. To cultivate the photography enthusiasm of smartphone users, smartphone corporates regularly organize smartphone photography competitions and workshops led by well-known photographers (Zhang, 2017). In a study, Diehl, Zauberman, and Barasch (2016) investigated how photography influences evaluations of experiences. Their results showed that, relative to not taking photos, photo taking can heighten enjoyment of positive experiences by increasing engagement. Furthermore, according to Storm and Soares (in press), positive experiences might be more likely to be posted to social media than negative or neutral experiences. In this sense, use of social media might even reinforce the bias toward positivity in autobiographical memory.

Previous studies investigated people’s motives and intentions in both taking and reviewing photos. An earlier research aimed to understand how people use their camera phones (Kindberg et al., 2005). It involved the collection and examination of images captured or received by camera phone users combined with in-depth interviews. Based on their findings, the authors explained the reasons for capturing images in two main categories: affective reasons versus functional reasons. *Affective images* were those captured for some sentimental or emotional reason. For example, the most common social reason for capturing an affective image was to enrich a mutual experience by sharing an image with those who were co-present at the time. Whereas *functional images* were taken to support a particular task, which made them more practical in nature. Here are few examples given in that study: a couple took a picture of pipes in discussing a plumbing task; one woman captured gift ideas in a shop; a man took an image of a whiteboard to remind himself of comments from a meeting.

Evidence from another study supported the idea that people use photography primarily for social purposes (Oeldorf-Hirsch & Sundar, 2016). In a series of interviews, Lux, Kogler and del Fabro (2010) aimed to find out the actual and explicit motivations of participants for taking photos in situations that best exemplified their photo-taking behavior. Their participants reported an intention to capture precious moments in high quality to share them with other people or just to be capable of looking at them later.

Photographs could never be qualified as realistic sources of personal memory; yet nowadays the smartphone camera allows more control over our memories by allowing us to manipulate our pictures (Van Dijck, 2008). In this sense, posting photos of oneself is a common practice today, and the ability to post carefully selected photos that may be digitally altered using online tools for photoshopping would result in developing unrealistic beauty ideals (Mabe et al., 2014). As a result, social media use may for example increase the risk of developing eating disorders through reinforcement of the "thin-ideal" (Rodgers & Melioli, 2016). This is particularly true because those platforms emerge as highly interactive and self-exposing, with others commenting on postings in a public manner (McLean et al., 2015). For example, a study found that higher levels of body-related and eating concerns were present for participants engaging in more online photo sharing, and higher frequency of photoshopping before posting their photos online (McLean et al., 2015).

4.3 What has changed in the era of digital photography?

For generations, people have captured photographs as a way to remember their past experiences (Chalfen, 1998), and thus documentation of life (e.g., photo albums) has been known as one of the primary functions of photography (Oeldorf-Hirsch & Sundar, 2016; van den Hoven & Eggen, 2014). Particularly, in the era of analogue photography, personal photos served as cues for autobiographical remembering, and archiving the family history (Broekhuijsen et al., 2017). However, with the advent of digital cameras, the primary role of photography has shifted from capturing special events and family life to communicating with one's social environment

(Kindberg et al., 2005). Concerning this transition, Sarvas and Frohlich (2011) suggested: "Communication has surpassed memory as the primary function of photography" (p. 133).

A revolution in the technology of photography has happened with the increased availability of digital cameras which altered the ways of capturing, organizing, and accessing photos (Whittaker et al., 2010). In the past, one would usually have small numbers of pictures associated with an event because of its high cost (Frohlich et al., 2002). Whereas today's digital pictures are extremely inexpensive to both capture and store compared with their analogue counterparts (Whittaker et al., 2010).

Smartphones play a key role in this transition from the analogue to the digital era, as they offer convenient and quick photo capturing and sharing options (Zürn et al., 2017). As a result, there is an increasing number of photos stored on smartphones and the default mode of personal photography becomes "sharing" (Van Dijck, 2008). The obvious changes resulting from smartphone camera technology can be specified: greater frequency of camera use, larger volume of photographs, higher level of discards and cheaper cost of production (Keightley & Pickering, 2014).

Nevertheless, photos are still considered as potent external memory cues that are able to trigger autobiographical recall. The distribution of digital photographs to wider audiences does not necessarily decrease photography's function as a vehicle of memory (Keightley & Pickering, 2014). Rather, the function of memory reappears in the networked nature of digital photographs, as most images are sent over the internet and stored in virtual space (Van Dijck, 2008).

4.4 Mnemonic effects of the act of taking photographs

In what ways does photo taking affect human memory? In this section, we will present an overview of the previous research on this topic in chronological order. The decision to use a chronological order is because, both theoretically and empirically, this is a very premature area of scientific work, and yet our knowledge on this research question continues to gradually improve.

A limited number of experimental studies on the topic of mnemonic effects of taking photographs have been published so far. The first major study on this topic comes from Henkel (2014), where she examined whether photographing objects impacts what is remembered about them. Two experiments took place in a real museum exhibit and each participant was instructed to take photos of certain objects (art pieces) while only observing the others. Meanwhile, they were told to pay attention to the objects as they would later be tested about their memory for those art objects. The next day, memory for all objects was assessed using several tests, including a multiple-choice visual detail test, a visual recognition test, and a verbal recognition test. In the first experiment, participants' memory for photographed objects was compared with their memory for non-photographed objects. Whereas in the second experiment, the participants were given extra time to view the objects which they were supposed to photograph. However, this time the participants were asked to either photograph the whole object or taking the photo by zooming in on one specified part of the object, or to only observe without photographing them. Henkel's findings showed that the photographed objects were less well remembered than the observed objects, a phenomenon referred to as "photo-taking-impairment effect". This effect was replicated in the second experiment as well, but only when objects were photographed as a whole. Instead, the photo-taking-impairment effect was attenuated when participants used the camera's zoom function to focus on a specific part of an object while photographing it. Based on her findings, Henkel speculated that this impairment could be a result of offloading memory, with people not needing to remember the photographed objects because they can safely rely on the camera's prosthetic memory.

Nowadays, cheap digital storage put no bounds on the number of images such that one can capture millions of pictures with one's camera phone during an event (Niforatos et al., 2014;

Whittaker et al., 2010). In 2014, Niforatos and his colleagues proposed a new research in which they aimed to re-introduce the concept of old film camera in the context of modern smartphones. They wanted to explore how users would behave when they had a photo capture limitation. The authors postulated that a photo capture limitation will lead smartphone users to be more engaged with the act of photo-taking. Finally, in 2017, Niforatos and his colleagues published a paper in which they investigated the effect of photo capture modality (i.e., limited, unlimited and automatic) on people's ability to recall a past event – with and without revisiting the pictures captured through these modalities. Contrasting limited and unlimited picture capture was an attempt to understand whether fewer images will lead to better memory cues. In line with their prediction, the data from the field experiment showed that having the possibility to capture only a limited number of photos may lead to photos with increased memory value. More importantly, their findings confirmed Henkel's photo-taking-impairment effect. However, this effect was not observed when participants used a body-worn automatic lifelogging camera, suggesting that the photo-taking-impairment effect can be attributed to the act of photo-taking, rather than to the presence of an external memory support (Niforatos et al., 2017).

In another study, Barasch et al. (2017) examined the effect of volitional photo taking on memory for both visual and auditory aspects of experiences. Contrary to Henkel's and Niforatos's findings, in their several experiments Barash et al. showed that photo taking can in fact boost memory for visual content. In this study, participants were assigned to camera and no-camera conditions. Note that, unlike in Henkel's, the participants *had not been informed* about the memory test before touring the exhibits. When memory for the art pieces was assessed using auditory and visual recognition tests, participants who took photos remembered visual, but not auditory, aspects of their experience better than did participants in the no-camera condition. This benefit of the visual memory could have been driven by item effects since they got to photograph the art objects volitionally (or by motivation). Here, Barasch and her colleagues argued that volitional photo taking improves visual memory by directing attention to what individuals consider photo-worthy visual aspects of experiences, rather than the auditory aspects. One potential explanation for the discrepancy between the results of the studies mentioned so far refers to the role of volition (Storm & Soares, in press). Choosing what to photograph seems to help focus visual attention and intensify engagement with the experience. And not just that. For example, we have seen that having an automatic camera like SenseCam does not interfere with remembering experiences, whereas taking photos seems to do so (Hodges et al., 2006; Lee & Dey, 2007; Milton et al., 2011). This result suggests that the impairment effect is not due to the possibility of taking photos, per se, but to the active engagement of the individual in taking the photos. The engagement might then have also a negative effect on memory, not only a positive one as suggested by Barasch and collaborators, and Storm and Soares.

The Photo-taking-impairment effect has been explained also by an offloading account, such that taking photos allows people to strategically offload the task of remembering onto the camera's prosthetic memory. Hence, photographed content may be processed less deeply in memory than non-photographed content because of the accessibility of revisiting. Soares and Storm (2018) tested this hypothesis across two experiments by manipulating whether participants would perceive photography as capable of serving as a form of offloading. In the first experiment, participants used the application Snapchat which allows its users to share temporary photos and videos. In the second experiment instead, participants manually deleted photos after taking them. In both experiments, a photo-taking-impairment effect has been observed even when the participants did not expect to have later access to their photos. These results suggest that cognitive offloading is not a reasonable hypothesis for the photo-taking-impairment effect. The authors concluded that an alternative explanation of the photo-taking-impairment effect is attentional disengagement. According to this hypothesis, picture taking may cause people to limit or disengage their attention during encoding, an effect that is assumed to take place regardless of whether participants believe the photos are being saved or not.

Lastly, not only the mnemonic effects of the act of taking photos but also the effects of reviewing and editing photos on people's memory has become a relevant topic for research. Several studies indicated that when people are exposed to photos that have been doctored by someone else, their beliefs about and memories of events depicted in the media and of their own autobiographical experiences can be reconstructed to accept the false information (e.g., Hessen-Kayfitz et al., 2017; Sacchi et al., 2007; Wade et al., 2002). A very recent study by Henkel and Milliken (2020) examined whether reviewing and self-doctoring photos alters people's memory for their original experiences. While applying a grayscale filter did not alter participants' memory, they were impoverished at recalling what objects they previously cropped out. Reviewing unedited photos helped them better remember the visual details compared to when they reviewed edited photos. Their findings suggest that reviewing and editing photos can shape what is remembered depending on the type of editing (cropping objects vs color filtering) and reviewing (edited vs unedited photos), and its corresponding cognitive demands.

4.5 Research objectives of the current studies

The main research objectives of the three empirical studies contained in the present dissertation were:

1) *To investigate the photo-taking-impairment effect of which several contradictive findings were reported in the literature, and in particular*

   In the first two experiments we examined whether the knowledge about an upcoming memory test affects the photo-taking-impairment effect. For this purpose, the experimental procedure and measures of the first two experiments were kept identical with the exception that participants' encoding condition was manipulated by giving intentional versus incidental instructions prior to the encoding phase. A computer-based experiment was conducted to test the mnemonic effects of manually taking photographs, and participants were randomly assigned to one of the three groups (no-photo, one-photo, and 8-photo groups) by which we aimed to explore the role of number of photos taken on recognition memory. During the presentation of a mock museum tour in our laboratory, participants - depending on their group - had to observe, take one photo of each painting, or take multiple photos of each painting. Participants in the one-photo group or in the 8-photo group were expected to exhibit lower memory accuracy scores at a later recognition task compared to the participants in the no-photo group, due to the photo-taking-impairment effect. For the same reason, we also expected to measure slower reaction times (as another indicator of a memory impairment) in response to cue images in the both one-photo and 8-photo groups than in the no-photo group.

2) *To determine possible causes of the photo-taking-impairment effect by exploring whether the memory impairment observed in memory retrieval is due to poor encoding rather than merely poor retrieval strategies*

   A third experiment was conducted to shed light on the mechanisms behind this type of memory impairment. The role of encoding strength and object detail was tested by presenting for half of the retrieval cues zoomed-in partial details of the original painting rather than the whole painting. The participants in the 8-photo group (a one-photo group was not included this time) were expected to exhibit lower memory accuracy scores at a later recognition task compared to the participants in the no-photo group, due to a limitation or a shift in attention caused by the act of taking photographs, which would in turn lead to poor encoding. In addition, for the within group effect, we hypothesized that if the memory impairment occurs due to poor encoding, the participants in the photo group should be less accurate in their responses to the cues that are zoomed in, rather than to the cues that are not zoomed in. Furthermore, we also changed one parameter which we called *time for recognition* to examine whether reaction times would differ under time pressure. To manipulate this variable, half of the participants of this experiment was given limited time to respond to yes/no recognition questions whereas the other half was given self-paced time to respond. By doing so, we expected to find that a limited time would increase the photo-taking impairment effect as an effect on encoding. In this experiment we wanted also to measure the slowest reaction times occurring in response to the cues when participants had to take multiple photos at encoding, completed the recognition task under time pressure and viewed the zoomed-in details as cues (zoomed-in in the center of the image). These predictions were based on the consideration that the encoding strength would be poorer in the photo group, and hence when recognition time is kept self-paced, people might rely more on familiarity with the painting that drives a longer memory search. In these conditions, finding the target in memory becomes even more problematic, and thus time consuming, when one is presented with a zoomed detail of a painting instead of the entire painting.

One main contribution of this project is to determine whether the photo-taking-impairment effect occurs with/without an expectation of a memory test (by giving intentional vs incidental encoding instructions). Another novel contribution is that response times in making memory decisions are examined here, which has not been studied in prior studies. These two variables (the expectation of a memory test; response times when making old/new recognition judgments) can shed light on encoding and retrieval processes in episodic memory.

Lastly, each participant of this study was instructed to rate their confidence right after making memory decisions. Those ratings along with their relative reaction times were calculated and then various comparisons were made between confidence in memory and other variables of this study. None of the prior studies investigating the photo-taking-impairment effect has included a detailed analysis of the role of metacognitive variables at retrieval, such as confidence in one’s memory as in our study. We believe that confidence in memory may serve as a valuable variable concerning our topic, in the sense that it is an indicator of how good a memory is being subjectively recognized.

CHAPTER 5

EXPERIMENT I

5.1 Introduction

The present experiment sought to explore the existence of a hindering effect of photography on memory encoding and/or retrieval. Although Henkel (2014) termed this phenomenon as "photo-taking-impairment effect", not all subsequent studies after hers have confirmed such an effect (e.g., Barasch et al., 2017). Therefore, our specific aim was to test whether the act of photo taking can indeed lead to a memory impairment. Our methodology slightly differed from most of the previous work on this topic. Instead of testing at a real-life museum tour, we chose to conduct laboratory experiments, and this made it possible to control for potential confounding variables. We preferred stronger control of potentially confounding variables to a more ecologically valid setting.

Using a computer-based experiment to test the mnemonic effects of manually taking photographs allowed us to hold the experience and its encoding time constant across conditions. Subjects were presented a mock museum tour with several paintings taken from a real museum (Metropolitan Museum of Art), and depending on the condition that they were assigned to (no-photo, one-photo and 8-photo groups), they were directed to follow the specific instructions (described in Procedure section below) during the experience. Shortly after the tour (encoding phase), we examined their behavioral performances on a memory test (recognition phase).

Importantly, we ensured that an intentional acquisition took place in this first experiment; all participants were asked to pay attention to the visual aspects of those artworks during the experience and told that they would later be tested for their memory. It was hypothesized that the three participant groups would differ (1) in the amount of their accurate responses in the recognition task, (2) in the mean reaction times in response to the retrieval cues in the recognition task, and (3) in the confidence ratings showing how certain they were about their recognition responses.

5.2 Methods

5.2.1 Participants

A total of fifty-four participants including mostly undergraduate students and researchers from Sapienza University of Rome were recruited to this study (31 females and 23 males, age range: 18-35 years, M = 26.37). The experiment was open to all people who were between 18 and 35 years. Participation occurred on a voluntary basis and nobody received any compensation for their participation. The participants were also informed that they have the right to withdraw at any time if they would not be comfortable with the study. Informed consent was obtained from all participants, with all procedures approved by the Ethics Committee of the Department of Dynamic and Clinical Psychology, Sapienza University of Rome. All participants had normal or corrected to normal vision.

Each participant was randomly assigned to three experimental groups:

- no-photo group (n=18) - simply observe a mock museum tour,
- one-photo group (n=18) – to take only one photo of each artwork on the tour,
- 8-photo group (n=18) – to take multiple photos of each artwork on the tour.

5.2.2 Materials

Mock Museum Tour: We created a computer-based laboratory paradigm for the presentation of a mock museum tour. A stimulus set for the mock museum tour was compiled with various paintings taken from Metropolitan Museum of Art open access collection (Metropolitan Museum of Art [MET], n.d.). The collection of those artworks was filtered based on specific criteria; only the oil paintings belonging to various European artists, between 17th to 20th centuries were chosen. To avoid any types of experimental errors arising from the effect of image feature itself, we categorized all paintings as female portraits, male portraits, groups of people, animals, landscapes and still life paintings and had an equal number in each category.

Each museum tour consisted of 36 photos out of the 54 original oil paintings initially selected presented in a random order. The remaining 18 paintings were presented as novel memory cues in the recognition phase. At recognition, all 36 paintings (18 novel & 18 old) were presented in counterbalanced order. All participants experienced the museum tour for the same duration, regardless of their condition.

Erikson Flanker Task: Attentional skills were assessed by using a variation of the *flanker paradigm* because it allows experimenters to measure reaction times to both compatible and incompatible conditions, and the flanker effect, thus providing more data on attentional skills of each individual participant. This task was used as an exploratory variable compared to the key variables of this study. We aimed to test participants' attentional skills before presenting the encoding procedure, with the idea that the photo-taking-impairment may stem from an attentional

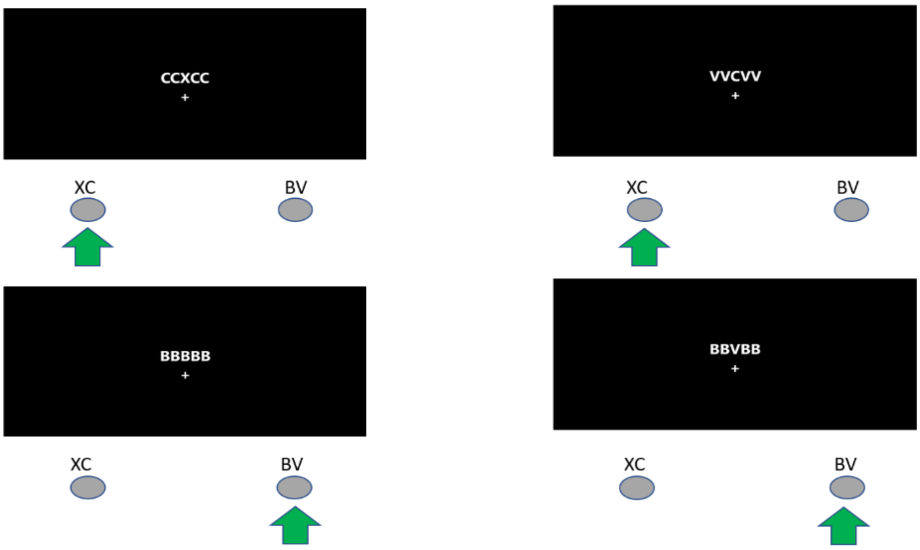

Figure 4. Illustration of the Flanker task. The target is the central letter which is above the fixation point. Letters X and C correspond to the left response key and need to be responded to with the A button of the keyboard, while letters B and V correspond to the right response key and need to be responded to with the L button of the keyboard. If there is a mismatch

disengagement due to the act of taking photos, and that participants with higher scores in the Flanker task would show attenuated photo-impairment effects. The flanker task was prepared on E-prime, using a letter paradigm (see demo; “Flanker task”, 2018) where the participants saw 5 letters appearing above the fixation point, and they only had to respond to the central letter. The critical trials lasted approximately 3 min, with a preliminary practice trial of 8 items (4 items responded with left key, e.g., 2 C and 2 X, and 4 items responded with right key, e.g., 2 B and 2 V).

<u>Self-Report Measures:</u> For exploratory purposes, we preferred to add subjective measures considering people’s smartphone habits, as there might be a link between problematic cell phone use and the photo-taking-impairment effect. To screen for cell phone use and problems due to excessive cell phone use, three paper-based questionnaires were presented:

1) *Problematic Mobile Phone Use Questionnaire - Short Version (PMPUQ–SV):* 15-item PMPUQ-SV has been found to be an appropriate psychometric tool to assess problematic mobile phone use for cross-cultural research (Lopez-Fernandez et al., 2018). Each item (e.g., “It is hard for me to turn my mobile phone off”, “I use my mobile phone where it is forbidden to do so”) is scored from 1 (‘I strongly agree’) to 4 (‘I strongly disagree’), except for the items that are reverse scored. Overall scores range from 15 to 60, with higher scores indicating more potential negative effects due to mobile phone use.

2) The Smartphone Addiction Scale Short Version (SAS-SV): 10 item SAS-SV yields a total score that is indicative of the severity of smartphone addiction. It consists of six factors (daily-life-disturbance, positive-anticipation, withdrawal, overuse, tolerance, and cyberspace-oriented relationship) which are accessed through 10 items (De Pasquale et al., 2017). It is responded on a six-point Likert scale (1: “strongly disagree”, 2: “disagree”, 3: “weakly disagree”, 4:

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between the flanking letters their response and the response required by the central letter, we speak of a "incongruent" or "incompatible" condition.

“weakly agree”, 5: “agree”, and 6: “strongly agree”) with higher scores indicating more severe addictions. Higher scores than the cut-off values (31 for males and 33 for females; see Kwon et al., 2013) are considered as high-risk for smartphone addiction.

3) *Perceived Attachment to Phones Scale (PA):* It is a five-item mini self-report assessment developed to measure perceived attachment to one’s phone (Weller et al., 2010). Sample items include: “I would feel lost if I didn’t have a cell phone” or ‘‘I would rather lose my wallet than my cell phone’’. The items are responded on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores can range from 5 to 25 with higher scores indicating greater possession attachment toward one’s cell phone.

Memory Test: To test the effect of capturing photos on memory, all participants of this study were given a computer-based recognition task. It consisted two sub-tasks: (1) In the first task it was required to give yes/no responses in response to presented stimuli. Therefore, 36 out of 54 paintings were provided as memory cues; 18 paintings from the mock museum tour and 18 novel paintings were presented. Paintings (including their categories) were counterbalanced across participants. (2) In the second task participants were asked to assess their own memory performances on a 1-6 confidence scale by stating how certain they were that their response to each painting was correct. The presentation of 36 out of 54 paintings were identically repeated; 18 paintings from the mock museum tour and 18 novel paintings were counterbalanced across participants.

5.2.3 Procedure

Experiment I consisted of two sessions. In Session 1, participants were given a mock museum tour with the presentation of 36 of 54 paintings, all counterbalanced so that all 54 paintings were used across participants. All participants experienced the same type of tour, with an equal duration for each painting (10 sec per painting) regardless of their experimental conditions. The exposure time was kept similar to the one in Soares and Storm’s (2018) study which was 15 sec for each stimulus. Participants in one-photo and 8-photo conditions were instructed to take photos by using their own smartphones during the museum experience. Note that participants in the 8-photo condition had a restriction of taking 8 photos for each artwork, as one can roughly take 8 photos in 10 sec with a smartphone camera. Prior to the mock museum tour, all participants had been informed about the memory test they would be given in next session. Thus, this was an intentional acquisition procedure.

Participants were seated at a viewing distance of 60 cm from a PC monitor. The stimuli were presented using E-Prime professional 3.0 software (Psychology Software Tools, Pittsburgh, PA). Before starting the mock museum tour, all participants completed a letter flanker task. Immediately after, the presentation of the museum tour started; each trial started with a fixation cross for 500 ms followed by the stimulus presentation for 10 sec with each slide advancing automatically. The photos of the original oil paintings were high quality and they were presented full screen.

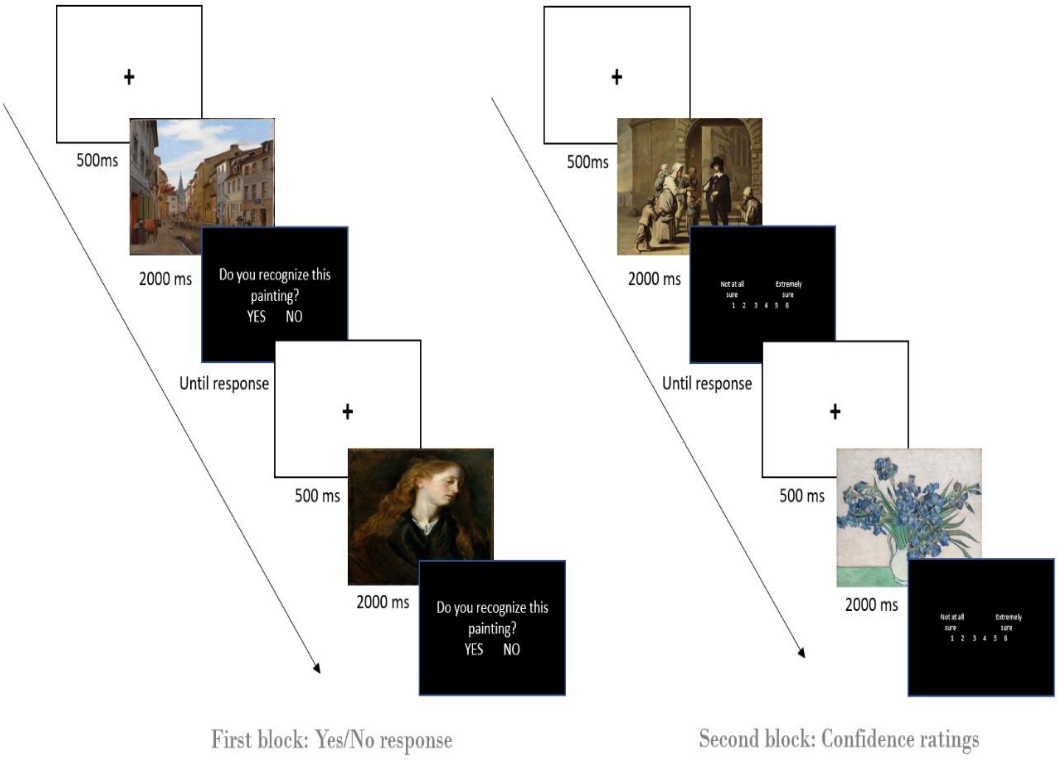
The specific instructions for each experimental condition are presented below:

No-photo condition: "Turn on the airplane mode of your cellphone and place your cellphone next to you face down on the desk. Then, look at the painting on the screen."

One-photo condition: "Turn on the airplane mode of your cellphone and keep it in front of you with the application Camera on. When you see the fixation cross appears, hold the phone to get ready to take the one photo you need to take. As you have taken the photo, put your phone down on the desk and continue to look at the painting on the screen, then when you see the next fixation cross, hold the phone in front of your eyes, get ready for the photo-taking. And do this for each fixation cross you see, which will be followed by a painting."

8-photo condition: "Turn on the airplane mode of your cellphone and hold your cellphone with the application Camera on, in front of you. When you see the fixation cross, hold the phone to get ready to take the eight photos of the painting you need to take. Continue to look at the painting through your cellphone. Be sure to have your cellphone on the photo setting all the time, so to be able to look at the screen through your phone all the time.”

During a 10-min delay following the museum tour (equal delay as in Soares & Storm, 2018), participants were given the self-report questionnaires described in the Materials section above. Immediately after filling out those questionnaires, participants were asked to turn back to the computer monitor.



First block: Yes/No response

Second block: Confidence ratings

Figure 5. Recognition task. The first task during retrieval required participants to give yes/no answers in response to the presented images. In second task, they were asked to rate images according to their confidence about their memory performance from 1 (not at all sure) to 6 (extremely sure). Each trial was launched with a 500ms fixation cross followed by an image presentation for 2000 ms.

In Session 2, participants performed a recognition test about the museum tour experience (see Figure 5). The recognition test consisted of two tasks as mentioned above in the Materials section. In the first recognition task, participants were presented a block of 36 randomized paintings respectively - 18 paintings from the previous museum tour and 18 novel paintings. Each trial was started with a 500 ms fixation cross and then was followed by a stimulus presentation lasting 2000 ms, which was also preceded by a new slide asking whether the subject remembers that painting from the previous museum tour ("Do you recognize this painting?"). The same procedure was repeated, for all 36 paintings. Note that that slide was set to infinite time, thereby participants were not able to skip and perform the next trial before giving their recognition responses. Response timing was self-paced. The task was to pay attention to each stimulus and to make yes/no recognition decisions whether each photograph portrayed a painting seen in the actual tour. Responses were given by pressing a 'yes' or 'no' key on the keyboard.

In the second recognition task (confidence ratings), each trial was again started with a 500 ms fixation cross and then was followed by a stimulus presentation lasted 2000 ms. All items in the first block were re-presented and participants were asked to rate their confidence in each recognition decision on a 6-point scale (see Figure 5). A block of 36 trials were presented in random order. The software recorded reaction times, along with recognition decisions and confidence ratings, that were subsequently analyzed.

5.2.4 Statistical Analyses

All statistical analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics, Version 25.0. Armonk, NY). All tests used the General Linear Model (ANOVA) and correlations. Post-hoc comparisons were conducted using additional t-tests as these are suitable statistical techniques to investigate the statistical relationships between one or several independent variables and one continuous dependent variable (Tabachnik & Fidell, 2005). Post hoc analyses were also conducted for multiple comparisons using Tukey's HSD test. Pearson's correlation coefficient values were calculated for correlational analyses. Statistical values were considered significant at a final corrected alpha level of .05.

5.3 Results

One-way analyses of variance (ANOVA) with three levels (no-photo, one-photo, 8-photo) were run to investigate differences in Flanker task performance, memory test performance, confidence ratings and response times. Other analyses were used for other data.

Recognition Accuracy and Recognition Reaction Time Analyses

The one-way ANOVA analysis revealed a photo-taking-impairment effect, as participants' correct recognition about the artworks was significantly lower in the 8-photo condition compared to one-photo and no-photo conditions. There was a significant main effect of Group on memory accuracy, *F*(2,51) = 7.99, *p* = .001. Participants in the 8-photo condition correctly recognized fewer paintings as old or new (*M* = 28.5, *SD* = 3.6) than the participants in no-photo condition (*M* = 32.4, *SD* = 3.01) and in one-photo condition (*M* = 32, *SD* = 3.01).

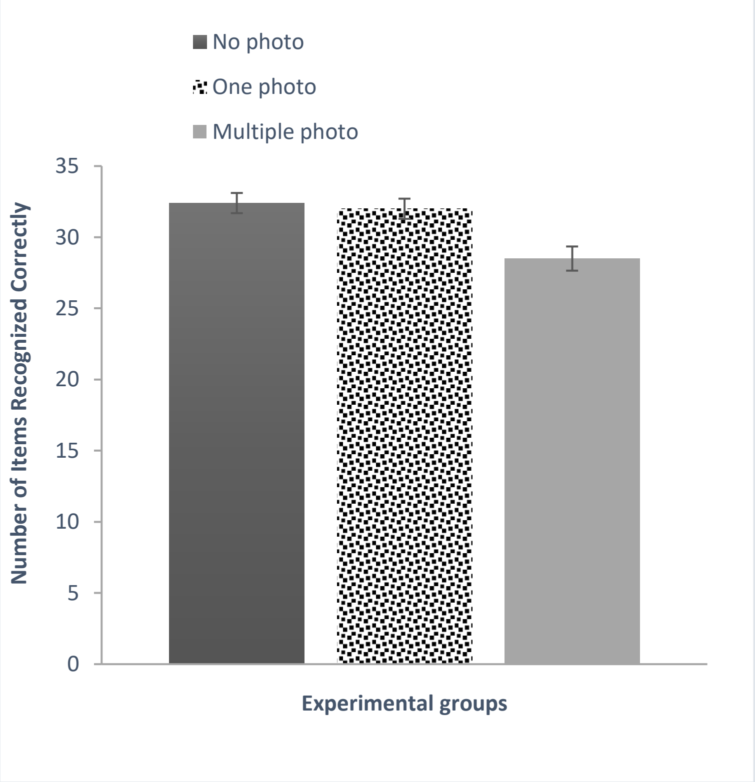


Figure 6. Group differences in mean number of items recognized correctly as measured by the recognition task. Error bars represent standard errors.

Differently from correct recognition, the effect of Group on RTs was not significant, *F*(2,51) = .63, *p* = .535. Analysis showed no significant difference among means of the 8-photo group (*M* = 1446.13, *SD* = 597), the no-photo group (*M* = 1335.13, *SD* = 520.34), the one-photo group (*M* = 1258.7, *SD* = 360) (see Figure 7). Moreover, there was no significant effect of photo taking on RTs of correct responses, *F*(2,51) = .59, *p* = .56, the 8-photo group (*M* = 1359.5, *SD* = 559.5), the no-photo group (*M* = 1283.5, *SD* = 514.62), the one-photo group (*M* = 1183.67, *SD* = 363.8). Furthermore, the three groups did not differ in their overall RTs for incorrect responses, *F*(2,51) = .56, *p* = .575, the 8-photo group (*M* = 1708.6, *SD* = 666.05), the no-photo group (*M* = 1680.04, *SD* = 972.2), the one-photo group (*M* = 1980.16, *SD* = 1122.81).

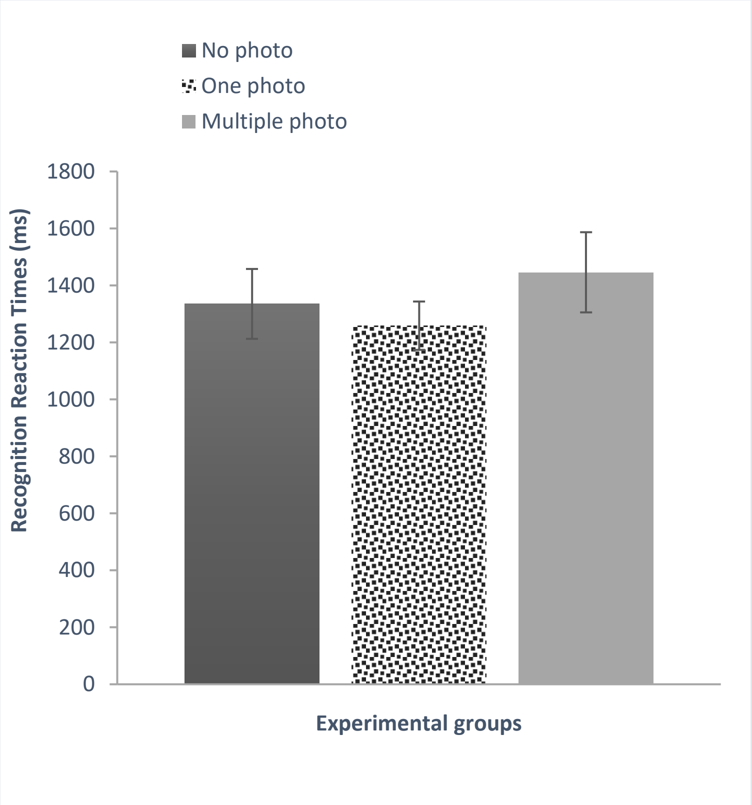


Figure 7. Group differences in mean reaction times (milliseconds) in response to retrieval cues. Error bars represent standard errors.

Confidence Ratings and Confidence Reaction Time Analyses

The results of ANOVA and additional independent samples t-test showed that there was a significant effect of Groups on confidence ratings *F*(2,51) = 3.57 , *p* = .035 and participants who were in the no-photo group gave higher confidence ratings (*M* = 4.19, *SD* = .82) than the ones who were assigned to the photo groups. While having lower confidence in the 8-photo group condition (*M* = 3.66, *SD* = .6) could be expected as memory performance was also lower, more unexpected is the results that also in the one-photo group confidence was lower (*M* = 3.65, *SD* = .7) compared to the no-photo group, even if they had been as accurate in their recognition responses as the ones in the no-photo group.

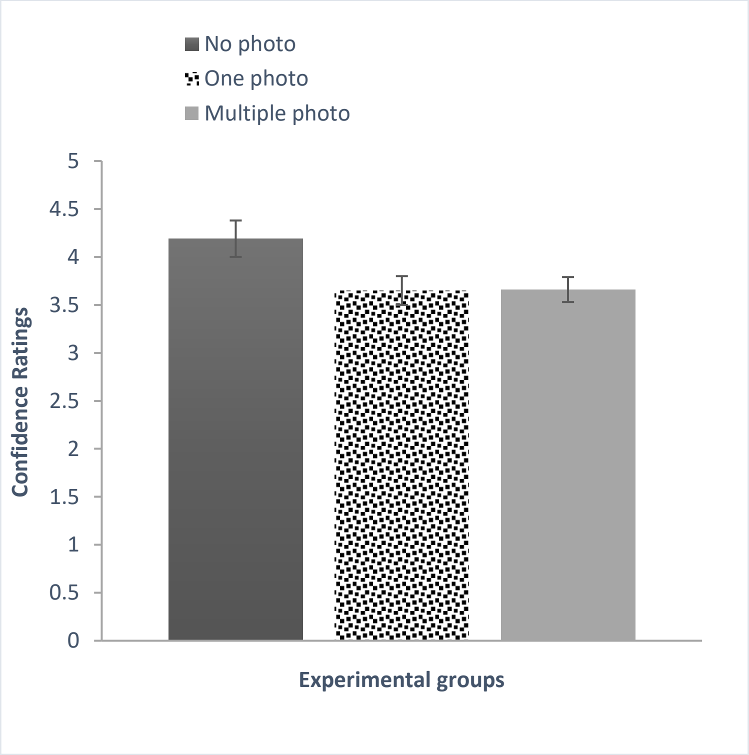


Figure 8. Mean confidence ratings as measured by the recognition task across the three groups. Error bars represent standard errors.

Further, there was no significant effect of Group on confidence ratings given for correct responses, *F*(2,51) = 2.64, *p* = .081 and between means; the 8-photo group (*M* = 3.74, *SD* = .55), the no-photo group (*M* = 4.18, *SD* = .85), the one-photo group (*M* = 3.7, *SD* = .65). Similarly, no significant effect was found for incorrect responses *F*(2,51) = .503, *p* = .61, the 8-photo group (*M* = 3.3, *SD* = 1.05), the no-photo group (*M* = 3.7, *SD* = 1.73), the one-photo group (*M* = 3.24, *SD* = 1.58).

The correlational analyses showed that there was not a significant correlation between recognition accuracies and confidence ratings, *r* = .151, n = 54, *p* > .05 (see Table 1). Results from the Pearson correlation tests revealed that, when recognition was separated into correct and incorrect, confidence ratings for correct responses significantly correlated in all groups, *r* = .981, *n* = 54, *p* < .01, as did confidence ratings for incorrect responses, *r* = .269, *n* = 54, *p* < .05.

Table 1. *Pearson Correlations Between the Number of Images Recognized Correctly and Confidence Ratings Given for These Images*

	Recognition accuracies	Confidence ratings
Recognition accuracies	—	.151
Confidence ratings	.151	—

*. Correlation is significant at the 0.05 level (2-tailed).

The RTs were measured for confidence ratings and the effect of Group on confidence RTs was not found to be significant, *F*(2,51) = .53, *p* = .594. Analysis showed no significant difference between means of the 8-photo group (*M* = 2047.38, *SD* = 741.9), the no-photo group (*M* = 2061.83, *SD* = 774.28), the one- photo group (*M* = 1828.77, *SD* = 741.97).

Self-Report Measures and Flanker Task Analyses

A one-way ANOVA was conducted to compare self-report measures and Flanker task scores in the three Groups. Results showed that there were no significant differences in scores of self-report measures; PMPUQ scores *F*(2,51) = .59, *p* = .56; SAS scores *F*(2,51) = .13, *p* = .881; and PA scores *F*(2,51) = .035, *p* = .97. Furthermore, the three Groups did not differ on their Flanker task performances, *F*(2,51) = .35, *p* = .704. Mean values of the no-photo group, the one-photo group and the 8-photo group are represented in the table shown below.

Table 2. *Group Differences in Mean Scores of Self-Report Measures and Flanker Task*

	No-photo group	One-photo group	Photo group
1. PMPUQ	29.67 (6.86)	29.00 (6.25)	31.28 (6.25)
2. SAS	23.89 (8.32)	24.22 (9.69)	25.28 (7.79)
3. PA	14.22 (5.39)	14.39 (4.09)	14.61 (3.66)
4. Flanker task	18.25(112.97)	43.49 (87.73)	23.90 (79.53)

Note: Standard deviations are shown in parentheses.

A Pearson correlation coefficient was computed to assess the relationship between the three self-report measures on cell-phone use, and they all found to be significantly and positively correlated with each other (Scales 1 & 2: $r = .572$, $n = 54$, $p < .01$; Scales 1 & 3: $r = .511$, $n = 54$, $p < .01$; Scales 2 & 3: $r = .67$, $n = 54$, $p < .01$) , yet they do not correlate with other variables in our study such as recognition accuracies, recognition reaction times, confidence ratings and confidence scale reaction times. Thus, participants' smartphone habits do not seem to have an impact on the photo-taking-impairment effect.

Table 3. *Pearson Correlations Between the Self-Report Measures*

	PMPUQ score	SAS score	PA score
1. PMPUQ score	—	$.572^{**}$	$.511^{**}$
2. SAS score	$.572^{**}$	—	$.667^{**}$
3. PA score	$.511^{**}$	$.667^{**}$	—

**. Correlation is significant at the 0.01 level (2-tailed).

5.4 Discussion

A photo-taking-impairment effect was observed in the present experiment. Consistent with the observations from earlier studies, our data showed that taking many photos of an object impaired participants' accuracy in remembering paintings from a mock museum tour, when encoding was intentional. One can speculate that taking photos of an object (e.g., artworks) may have diverted participants' attention from the object to the camera, thereby hindering the memory for the actual object. However, our results differ from the Henkel (2014) results, as the impairment effect was not observed in participants of the one-photo group. The one-photo group did not show any significant differences with the no-photo group in terms of recognition accuracies. Thereby taking fewer photos did not impair memory, as instead seen in Henkel's (2014) results, nor it did enhance memory recall, as it was claimed in a previous work (Niforatos, 2017).

Differently from recognition accuracy, the three groups did not differ in terms of their recognition RTs in response to presented cue paintings. This finding is particularly important, because it confirms that what we had measured was the direct effect of photo taking on memory reports, not just on the amount of time it takes to report the memory.

It is interesting to notice that, in spite of having the same performance in the recognition task as the no-photo group, the participants of the one-photo group gave lower confidence ratings which were very similar to those of the 8-photo group, for their memory about the artworks. In other words, overall confidence ratings were the highest in the no-photo group compared to the photo groups. The significant effect of group on confidence ratings suggests that engaging in the activity of taking photos (independent of the number of photos taken) makes people more uncertain about the correctness of what they remember, and the discrepancy between actual memory performance and relative confidence in the one-photo group suggests that people to a certain sense expect to do worse in their memory task when they use the cellphone to take photos, independently of their number.

CHAPTER 6

EXPERIMENT II

6.1 Introduction

In the first experiment we found that when the memory task is intentional, and people are aware that they will be tested later about what they see, taking photos makes people more uncertain, while only taking multiple photos creates an actual impairment in memory performance. Here we wanted to test the extent to which these effects are due to the initial awareness of the memory task. What happens when people just take photos and are not aware that they will be later tested? If the impairment is due to the actual taking photos, then we should expect results very similar in this experiment than in the previous one. The present experiment was identical to Experiment 1 with the only exception that encoding condition was changed to incidental. Before their participation, they were told that the broad purpose of this study was to investigate the impact of smartphones on human cognition. Apart from this, we aimed to hold all aspects of the experimental procedure constant. A completely new group of participants was presented the same museum tour as in Experiment 1, and depending on the condition that they were assigned to (no-photo, one-photo and 8-photo groups), they were directed to follow the specific instructions (described in Procedure section below) during the experience. Shortly after the tour (encoding phase), we examined their behavioral performances on a memory test (recognition phase). This time, however, participants underwent a surprise recognition test where they were asked to indicate whether they recognize given artworks without knowing about this test before presenting the mock museum tour.

As in Experiment 1, it was hypothesized that the three participant groups would differ (1) in the amount of their accurate responses in the recognition task, (2) in the mean reaction times in response to the retrieval cues in recognition task, and (3) in the confidence ratings showing how certain they were about their recognition answers. Even if a memory impairment due to the act of taking photographs was predicted, findings obtained from this experiment were unexpected.

6.2 Methods

6.2.1 Participants

A total of fifty-four participants including mostly undergraduate students and researchers from Sapienza University of Rome were recruited to this study (33 females and 21 males, age range: 19-31 years, M = 23.89). The experiment was open to all people who were between the ages of 18 to 35 years. Participation occurred on a voluntary basis and nobody received any compensation for their participation. The participants were also informed that they have the right to withdraw at any time if they would not be comfortable with the study. Informed consent was obtained from all participants, with all procedures approved by the Ethics Committee of the Department of Dynamic and Clinical Psychology, Sapienza University of Rome. All participants had normal or corrected to normal vision.

Each participant was randomly assigned to three experimental groups:

- no-photo group (n=18) - simply observe a mock museum tour,
- one-photo group (n=18) – to take only one photo of each artwork on the tour,
- 8-photo group (n=18) – to take multiple photos of each artwork on the tour.

6.2.2 Materials

Mock Museum Tour: We created a computer-based laboratory paradigm for the presentation of a mock museum tour. A stimulus set for the mock museum tour was compiled with various paintings taken from Metropolitan Museum of Art open access collection (Metropolitan Museum of Art [MET], n.d.). The collection of those artworks was filtered based on specific criteria; only the oil paintings belonging to various European artists, between 17th to 20th centuries were chosen. To avoid any types of experimental errors arising from the effect of image feature itself, we categorized all paintings as female portraits, male portraits, groups of people, animals, landscapes and still life paintings and had an equal number in each category. Each museum tour consisted of 36 photos out of the 54 original oil paintings initially selected presented in a random order. The remaining 18 paintings were presented as novel memory cues in the recognition phase. At recognition, all 36 paintings (18 novel & 18 old) were presented in counterbalanced order. All participants experienced the museum tour for the same duration, regardless of their condition.

Erikson Flanker Task: Attentional skills were assessed by using a variation of the *flanker paradigm* because it allows experimenters to measure reaction times to both compatible and incompatible conditions, and the flanker effect, thus providing more data on attentional skills of each individual participant. The flanker task was prepared on E-prime, using a letter paradigm (see demo; “Flanker task”, 2018) where the participants saw 5 letters appearing above the fixation point, and they only had to respond to the central letter. The critical trials lasted approximately 3 min, with a preliminary practice trial of 8 items (4 items responded with left key, e.g., 2 C and 2 X, and 4 items responded with right key, e.g., 2 B and 2 V) (see Figure 4).

Self-Report Measures: To screen for cell phone use and problems due to excessive cell phone use, three paper-based questionnaires were presented:

1) *Problematic Mobile Phone Use Questionnaire - Short Version (PMPUQ–SV):* 15-item PMPUQ-SV has been found to be an appropriate psychometric tool to assess problematic mobile phone use for cross-cultural research (Lopez-Fernandez et al., 2018). Each item (e.g., “It is hard for me to turn my mobile phone off”, “I use my mobile phone where it is forbidden to do so”) is scored from 1 (‘I strongly agree’) to 4 (‘I strongly disagree’), except for the items that are reverse scored. Overall scores range from 15 to 60, with higher scores indicating more potential negative effects due to mobile phone use.

2) *The Smartphone Addiction Scale Short Version (SAS-SV):* 10 item SAS-SV yields a total score that is indicative of the severity of smartphone addiction. It consists of six factors (daily-life-disturbance, positive-anticipation, withdrawal, overuse, tolerance, and cyberspace-oriented relationship) which are accessed through 10 items (De Pasquale et al., 2017). It is responded on a six-point Likert scale (1: "strongly disagree", 2: "disagree", 3: "weakly disagree", 4: "weakly agree", 5: "agree", and 6: "strongly agree") with higher scores indicating more severe addictions. Higher scores than the cut-off values (31 for males and 33 for females; see Kwon et al., 2013) are considered as high-risk for smartphone addiction.

3) *Perceived Attachment to Phones Scale:* It is a five-item mini self-report assessment developed to measure perceived attachment to one's phone (Weller et al., 2010). Sample items include: "I would feel lost if I didn't have a cell phone" or ''I would rather lose my wallet than my cell phone''. The items are responded on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores can range from 5 to 25 with higher scores indicating greater possession attachment toward one's cell phone.

Memory Test: To test the effect of capturing photos on memory, all participants of this study were given a computer-based recognition task. It consisted of two sub-tasks: (1) In the first task it was required to give yes/no responses in response to presented stimuli. Therefore, 36 out of 54 paintings were provided as memory cues; 18 paintings from the mock museum tour and 18 novel paintings were presented. Paintings (including their categories) were counterbalanced across participants. (2) In the second task participants were asked to assess their own memory performances on a 1-6 confidence scale by stating how certain they were that their response to each painting was correct. The presentation of 36 out of 54 paintings were identically repeated; 18 paintings from the mock museum tour and 18 novel paintings were counterbalanced across participants.

6.2.3 Procedure

Experiment II consisted of two sessions, exactly as in Experiment 1. In Session 1, participants were given a mock museum tour with the presentation of 36 of 54 paintings, all counterbalanced so that all 54 paintings were used across participants. All participants experienced the same type of tour, with an equal duration for each painting (10 sec per painting), regardless of their experimental conditions. Participants in one-photo and 8-photo conditions were instructed to take photos by using their own smartphones during the museum experience. Note that, participants in the 8-photo condition had a restriction of taking 8 photos for each artwork.

Participants were seated at a viewing distance of 60 cm from a PC monitor. The stimuli were presented using E-Prime professional 3.0 software (Psychology Software Tools, Pittsburgh, PA). Before starting the mock museum tour, all participants completed a letter flanker task. Immediately after, the presentation of the museum tour started; each trial started with a fixation cross for 500 ms followed by the stimulus presentation for 10 sec with each slide advancing automatically. The photos of the original oil paintings were high quality and they were presented full screen.

The specific instructions for each experimental condition are presented below:

<u>No-photo condition:</u> “Turn on the airplane mode of your cellphone and place your cellphone next to you face down on the desk. Then, look at the painting on the screen.”

<u>One-photo condition:</u> “Turn on the airplane mode of your cellphone and keep it in front of you with the application Camera on. When you see the fixation cross appears, hold the phone to get ready to take the one photo you need to take. As you have taken the photo, put your phone down on the desk and continue to look at the painting on the screen, then when you see the next fixation cross, hold the phone in front of your eyes, get ready for the photo-taking. And do this for each fixation cross you see, which will be followed by a painting.”

8-photo condition: “Turn on the airplane mode of your cellphone and hold your cellphone with the application Camera on, in front of you. When you see the fixation cross, hold the phone to get ready to take the eight photos of the painting you need to take. Continue to look at the painting through your cellphone. Be sure to have your cellphone on the photo setting all the time, so to be able to look at the screen through your phone all the time.”

During a 10-min delay following the museum tour, participants were given the self-report questionnaires described in the Materials section above. Immediately after filling out those questionnaires, participants were asked to turn back to the computer monitor.

In Session 2, participants performed a recognition test about the museum tour experience (see Figure 5). The recognition test consisted of two tasks as mentioned above in the Materials section. In the first recognition task, participants were presented a block of 36 randomized paintings respectively - 18 paintings from the previous museum tour and 18 novel paintings. Each trial was started with a 500 ms fixation cross and then was followed by a stimulus presentation lasting 2000 ms, which was also preceded by a new slide asking whether the subject remembers that painting from the previous museum tour (“Do you recognize this painting?”). The same procedure was repeated, for all 36 paintings. Note that that slide was set to infinite time, thereby participants were not able to skip and perform the next trial before giving their recognition responses. Response timing was self-paced. The task was to pay attention to each stimulus and to make yes/no recognition decisions whether each photograph portrayed a painting seen in the actual tour. Responses were given by pressing a ‘yes’ or ‘no’ key on the keyboard.

In second recognition task (confidence ratings), each trial was again started with a 500 ms fixation cross and then was followed by a stimulus presentation lasted 2000 ms. All items in the first block were re-presented and participants were asked to rate their confidence in each recognition decision on a 6-point scale (see Figure 5). A block of 36 trials were presented in random order. The software recorded reaction times, along with recognition decisions and confidence ratings, that were subsequently analyzed.

6.2.4 Statistical Analyses

All statistical analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics, Version 25.0. Armonk, NY). All tests used the General Linear Model (ANOVA) and correlations. Post hoc analyses were also conducted for multiple comparisons using Tukey's HSD test. Pearson's correlation coefficient values were calculated for correlational analyses. Statistical values were considered significant at a final corrected alpha level of .05.

6.3 Results

One-way ANOVAs in three levels were run to investigate differences in the Flanker task, memory test performance, memory confidence and response times in the recognition task. Other analyses were performed for other measures.

Recognition Accuracy and Recognition Reaction Time Analyses

Differently from the results of Experiment 1, and rather surprisingly, ANOVA results showed no effect of photo taking on recognition accuracies, *F*(2,51) = .76 , *p* = .47 (see Figure 9). There was no significant difference among means of the 8-photo group (*M* = 24.4, *SD* = 7.95), the no-photo group (*M* = 27.7, *SD* = 9.72), the one-photo group (*M* = 27.7, *SD* = 9.68). ***The calculated post-hoc power for this analysis, with a medium effect size, was .901.***

There was also no significant effect of group in the average amount of time the participants spent to respond the recognition questions, although in this case we observed a tendency towards significance in the photo-taking groups, suggesting that photo taking seems to have a certain influence on recognition RTs, *F*(2, 51) = 2.64, *p* = .081. As shown in Figure 10, the subsequent post hoc analysis indicated that recognition RTs of the 8-photo condition were tendentially – albeit not significantly - higher than the other two conditions: the 8-photo group

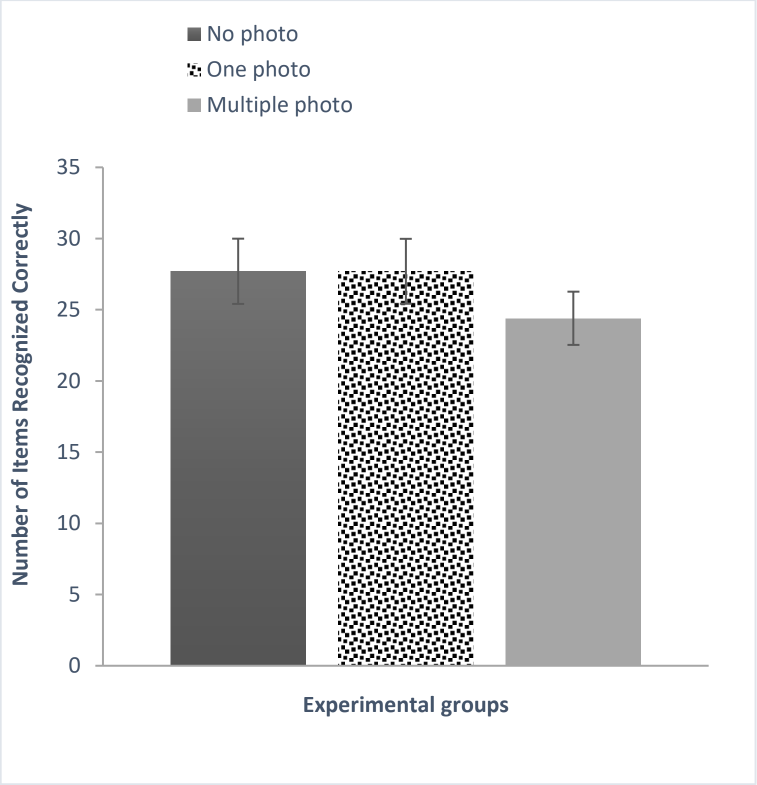


Figure 9. Group differences in mean number of items recognized correctly as measured by the recognition task. Error bars represent standard errors.

(*M* = 1545.56, *SD* = 564.8), the no-photo group (*M* = 1254,85, *SD* = 528.85) and the one-photo group (*M* = 1156.34, *SD* = 490.36). This increase in RTs can be considered as a sort of memory impairment, as in the 8-photo group more time seems to be needed in order to reach the same level of recognition as in the other two groups.

Furthermore, ANOVA results showed that there was no significant effect of photo taking on recognition RTs of average correct responses, *F*(2,51) = 2.36, *p* = .105 and among means of the 8-photo group (*M* = 1488.3, *SD* = 549.94), the no-photo group (*M* = 1234.12, *SD* =546.04), the one-photo group (*M* = 1127.03, *SD* = 434.41). Similarly, the three groups did not differ in their overall recognition RTs of incorrect responses, *F*(2,51) = 2.08, *p* = .136 and among means of the 8-photo group (*M* = 1669.6, *SD* = 584.12), the no-photo group (*M* = 1268.13, *SD* = 616.12), the one- photo group (*M* = 1292.04, *SD* = 772.5).

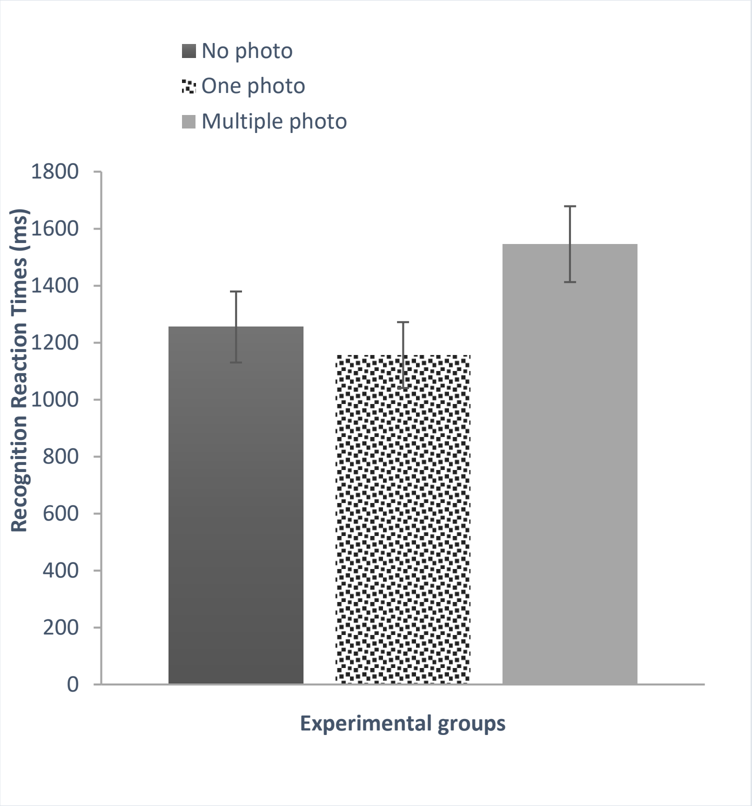


Figure 10. Group differences in mean reaction times (milliseconds) in response to retrieval cues. Error bars represent standard errors.

Confidence Ratings and Confidence Reaction Time Analyses

There was no main effect of Group on given confidence ratings, *F*(2, 51) = 1.39 , *p* = .26 (see Figure 11). ANOVA results showed no significant differences between means of the 8-photo group (*M* = 3.52, *SD* = .63), the no-photo group (*M* = 3.8, *SD* = .79), the one-photo group (*M* = 3.85, *SD* = .44).

Nevertheless, the correlational analyses showed that there was a positive correlation between recognition accuracies and confidence ratings, *r* = .36, *n* = 54, *p* < .01 (see Table 4). In other words, when the participants rated how good their memory was, they gave higher confidence ratings for the items that they had initially recognized correctly.

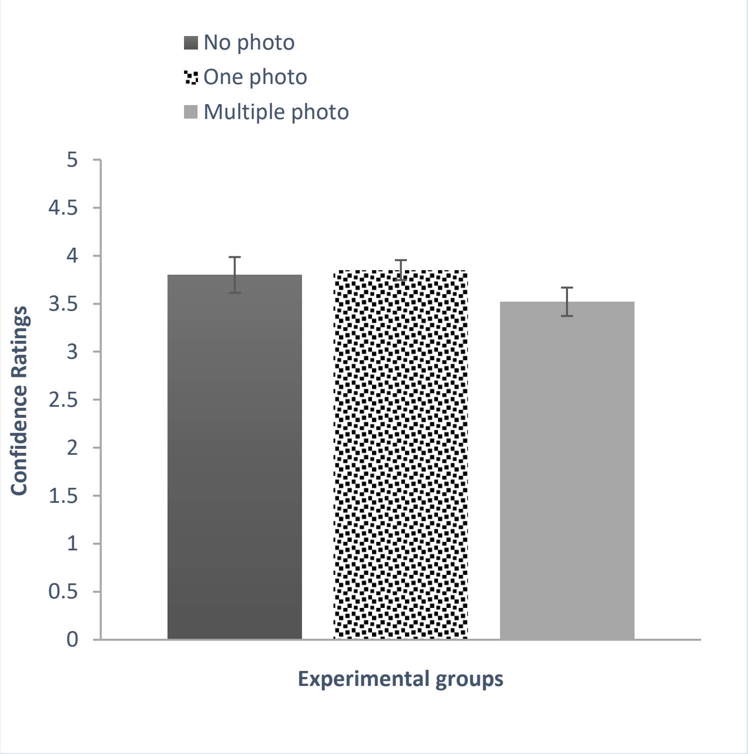


Figure 11. Mean confidence ratings during the recognition task across the three groups. Error bars represent standard errors.

Table 4. *Pearson Correlations Between the Number of Images Recognized Correctly and Confidence Ratings Given for These Images*

	Recognition accuracies	Confidence ratings
Recognition accuracies	—	.358**
Confidence ratings	.358**	—

**. Correlation is significant at the 0.01 level (2-tailed).

ANOVA results also showed no Group differences on confidence ratings given for correct responses, $F(2,51) = 1.47$, $p = .240$ and among means of the 8-photo group ($M = 3.47$, $SD = .69$), the no-photo group ($M = 3.8$, $SD = .79$), the one-photo group ($M = 3.82$, $SD = .53$). No group differences was found on confidence ratings given for incorrect responses $F(2,51) = .27$, $p = .764$ and among means of the 8-photo group ($M = 3.65$, $SD = .78$), the no-photo group ($M = 3.8$, $SD = 1.93$), the one-photo group ($M = 3.44$, $SD = 1.34$). On the other hand, results from the Pearson correlation tests revealed that confidence ratings for correct recognitions were significantly correlated across groups, $r = .966$, $n = 54$, $p < .01$ as they were for incorrect recognitions, $r = .397$, $n = 54$, $p < .01$.

The RTs were measured for confidence ratings and the effect of Group on confidence ratings RTs was not found to be significant, $F(2,51) = .95$, $p = .395$. Analysis did not show any significant differences between means of the 8-photo group ($M = 1958.54$, $SD = 1004.51$), the no-photo group ($M = 1702.66$, $SD = 671.91$), the one-photo group ($M = 1618.17$, $SD = 575.21$).

Self-Report Measures and Flanker Task Analyses

A one-way ANOVA was conducted to compare self-report measures and Flanker task scores in the three Groups. Results showed that there were no significant differences in scores of self-report measures; PMPUQ scores $F(2,51) = .31$, $p = .74$; SAS scores $F(2,51) = .85$, $p = .92$; and PA scores $F(2,51) = .414$, $p = .663$. Furthermore, the three Groups did not differ on their Flanker task performances, $F(2,51) = .87$, $p = .424$. Mean values of the no-photo group, the one-photo group and the 8-photo group are represented in the table shown below.

Table 5. *Group Differences in Mean Scores of Self-Report Measures and Flanker Task*

	No-photo group	One-photo group	Photo group
1. PMPUQ	29.39 (6.8)	30.78 (6.25)	29.44 (4.89)
2. SAS	25.06 (8.89)	24.67 (7.14)	24.00 (7.19)
3. PA	14.67 (4.54)	13.72 (4.52)	13.44 (3.53)
4. Flanker task	-.95 (113.95)	26.73 (135.22)	51.41 (105.69)

Note: Standard deviations are shown in parentheses.

A Pearson correlation coefficient was computed to assess the relationship between the three self-report measures, and they all found to be significantly and positively correlated with each other, replicating the results of Experiment 1 (Scales 1 & 2: $r = .64$, $n = 54$, $p < .01$; Scales 1 & 3: $r = .535$, $n = 54$, $p < .01$; Scales 2 & 3: $r = .714$, $n = 54$, $p < .01$). As in Experiment 1, these measures do not correlate with other variables in our study such as recognitions accuracies, recognition reaction times, confidence ratings and confidence scale reaction times.

People's smartphone habits do not seem to have an impact on the photo-taking-impairment effect. Moreover, the three Groups did not differ in their Flanker task performances, $F(2,51) = .87$, $p = .424$.

Table 6. *Pearson Correlations Between the Self-Report Measures*

	PMPUQ score	SAS score	PA score
1. PMPUQ score	—	$.636^{**}$	$.535^{**}$
2. SAS score	$.636^{**}$	—	$.714^{**}$
3. PA score	$.535^{**}$	$.714^{**}$	—

**. Correlation is significant at the 0.01 level (2-tailed).

6.4 Discussion

Differently from Experiment 1, the present experiment did not show a memory disadvantage for photographed images when encoding condition was incidental. When people had no expectations about a later memory test, their memory was not impaired.

On the other hand, in terms of recognition RTs, participants in the 8-photo group took more time to give their recognition answers in response to cue paintings compared to the one-photo and no-photo groups. Although this difference in overall RTs was only tendentially - but not significantly - higher than it was in the other two groups, photo taking seems to influence recognition RTs. Longer amounts of time that is spent to recall a memory can be considered as a sort of memory impairment, not at the level of recognition accuracies but at the level of recognition RTs. Longer times indicate greater difficulty when searching the memory for the stimulus during the recognition task (or greater willingness to search when no memory is easily accessible), and in this experiment longer retrieval times seem to have possibly compensated for the impairment in recognition accuracy that was instead observed in Experiment 1, when encoding was intentional. In this experiment, the three groups did not differ in confidence in memory, suggesting that participants in the photo groups were confident with their memory decisions as much as the ones in the no-photo group. The overall significant correlation between recognition accuracy and confidence in memory suggests that in all groups, participants were able to discriminate between paintings they recognized correctly and paintings they recognized incorrectly, assigning greater confidence ratings to the former.

Considering all the results together, it is important at this point to comment more in detail the differences obtained in the two experiments, taking into account also the results on retrieval time. When people know in advance that their memory will be later tested, as in Experiment 1, taking many photos lowers recognition and subsequent confidence in the correctness of what they recognized. This result has more than one interpretation as it could be interpreted as suggesting poorer encoding, or greater difficulty during retrieval. The results of Experiment 2 suggest that greater difficulty during retrieval is a viable explanation, as in Experiment 2 taking multiple photos required more time at retrieval, suggesting less accessibility of the memory. However, the difference between Experiment 1 and 2 is in the type of acquisition, which in one case occurs while knowing that a memory test will follow, while in the other case no memory test is expected. Expecting a memory test (Exp 1) seems to be the factor then that hinders memory when one takes multiple photos. This expectation can change either encoding strategies, or retrieval strategies. One can speculate that, if expectations affect encoding strategies, participants who expect to do worse might put greater effort in encoding fewer items, while those who do not hold this expectation might put lower effort on more items. If this is true, the result would show fewer items correctly recognized in the 8-photo condition compared to the other groups when people expect to remember less, for the very reason that they selected fewer paintings to study, compared to those who did not have the expectation of having a poorer memory. The possibility that people select at encoding which items to encode better represents established results in metacognitive studies (Kornell & Metcalfe, 2006; Mazzoni et al., 1990; Mazzoni & Nelson, 1995; Nelson et al., 1994). In this situation, recognition RTs on average should not be different. These are indeed the results of Experiment 1. Lower performance and, afterwards, also lower confidence ratings, while no difference is observed across groups in RTs. Confidence ratings (lower confidence ratings in the 8-photo condition when a memory test is expected) in addition suggests that, in spite of such change in strategy at encoding, memories are still evaluated, when recognized, to be of lower strength or quality compared to those in the no-photo condition, and this happens even in the one-photo condition, when strategies at encoding have been successful at bringing the performance at the same level of the no-photo condition, but confidence ratings remain significantly lower.

This way to explain what happens when photos are taken and a memory test is expected would speak in favor of a progressive photo impairment effect: the more the photos of the same object, the greater the difficulty at encoding, which is partially (8 photos) or totally (1 photo) compensated by the strategies used when encoding the items.

To test more specifically the role of encoding and retrieval, in Experiment 3 we manipulated the material presented at retrieval, as well as the amount of time available during recognition.

CHAPTER 7

EXPERIMENT III

7.1 Introduction

The results obtained in the previous two experiments can be interpreted as either due to an effect during encoding or an effect that occurs at retrieval. We argue that manually taking photographs during an experience should affect one’s memory by limiting or shifting the attention while encoding that experience. In the present experiment, we attempted to replicate the finding of Experiment 1 which has already confirmed a photo-taking-impairment effect due to photographing a scene, when intentional but not incidental encoding takes place.

Participants of this experiment were presented a mock museum tour as in both previous experiments, and depending on the condition that they were assigned to (no-photo and photo groups), they were directed to follow the specific instructions (described in the Procedure section below) during the experience. Shortly after the tour (encoding phase), we examined their behavioral performances on a recognition test (retrieval phase). It should be noted that the recognition task used in Experiment 3 differed in two respects from the earlier experiments. First, to directly test our hypothesized attention-based mechanism at encoding, the new recognition task provided half of the retrieval cues as partial (zoomed in) details of the original painting. Doing so allowed us to postulate that if the impairment effect is due to poor encoding which would lead to lower detail memory, the participants in the photo taking condition should be less accurate in their responses to the cues that are zoomed in than the cues that are not zoomed in. Second, we manipulated the amount of time available for recognition. To half of the participants in Experiment 3 a limited time (max 3 sec) was available per painting to respond to yes/no recognition questions, whereas the other half was assigned to a self-paced procedure in which time was virtually infinite respond (as in the first two experiments, in which responses were self-paced). With this time manipulation for memory retrieval, we aimed to manipulate participants' retrieval strategies, while also testing the quality of encoding. We expected to find a greater impairment for the zoomed-in cues in the 3-sec condition compared to the self-paced condition (i.e., a significant amount of time x type of cue interaction). To summarize the predictions, if in the 8-photo group the items have received sufficient elaboration during encoding, memories should be easily accessible, and thus retrieval times should be relatively fast. In this case, no detrimental effect should be observed when retrieval time is set to be max 3 sec, compared to when it is set as self-paced. At the same time, the detrimental effect of having to recognize zoomed-in details should be the same across all groups, because all groups have adequately and sufficiently encoded the items. If, instead, encoding is superficial and insufficient in the 8-photo group, then one can expect lower performance compared to the no-photo group, and the difference to be more accentuated when recognizing the zoomed-in details.

To replicate the impairment effect, Experiment 3 involved intentional memory retrieval as in Experiment 1. All participants were asked to pay attention to the visual aspects of those artworks during the experience and told that they would later be tested for their memory. It was hypothesized that the three participant groups would differ (1) in the amount of their accurate responses for the recognition task, (2) in mean reaction times in response to the retrieval cues in recognition task, and (3) in confidence ratings showing how certain they were about their recognition answers.

7.2 Methods

7.2.1 Participants

A total of one hundred and eight participants including mostly undergraduate students and researchers from Sapienza University of Rome were recruited to this study (59 females and 49 males, age range: 19-35 years, M = 22.06). The experiment was open to all people who were between the ages of 18 to 35 years. Participation occurred on a voluntary basis, and nobody has received any compensation for their participation. The participants were also informed that they have the right to withdraw at any time if they would not be comfortable with the study. Informed consent was obtained from all participants, with all procedures approved by the Ethics Committee of the Department of Dynamic and Clinical Psychology, Sapienza University of Rome. All participants had normal or corrected to normal vision.

This time we had removed the one-photo condition because based on our first two experiments, taking one photo does not seem to show any significant effect on memory performances compared to the other two conditions. Thus, each participant was randomly assigned to two experimental groups:

- no-photo group (n=54) - simply observe a mock museum tour,
- photo group (n=54) - to take multiple photos of each artwork on the tour.

7.2.2 Materials

Mock Museum Tour: We created a computer-based laboratory paradigm for the presentation of a mock museum tour. A stimulus set for the mock museum tour was compiled with various paintings taken from Metropolitan Museum of Art open access collection (Metropolitan Museum of Art [MET], n.d.). The collection of those artworks was filtered based on specific criteria; only the oil paintings belonging to various European artists, between 17th to 20th centuries were chosen. To avoid any types of experimental errors arising from the effect of image feature itself, we categorized all paintings as female portraits, male portraits, groups of people, animals, landscapes and still life paintings and had an equal number in each category.

Each museum tour consisted of 36 photos out of the 54 original oil paintings initially selected presented in a random order. The remaining 18 paintings were presented as novel memory cues in the recognition phase. At recognition, all 36 paintings (18 novel & 18 old) were presented in counterbalanced order. All participants experienced the museum tour for the same duration, regardless of their condition.

Erikson Flanker Task: Attentional skills were assessed by using a variation of the *flanker paradigm* because it allows experimenters to measure reaction times to both compatible and incompatible conditions, and the flanker effect, thus providing more data on attentional skills of each individual participant. The flanker task was prepared on E-prime, using a letter paradigm (see demo; "Flanker task", 2018) where the participants saw 5 letters appearing above the fixation point, and they only had to respond to the central letter. The critical trials lasted approximately 3 min, with a preliminary practice trial of 8 items (4 items responded with left key, e.g., 2 C and 2 X, and 4 items responded with right key, e.g., 2 B and 2 V) (see Figure 4).

Self-Report Measures: To screen for cell phone use and problems due to excessive cell phone use, three paper-based questionnaires were presented. Differently from the first two experiments, a fourth scale was added to monitor the subjects' state anxiety levels.

1) *Problematic Mobile Phone Use Questionnaire - Short Version (PMPUQ–SV):* 15-item PMPUQ-SV has been found to be an appropriate psychometric tool to assess problematic mobile phone use for cross-cultural research (Lopez-Fernandez et al., 2018). Each item (e.g., "It is hard for me to turn my mobile phone off", "I use my mobile phone where it is forbidden to do so") is scored from 1 ('I strongly agree') to 4 ('I strongly disagree'), except for the items that are reverse scored. Overall scores range from 15 to 60, with higher scores indicating more potential negative effects due to mobile phone use.

2) *The Smartphone Addiction Scale Short Version (SAS-SV):* 10 item SAS-SV yields a total score that is indicative of the severity of smartphone addiction. It consists of six factors (daily-life-disturbance, positive-anticipation, withdrawal, overuse, tolerance, and cyberspace-oriented relationship) which are accessed through 10 items (De Pasquale et al., 2017). It is responded on a six-point Likert scale (1: "strongly disagree", 2: "disagree", 3: "weakly disagree", 4: "weakly agree", 5: "agree", and 6: "strongly agree") with higher scores indicating more severe

addictions. Higher scores than the cut-off values (31 for males and 33 for females; see Kwon et al., 2013) are considered as high-risk for smartphone addiction.

3) *Perceived Attachment to Phones Scale:* It is a five-item mini self-report assessment developed to measure perceived attachment to one's phone (Weller et al., 2010). Sample items include: "I would feel lost if I didn't have a cell phone" or ''I would rather lose my wallet than my cell phone'' The items are responded on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores can range from 5 to 25 with higher scores indicating greater possession attachment toward one's cell phone.

4) *The State-Trait Anxiety Inventory for Adults (STAI-AD):* STAI is a definitive instrument which can differentiate between temporary conditions and more long-standing quality of anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). In this study we have only used the 20-item STAI-S Anxiety scale which measures the temporary characteristics of anxiety construct. Scores on the STAI-S Anxiety tend to increase under conditions of psychological distress or physical danger. While anxiety-present items (e.g., "I feel indecisive") are scored from 1 ('not at all') to 4 ('very much so'), the anxiety-absent items (e.g., "I feel at ease") are reversely scored. Overall scores can vary from a minimum of 20 to a maximum of 80.

Memory Test: To test the effect of capturing photos on memory, all participants of this study were given a computer-based recognition task. It consisted of two sub-tasks: (1) In the first task it was required to give yes/no responses in response to presented stimuli. Therefore, 36 out of 54 paintings were provided as memory cues; 18 paintings from the mock museum tour and 18 novel paintings were presented. Paintings (including their categories) were counterbalanced across participants. (2) In the second task participants were asked to assess their own memory performances on a 1-6 confidence scale by stating how certain they were that their response to each painting was correct. The presentation of 36 out of 54 paintings were identically repeated;

18 paintings from the mock museum tour and 18 novel paintings were counterbalanced across participants.

7.2.3 Procedure

Experiment II consisted of two sessions, exactly as in Experiment 1. In Session 1, participants were given a mock museum tour with the presentation of 36 of 54 paintings, all counterbalanced so that all 54 paintings were used across participants. All participants experienced the same type of tour, with an equal duration for each painting (10 sec per painting), regardless of their experimental conditions. Participants in the photo condition were instructed to take photos by using their own smartphones during the museum experience. Note that, participants in the multiple photo condition had a restriction of taking 8 photos for each artwork.

Participants were seated at a viewing distance of 60 cm from a PC monitor. The stimuli were presented using E-Prime professional 3.0 software (Psychology Software Tools, Pittsburgh, PA). Before starting the mock museum tour, all participants completed a letter flanker task. Immediately after, the presentation of the museum tour started; each trial started with a fixation cross for 500 ms followed by the stimulus presentation for 10 sec with each slide advancing automatically. The photos of the original oil paintings were high quality and they were presented full screen.

The specific instructions for each experimental condition are presented below:

<u>No-photo condition:</u> “Turn on the airplane mode of your cellphone and place your cellphone next to you face down on the desk. Then, look at the painting on the screen.”

<u>8-photo condition:</u> “Turn on the airplane mode of your cellphone and hold your cellphone with the application Camera on, in front of you. When you see the fixation cross, hold the phone to get ready to take the eight photos of the painting you need to take. Continue to look at the painting through your cellphone. Be sure to have your cellphone on the photo setting all the time, so to be able to look at the screen through your phone all the time.”

During a 10-min delay following the museum tour, participants were given the self-report questionnaires described in the Materials section above. Immediately after filling out those questionnaires, participants were asked to turn back to the computer monitor.

In Session 2, participants performed a recognition test about the museum tour experience (see Figure 5). The recognition test consisted of two tasks as mentioned above in the Materials section. In the first recognition task, participants were presented a block of 36 randomized paintings respectively - 18 paintings from the previous museum tour and 18 novel paintings. we remind that differently from the first two experiments, the new recognition task provided half of the retrieval cues as partial (zoomed in) details of the original painting. These paintings were 50% zoomed in exactly in the center of the image.

Figure 12. Examples of retrieval cues and edits applied; showing from left to right the original size cue painting, the 50% zoomed-in cue painting.

Each trial was started with a 500 ms fixation cross and then was followed by a stimulus presentation lasting 2000 ms, which was also preceded by a new slide asking whether the subject remembers that painting from the previous museum tour (“Do you recognize this painting?”). The same procedure was repeated, for all 36 paintings. The task was to pay attention to each stimulus and to make yes/no recognition decisions whether each photograph portrayed a painting seen in the actual tour. Responses were given by pressing a ‘yes’ or ‘no’ key on the keyboard. Note that, differently from the first two experiments, to half of the participants a limited time (3 sec) was available per painting to respond to recognition questions, whereas the other half was assigned to a self-paced procedure in which time participants were not able to skip and perform the next trial before giving their recognition responses.

In second recognition task (confidence ratings), each trial was again started with a 500 ms fixation cross and then was followed by a stimulus presentation lasted 2000 ms. All items in the first block were re-presented and participants were asked to rate their confidence in each recognition decision on a 6-point scale (see Figure 5). A block of 36 trials were presented in random order. The software recorded reaction times, along with recognition decisions and confidence ratings, that were subsequently analyzed.

7.2.4 Statistical Analyses

All statistical analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics, Version 25.0. Armonk, NY). All tests used the General Linear Model (ANOVA and correlations). Post hoc analyses were conducted for multiple comparisons using Tukey's HSD test. Pearson’s correlation coefficient values were calculated for correlational analyses. Statistical values were considered significant at a final corrected alpha level of .05.

7.3 Results

A 2 x 2 x 2 mixed ANOVA was performed with Group (no-photo vs photo) and Time for recognition (infinite vs limited time) as the between-subjects variables and Retrieval cue (zoomed in vs whole paintings) as the within-subjects variable. ***The post-hoc power for these analyses with a medium effect size was 1.***

Recognition Accuracy and Recognition Reaction Time Analyses

Replicating the photo-taking-impairment effect seen in Experiment 1, the ANOVA showed that participants' recognition accuracy about the artworks was overall significantly lower in the photo condition compared to the no-photo condition (see Figure 13). The main effect of photo taking was significant, $F(1,104) = 49.62$, $p < .001$, $\eta_p^2 = .323$. Participants recognized fewer paintings when they had photographed ($M = 27.26$, $SD = 3.37$) than when they had observed them solely but not photographed ($M = 31.41$, $SD = 2.82$).

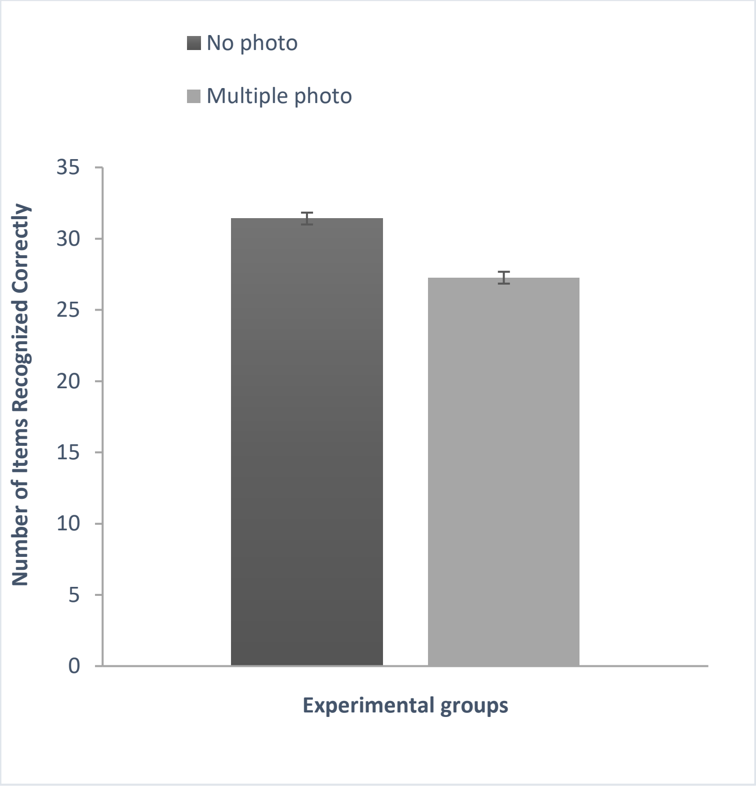


Figure 13. Group differences in mean numbers of items recognized correctly as measured by the recognition task. Error bars represent standard errors.

The effect of time pressure on memory accuracy was also significant, $F(1,104) = 5.13$, $p = .03$, $\eta_p^2 = .05$, (for infinite time $M = 30$, $SD = 3.44$; for limited time $M = 28.7$, $SD = 3.92$). The interaction between time for recognition and groups on accuracy was not significant, $F(1,104)$

$= .39$, $p = .53$, $\eta_p^2 = .004$. Means were for infinite time – the 8-photo group ($M = 2.8$, $SD = 2.97$), infinite time – the no-photo group ($M = 3.2$, $SD = 2.82$), limited time – the photo group ($M = 2.64$, $SD = 3.59$), and limited time – the no-photo group ($M = 3.1$, $SD = 2.8$).

Type of memory cues had a significant effect on recognition accuracy, $F(1,104) = 55.85$, $p < .001$, $\eta_p^2 = .349$, as during the retrieval phase, the participants recognized more accurately when the paintings were presented as a whole ($M = 15.44$, $SD = 2.42$) than when they were zoomed in ($M = 13.86$, $SD = 1.94$). However, there were no significant interactions; there was no significant Retrieval cue X Time for recognition interaction, $F(1,104) = .094$, $p = .76$, $\eta_p^2 = .001$: infinite time – zooming ($M = 14.07$, $SD = 2.42$), infinite time – no zooming ($M = 15.72$, $SD = 1.72$), limited time – zooming ($M = 13.65$, $SD = 2.43$), and limited time – no zooming ($M = 15.17$, $SD = 2.13$). The three-way Retrieval cue X Group X Time for recognition interaction was also not significant, $F(1,104) = .842$, $p = .36$, $\eta_p^2 = .008$. Analyses did not show any significant difference between means; the photo group - infinite time – zooming ($M = 12.93$, $SD = 2.23$), the photo group - infinite time – no zooming ($M = 14.9$, $SD = 1.72$), the photo group- limited time – zooming ($M = 12.5$, $SD = 2.16$), the photo group - limited time – no zooming ($M = 13.93$, $SD = 2.07$), the no-photo group - infinite time – zooming ($M = 15.22$, $SD = 2.06$), the no-photo group - infinite time – no zooming ($M = 16.56$, $SD = 1.25$), the no-photo group - limited time – zooming ($M = 14.81$, $SD = 2.13$), and the no-photo group - limited time – no zooming ($M = 16.41$, $SD = 1.31$). The detrimental effect of having to recognize zoomed-in details, compared to whole paintings, was not significantly different in the two groups, and time did not affect this.

RTs at recognition. We ran a 2 (Group) x 2 (Time for recognition) x 2 (Retrieval cue) ANOVA for mixed design on RTs at recognition. The analyses revealed a main effect for zooming, $F(1,104) = 69.63$, $p = .001$, $\eta_p^2 = .40$. The measured RTs were higher when the paintings were zoomed in ($M = 1942.62$, $SD = 631.17$) than they were presented as a whole ($M = 1731.49$, SD

= 642.92).Time for recognition (unlimited vs 3 sec max) did have a significant effect on RTs, *F*(1,104) = 16.17, $p < .001$, $\eta_p^2 = .14$ and RTs were higher when the participants had given unlimited time to give a recognition answer (*M* = 2030.76, *SD* = 655.18) than when timing was set at 3 sec (*M* = 1614.77, *SD* = 383.91), even if in both cases response times never exceeded 3 sec.

Photo vs no-photo conditions did not show any significant effects on RTs, *F*(1,104) = 1.8, $p = .18$, $\eta_p^2 = .017$, no significant difference was found between means of the photo group (*M* = 1892.14, *SD* = 639.22) and the no-photo group (*M* = 1753.4, *SD* = 496.38). However, importantly, the interaction between groups and type of retrieval cues was significant, *F*(1,104) = 7.77, $p < .05$, $\eta_p^2 = .07$.

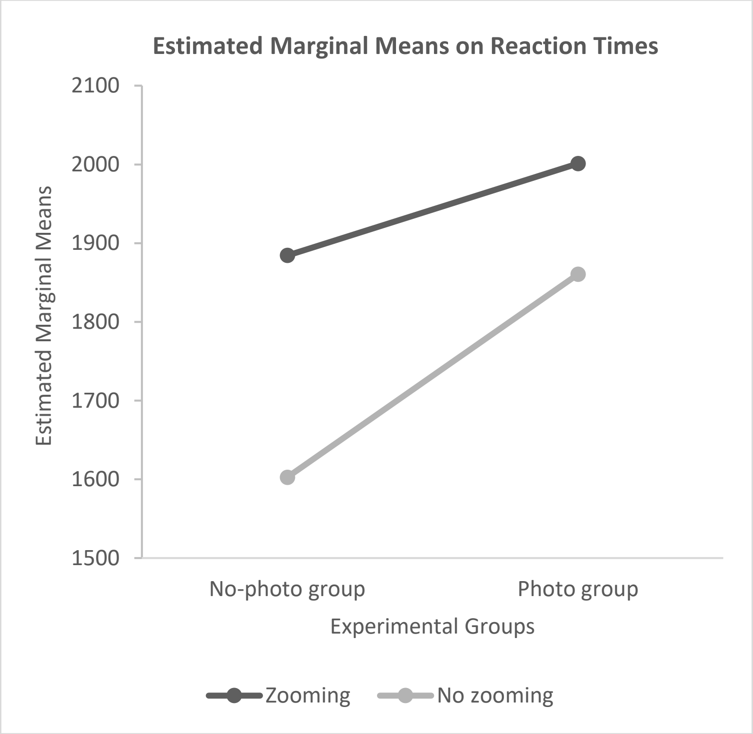


Figure 14. Estimated marginal means on reaction times (milliseconds) in response to retrieval cues

Looking at the figure above, the participants gave the shortest RTs in the no-photo - no zooming condition (*M* = 1602.6, *SD* = 459.63), whereas the longest RTs occurred in the combination of photo - zooming condition (*M* = 2001.01, *SD* = 689.9). The figure also shows that seeing zoomed-in details was more detrimental for retrieval time for the group that did not take any photos, than for the photo group, even if overall retrieval times remained faster in the no-photo group. This significant interaction goes in the opposite direction of what expected according to the hypothesis that the deficit due to photo taking occurs at encoding. If it were so, we should have observed a larger difference in the photo group than in the no-photo group.

Lastly, no interaction effect was found between Group X Time for recognition, $F(1,104) = .002$, $p = .97$, $\eta_p^2 = .000$. For the photo group - infinite time ($M = 2102.43$, $SD = 744.21$), the photo group- limited time ($M = 1681.85$, $SD = 432.69$), the no-photo group - infinite time ($M = 1959.1$, $SD = 557.25$), the no-photo group - limited time ($M = 1547.7$, $SD = 322.28$).

The three way interaction was not significant, $F(1,104) = 1.004$, $p = .32$, $\eta_p^2 = .01$. Mean reaction times of the no-photo group and the photo group are represented in the table shown below.

Table 7. *Three-way Interaction Between Groups, Time for Recognition (milliseconds) and Type of Retrieval Cues*

Retrieval timing & Type of retrieval cues	No-photo group	Photo group
Self-paced & Zoomed	2098.02 (641.94)	2133.11 (692.73)
Self-paced & Not zoomed	1743.1 (506.34)	1969.93 (794.92)
Limited time & Zoomed	1670.5 (384.96)	1868.91 (673.8)
Limited time & Not zoomed	1462.1 (365.04)	1750.9 (737.98)

Note: Standard deviations are shown in parentheses.

Correct responses. ANOVA results showed a significant effect of Time for recognition on RTs of average correct responses, $F(1,104) = 13.49$, $p < .001$, $\eta_p^2 = .115$. The RTs were longer when the given time was infinite ($M = 1944.05$, $SD = 630.49$) than when it was limited ($M = 1577.84$, $SD = 370.2$). However, the effect of Group on RTs of average correct responses was not significant, $F(1,104) = 1.50$, $p = .22$, $\eta_p^2 = .014$. Analysis did not show a significant difference between means of the photo group ($M = 1822.06$, $SD = 610.71$) and the no-photo group ($M = 1699.83$, $SD = 471.49$). There was no significant Group X Time for recognition interaction for

RTs of average correct responses, *F*(1,104) = .023, *p* = .88, η_p^2 = .000, no significant difference was found between means of the photo group - infinite time (*M* = 2012.8, *SD* = 720.05), the photo group- limited time (*M* = 1631.34, *SD* = 407.75), the no-photo group - infinite time (*M* = 1875.32, *SD* = 531.07), the no-photo group - limited time (*M* = 1524.34, *SD* = 327.35).

Incorrect responses. While the two groups did not differ in their overall RTs of incorrect responses, *F*(1,104) = 1.16, *p* = .28, η_p^2 = .011 (means of the photo group (*M* = 2088.9, *SD* = 123.76) and the no-photo group (*M* = 2277.06, *SD* = 123.76)) a main effect of Time for recognition on RTs for incorrect responses was found, *F*(1,104) = 25.23, *p* < .001, η_p^2 = .195. The RTs of average incorrect responses were longer when the time was self-paced (*M* = 2622.58, *SD* = 1159.16) than when the time was limited (*M* = 1743.36, *SD* = 619.07). Importantly, a significant interaction was revealed between Groups and time for recognition (see Figure 15), *F*(1,104) = 5.5 , *p* = .02, η_p^2 = .050. When there was no time pressure, it was the no-photo group that took more time searching for memories that turned out to be incorrect.

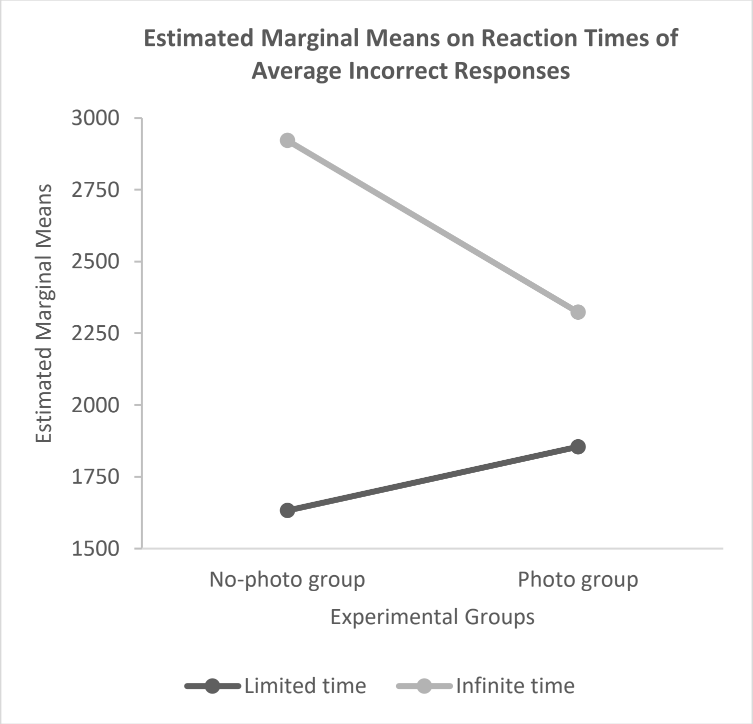


Figure 15. Estimated marginal means on reaction times (milliseconds) of average incorrect responses in the recognition task

Confidence Ratings and Confidence Reaction Time Analyses

An additional ANOVA revealed a significant effect of Groups on confidence ratings *F*(1,104) = 29.06 , $p < .001$, $\eta_p^2 = .218$, and participants who were in the no-photo group gave higher confidence ratings (*M* = 5.17, *SD* = .49) than the ones who were assigned to the photo

group (*M* = 4.55, *SD* = .68). Whereas time pressure did not show any effect on confidence ratings,

F(1,104) = .90, $p = .34$, $\eta_p^2 = .009$. Analysis showed no significant difference between means for the self-pace (*M* = 4.91, *SD* = .72) and limited time (*M* = 4.8, *SD* = .60) conditions. There was no significant Group X Time for recognition interaction for confidence ratings *F*(1,104) = .49, $p = .48$, $\eta_p^2 = .005$. No significant difference was found among means of the photo group – limited time (*M* = 4.53, *SD* = .60), the photo group – infinite time (*M* = 4.56, *SD* = .76), the no-photo group – limited time (*M* = 5.07, *SD* = .48) and the no-photo group – infinite time (*M* = 5.26, *SD* = .48).

Correct responses. There was a main effect of Group on confidence ratings given for the average correct responses, *F*(1,104) = 27.12, $p < .001$, $\eta_p^2 = .207$. Participants who were in the no-photo group gave higher confidence ratings (*M* = 5.3, *SD* = .43) than the ones who were assigned to the photo group (*M* = 4.74, *SD* = .65). Whereas the effect of Time for recognition on confidence ratings for average correct responses was not significant, *F*(1,104) = .39, $p = .534$, $\eta_p^2 = .004$. Analysis showed no significant difference between means of the infinite time (*M* = 5.05, *SD* = .66) and limited time (*M* = 5, *SD* = .58) conditions. There was no significant Group X Time for recognition interaction for the same variable *F*(1,104) = .47, $p = .494$, $\eta_p^2 = .005$. No significant difference was found among means of the photo group – limited time (*M* = 4.74, *SD* = .60), the photo group – infinite time (*M* = 4.73, *SD* = .71), the no-photo group – limited time (*M* = 5.23, *SD* = .44) and the no-photo group – infinite time (*M* = 5.4, *SD* = .43).

Incorrect responses. Analysis showed that confidence ratings given for incorrect responses did not differ between groups *F*(1,104) = .41, *p* = .525, η_p^2 = .004. Analysis showed no significant difference between means of the no-photo group (*M* = 4.03, *SD* = 1.22) and the photo group (*M* = 3.9, *SD* = .93). Similar results were found in terms of Time for recognition *F*(1,104) = .315, *p* = .58, η_p^2 = .003, without any significant differences between means of the limited time (*M* = 3.9, *SD* = 1.08), the infinite time (*M* = 4.02, *SD* = 1.09) conditions. No significant effects was found in Group X Time for recognition interaction *F*(1,104) = .005, *p* = .944, η_p^2 = .000 with means of the photo group – limited time (*M* = 3.84, *SD* = .83), the photo group – infinite time (*M* = 3.94, *SD* = 1.04), the no-photo group – limited time (*M* = 3.96, *SD* = 1.29) and the no-photo group – infinite time (*M* = 4.1, *SD* = 1.16).

As shown in Figure 16, RTs of confidence ratings were tendentially - but not significantly - higher when the given time for recognition was limited than it was infinite, *F*(1,104) = 3.37, *p* = .07, η_p^2 = .031.

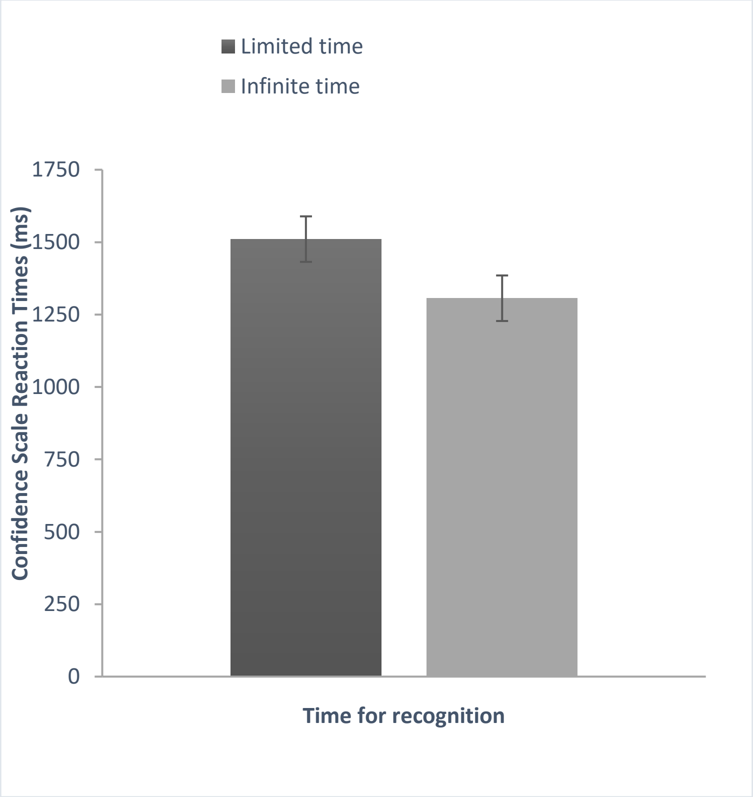


Figure 16. Mean reaction times (milliseconds) when giving confidence ratings. Error bars represent standard errors

The effect of Group on confidence RTs was not significant, $F(1,104) = 1.78$, $p = .185$, $\eta_p^2 = .017$. Analysis showed no significant difference between means of the no-photo group ($M = 1334.25$, $SD = 497.18$) and the photo group ($M = 1482.6$, $SD = 658.69$). Finally, there was no significant Group X Time for recognition interaction, $F(1,104) = .80$, $p = .373$, $\eta_p^2 = .008$ with means of the photo group – limited time ($M = 1534.96$, $SD = 761.89$), the photo group – infinite time ($M = 1430.23$, $SD = 546.15$), the no-photo group – limited time ($M = 1486$, $SD = 458.8$) and the no-photo group – infinite time ($M = 1182.52$, $SD = 495.54$).

Self-Report Measures and Flanker Task Analyses

An independent-samples t-test was conducted to compare self-report measures and flanker task scores in the two Groups. Results showed that there were no significant differences in scores of self-report measures; PMPUQ scores t(106) = .45, p = .66; SAS scores t(106) = .34, p = .74; PA scores t(106) = -1.17, p = .243; and STAI scores t(106) = .26, p = .80. Furthermore, the two groups did not differ on their Flanker task performances t(106) = .70, p = .49. Mean values of the no-photo group and the photo group are represented in the table shown below.

Table 8. *Group Differences on Mean Scores of Self-Report Measures and Flanker Task*

	No-photo group	Photo group
1. PMPUQ	30.54 (6.33)	30.02 (5.71)
2. SAS	26.50 (7.53)	26.00 (8.02)
3. PA	13.91 (4.15)	14.80 (3.71)
4. STAI	35.63 (8.25)	35.20 (9.01)
5. Flanker task	14.47 (88.94)	3.62 (72.22)

Note: Standard deviations are shown in parentheses.

7.4 Discussion

With this experiment in which several variables were manipulated, we confirmed the existence of a photo-taking-impairment effect in a larger sample. Time available at retrieval was also manipulated (self-paced vs 3 sec max), as were the type of items presented for recognition (presenting half of the times the images as in their original size, as in Experiment1, and half of the times as a 50% zoomed-in image. Replicating the photo-taking-impairment effect seen in Experiment 1, results showed that participants in the photo group recognized correctly fewer paintings that they had photographed than the participants in no-photo group who had solely observed the paintings without photographing them.

As mentioned earlier, Experiment 3 aimed to investigate whether the photo-taking-impairment effect occurs due to poor encoding. To test this hypothesis, subjects were presented two types of retrieval cues (zooming vs. no-zooming), with the idea that, if encoding is poorer in the photo group, recognition of zoomed images would be worse in this group than in the no-photo group. Results showed that, while it is true that the zooming variable caused a memory impairment on recognition accuracy, it affected both groups. Thus, all participants recognized more accurately when retrieval cues were presented as a whole than when they were zoomed in. The lack of a Group x Type of cues interaction suggests that the specific impairment observed in the 8-photo group might not occur at encoding. While taking into account that the task performance in the photo group was worse than in the no-photo group for both types of cues, suggesting a poorer overall quality of the memory in the photo group, we also need to consider the significant interaction of Group x Zooming on response times in recognition. The interaction between group and type of cues goes in the opposite direction than expected in case encoding was poorer for the photo group. Our results showed that presenting zoomed-in material at recognition slowed down more the no-photo group than the photo group (see Figure 15).

However, we cannot fully exclude a role for encoding. Along with the interpretation of a non-specific impairment due to a general poorer/more superficial encoding in the photo group, this result could indicate that presenting zoomed-in details made participants in the no-photo group search longer in memory than those in the photo group, which increased their performance also in this condition. However, one should also notice that the 8-photo group was overall less confident when providing confidence ratings for their recognition, compared to the no-photo group, a difference that was evident for correct recognition, but not for incorrect recognition, for which no difference was found between groups. This might suggest that the greater time spent by the no-photo group when attempting to recognize the zoomed-in details might reflect more of a metacognitive strategy or a greater willingness to search in memory based on a greater confidence in this group, rather than simply a greater cost during retrieval, as confidence tends to make people search more for a solicited target in their memory before they give up (see Koriat, 2002). If so, given the higher memory performance in this group, this result might also suggest that items encoded without taking any photo were of better quality in the no-photo than in the photo group, providing some support for a role of encoding in creating the photo-impairment effect.

Although the greater difference between zoomed-in vs. not zoomed paintings was observed in the no-photo group, nonetheless the participants gave the shortest recognition RTs in the combination of no-photo - no zooming condition whereas the longest recognition RTs occurred in the combination of photo - zooming condition. This finding suggests that the more the task difficulty increases, the more the detrimental effect of taking photographs becomes apparent in terms of amount of time taken to respond. Yet we cannot say that the impairment is totally attributable to encoding. In terms of time pressure at retrieval (limited vs. unlimited), as easily predictable, people took more time to give their recognition responses when they were given more time. In the no-photo group, the RTs of average incorrect responses were longer when the time for recognition was self-paced than when it was limited. More interestingly, the result showed that the time for recognition for the incorrect responses was the longest in the no-photo group, suggests that the longer search in memory not only accessed correct memories, but also incorrect memories.

Lastly, RTs of confidence ratings were tendentially higher when the time for recognition was limited (*M*=1510.48) than when it was self-paced (*M*=1306.37). This can be interpreted as if people feel less confident when they are under time pressure to recognize the painting, and it takes longer for them to rate their confidence. And, more interestingly, the longest confidence RTs were obtained for those who did not take any photos during encoding and were given self-paced time during recognition. The interpretation of this finding aligns with the interpretation of the other finding, overall showing that the time spent searching memory of zoomed-in details was greater in the no-photo than in the photo group. People in the no-photo group were overall more confident in their memory, and, when time was unlimited, searched their memory for a longer time. This led on one hand to greater recognition, items for which they had greater confidence, but also led to accessing items for which they were not really confident, taking then more time to give a confidence rating for them.

CHAPTER 8

GENERAL DISCUSSION

Online communication has clearly taken a visual turn with increasing focus on posting photos and videos for sharing experiences (Oeldorf-Hirsch & Sundar, 2016). Capturing, storing, and sharing photographs have become easier than ever by means of camera phones. According to Zhang (2017), smartphone plays a significant role in media convergence, and in particular, smartphone photography is reconstructing the way we communicate and think. The potential influence of smartphone photography on autobiographical memory mostly becomes visible in the context of social media. Then what could be the mnemonic consequence of posting personal memories online? For example, research has shown that when events are posted online, they are more likely to be recalled than unposted events (Wang, Lee, & Hou, 2017). Therefore, one might think that posting photos on social media in a care-free way would take the attention away and decrease memory, whereas getting a perfect photograph for sharing on social media would lead to a better memory of the event with less distraction (Berry, 2019).

The limited research on the impact of photographing a content on memory suggests that photo taking can diminish memory (Henkel, 2014; Niforatos et al., 2014; Soares & Storm, 2018). We conducted three experiments to investigate whether the act of taking photographs might have a hindering effect on memory and if so, we aimed to establish the main factors underlying this type of memory impairment. There are several contradicting findings reported in the literature about the so-called *photo-taking-impairment effect*, and in this study, we intended to take into consideration some of the variables that might possibly be involved in this phenomenon and that none of the previous studies on this topic had tested before.

In the first two experiments reported here we sought to explore whether manipulating encoding condition, by giving subjects either incidental or intentional memory instructions, would bring to different results on the detrimental effect of taking photos on memory. Our aim was to hold all aspects of the experimental procedure constant and manipulate only whether subjects incidentally or intentionally encoded the paintings presented during a mock museum tour. Participants who took one-photo of each item or the ones who continuously took photos while viewing the tour were expected to exhibit lower memory accuracy scores at a later recognition task compared to the participants of the no-photo group. According to the results obtained from these two experiments, a photo-taking-impairment effect was observed in Experiment 1, in which we confirmed that taking photos reduced people's ability to recognize objects they had photographed, but somewhat surprisingly, the detrimental effect of taking photos was eliminated in Experiment 2. The former used an intentional encoding instruction prior to the encoding phase, while in the latter the purpose of encoding was kept hidden from the participants.

Investigating the photo-taking-impairment effect in a laboratory setting allowed us to consider a critical variable which is *recognition response times* for a previously photographed content. This has never been measured in prior studies on this topic. Aside from the impairment in memory accuracy scores, in photo groups we also expected to observe slower RTs in response to memory cues (paintings from the museum tour) compared to the no-photo group, as this may also indicate a sign of memory impairment. When encoding was intentional, differently from recognition accuracy, the three groups did not differ in terms of their recognition RTs. However, when encoding was incidental, and a direct detrimental effect on memory was not observed, recognition RTs of the 8-photo group was found to be *tendentially* higher than of the one-photo and no-photo groups. This may be considered as sort of a memory impairment, as people took somewhat longer to access their memories. Yet further research needs to replicate this finding and see whether with more participants this difference in recognition time can become significant. In addition, more work needs to be done to more solidly establish a photo-taking-impairment effect that is reflected in RTs.

Here we discuss what one can infer by comparing the two experiments. Even if a direct comparison is not possible given that the experiments were run in two different periods, by comparing the results of the two experiments, as already mentioned in the discussion of Experiment 2, one could hypothesize that taking several photos during encoding when people expect a memory test, makes encoding processes less efficient, and very similar to a more superficial elaboration that is found in an incidental task. The better results in intentional recognition are in line with the established literature in this topic, consistently showing that intentional encoding helps over incidental encoding. Indeed, intentional encoding is essentially a "metaplan” for constructing a plan that will guide recall (Eagle & Leiter, 1964), which makes it an operation that is mentally demanding through the engagement of attentional and executive resources. Whereas incidental encoding occurs without an individual’s deliberate attempt to learn, which makes it less effortful (Bjorklund, 1995; Karrasch et al., 2010; Kontaxopoulou et al., 2017). On the other hand, the distinction between incidental and intentional encoding has been assessed in a variety of behavioral and neural measures (Coutanche & Thompson-Schill, 2014; Merhav et al., 2015; Rüsseler et al., 2003; Sharon et al, 2011). What we know so far is that incidental and intentional encoding are processed differently, and the superiority of intentional over incidental learning might depend upon factors as the nature of the orienting task accompanying the type of encoding condition.

Note that the impairment effect was not observed in the participants of the one-photo group in Experiment 1, even when a memory test was expected. Thereby, taking one photo or fewer photos did not lead to any memory disadvantage, a result that is from what observed by Henkel (2014) and others, nor to a memory advantage, unlike it was claimed in a previous study (Niforatos, 2017). We found this result rather surprising, and not straightforward to explain, although we talk more expansively about it in a later section of this chapter, also given the lower level of confidence ratings given by this group compared to the group that did not take photos.

It is as if in the one-photo group our participants, expecting a memory task, tried and were able to engage more with the material during encoding, in spite of (or may be to compensate for) a general sense of difficulty in remembering properly (which is shown by their lower confidence ratings). If this hypothesis is correct, we can also see that no compensation occurred in the group that took multiple photos. Overall, the comparison between the two experiments, although taken with the necessary caution, seems to suggest a very odd hypothesis: when people take photos, knowing in advance about a subsequent memory task creates itself the memory impairment. By making the photo-taking-impairment effect vanish in our second experiment, we established that the detrimental effect of photographing might be due to poor encoding, but also there might be other factors involving in this phenomenon such as poor retrieval strategies, which is directly linked to metacognitive processes. Metamemory judgments affect a variety of strategic decision processes that can affect people's ultimate memory performance. It includes beliefs about one's own memory, its strengths and weaknesses, as well as the conditions and variables that affect memory performance for developing different encoding and retrieval strategies (Koriat, 2002; see also Flavell's, 1979 model of metacognitive monitoring). For example, at the retrieval stage alone, people can decide whether to initiate search on the basis of their preliminary feeling of knowing, whether to use an inferential or a direct-retrieval strategy, when to terminate the search and so forth (see Koriat & Goldsmith, 1996).

Then how one can explain the reason why photo taking diminishes the memory for a photographed content in certain conditions? The photo-taking-impairment effect has been explained by an offloading account which states that if individuals do not expect the camera to save their photos, then the photo-taking-impairment effect should be eliminated or greatly reduced and vice versa. Remember the pioneer research on "Google effect" by Sparrow and his colleagues (2011); as much as having access to the Internet can reduce memory for factual information and having access to photographs may reduce memory for one's experiences

(Barasch et al., 2017). Nevertheless, based on the empirical findings of a recent study by Soares and Storm (2018) that is summarized in a preceding chapter above, we do not find the offloading hypothesis to be able to explain our results, as Soares and Storm themselves refuted the offloading hypothesis and opted for an alternative explanation of the photo-taking-impairment effect, that of attentional disengagement. This hypothesis assumes that encoding suffers automatically as a consequence of taking photos, and therefore the photo-taking-impairment effect should not depend on whether the photographer considers the camera a reliable external memory source (Soares & Storm, 2018).

While conducting a third experiment, we aimed to replicate the photo-taking-impairment effect which was observed in the first experiment but not in the second one, and to have a better understanding of the possible mechanisms behind this effect. In particular, what we wanted to investigate with this third experiment was whether the photo-taking-impairment effect occurs due to poor encoding of the photographed object, as it was claimed in previous studies (Henkel, 2014; Soares & Storm, 2018). In order to test whether the task of capturing an experience with a camera leads participants to encode it less deeply or elaborately than they would have otherwise (which is the assumption of attentional disengagement hypothesis) we presented half of the retrieval cues as partial (zoomed-in) details of the original image. Note that in order to replicate the impairment effect, encoding condition was kept intentional as in Experiment 1. Poorer encoding is a viable explanation of the effect if one finds a greater memory impairment effect when using zoomed-in details during recognition. This should happen, however, more in the photo group than in the no-photo group. In other words, due to a limitation or a shift in attention caused by the act of photo taking itself, the participants in the photo group (a one-photo group was not included this time) were expected to exhibit lower memory accuracy scores at a later recognition task compared to the participants in the no-photo group, and in particular more so when zoomed-in details were presented rather than whole paintings.

In line with part of our predictions, results of Experiment 3 replicated the photo-taking-impairment effect. However, the detrimental effect of using zoomed-in details was not different between the two groups, limiting the conclusions one can draw about the poorer encoding when taking photos. Furthermore, we also modulated a parameter which we called *time for recognition*; that is a half of the participants of this experiment was given limited time to complete recognition questions whereas the other half was given infinite time to respond as in Experiment 1 & 2. Besides, doubling the sample size in Experiment 3 allowed us to examine the effect of photography on memory with an increased confidence in more robust results.

In line with our predictions, participants gave the shortest recognition RTs in the combination of *no-photo - no zooming* condition whereas the longest recognition RTs occurred in the combination of *photo - zooming* condition. This finding suggests that the greater the task difficulty, the greater the detrimental effect of taking photographs becomes apparent. Yet, as discussed more in depth in the discussion of Experiment 3, we still cannot say that the memory impairment extends to encoding.

In terms of time pressure during recognition, as easily predictable, participants of both groups took more time to give their recognition answers when they had more time available. The retrieval latency which was observed here can be interpreted as proposed by Schwartz (2001), that is when people feel that they know the answer to a question, they would try harder to search them in their memory. For this reason, it is not a surprise to see that participants look longer for a solicited target in their memory when they are given infinite time to give their responses. Moreover, presenting a detail of a painting slowed down recognition in both photo and no-photo groups. Furthermore, in the no-photo group, the RTs of average incorrect responses were found to be longer when the time for recognition was infinite than when it was limited. Since the no-photo group did not experience any distractions and had a chance to merely observe each painting in the museum tour, it is more likely that the participants of the no-photo group had higher subjective confidence (as it was also confirmed by their confidence scores) while performing the memory test compared to the photo-group. As is known, confidence plays a major role in memory retrieval, and it makes people search more in their memory. For example, research has shown that people search longer for an elusive memory target when they experience a high feeling of knowing or when they are in a state of tip-of-the-tongue (Gruneberg et al., 1977; Nelson et al., 1984; see also Koriat, 2002). In addition, a large proportion of incorrect answers may be held in high confidence (Koriat & Goldsmith, 1996), and the longer search times observed in the current study in the no-photo group when giving an incorrect response seem to confirm that participants in this group were more willing to search longer, thus accessing incorrect items that were however rated with a sufficient level of confidence to be then reported (Robinson et al., 1997).

RTs of confidence ratings were found longer in both groups when the time for recognition was limited than when it was infinite. Remember that search time is affected by the person's goals (Barnes et al., 1999), like in our case, and that there is typically a speed versus accuracy tradeoff. This suggests that participants who were previously asked to recall their memory in a limited amount of time were not really confident about their memory performances, and as a result, it took more time for them to make a confidence judgment compared to the people who had given infinite time for the memory test.

It is worth noting that testing in a laboratory setting allowed us to control a potentially confounding variable, i.e., the inhibition of automatic attention caused by one’s own smartphone. Across three experiments, each participant in photo groups was directed to use his/her own personal smartphone camera during encoding. Participants in no-photo groups instead were asked to keep their personal cellphones on the table next to them. The reasoning behind this set of instructions comes from an important paper which was mentioned in a preceding chapter. It has been shown that the mere presence of one’s own smartphone impaired people's performance by reducing available cognitive capacity. Having our smartphones next to us while performing a task, even when we do not consciously attend to our cellphones, would inhibit attention which would in turn occupy cognitive resources (Ward et al., 2017), which we avoided by allowing participants to keep their cellphone visible on the desk even when they were not supposed to take photos.

This study also included exploratory variables such as the Flanker task, and paper-based questionnaires about smartphone habits. By administering the Flanker task, we aimed to test participants' attentional skills before starting the encoding procedure, with the idea that the photo-taking-impairment effect might be related to one's attentional skills in general. However, the three groups did not differ in their Flanker task performances, which makes the memory impairment due to taking pictures a phenomenon that can be observed in the general population rather than its association with one's own attentional skills. Yet, this can be tested in future studies by using different attentional tasks and in larger samples. Further, for exploratory purposes, smartphone habits were screened with subjective measures, considering that these habits can affect peoples' cognitive and attentional abilities, which might be an underlying factor for the memory impairment occurring when one takes pictures with a smartphone camera. Yet, our results showed no link between problematic cell phone use and the photo-taking-impairment effect.

As it was mentioned above, Henkel (2014) showed that photographing objects at a museum tour had detrimental effect on memory of those objects. When participants took photos of the objects after viewing them, they remembered fewer objects and remembered fewer details about the objects and the objects' locations than when they only observed the objects without photographing them. Despite this finding, Henkel's study eliminated the photo-taking-impairment effect by using a zooming condition during encoding. She found that photographing an object while zooming in on can instead boost memory for that object. Clearly her methodological decision differed from ours as her participants zoomed in to the objects while photographing them, meaning that she directly interfered with the memory encoding processes by manipulating interest in the object. Our results did not reveal any memory advantage as we used zoomed images as retrieval cues. Furthermore, these contradicting findings might also be linked to the *exposure duration*; specifically, Henkel had participants view the museum objects for a specified amount of time before taking a photograph - which can again enhance memory encoding, whereas our participants exposed the artworks while continuously photographing them, so that they saw the artworks in a mediated version by viewing them not directly but constantly from a smartphone screen.

Barasch and her colleagues (2017) on the other hand, examined the effect of volitional photo taking on memory in terms of visual and auditory aspects of experiences, and they reported several experiments showing that picture taking can boost memory for visual content. Their study did not reveal a photo-taking-impairment effect, and there are two potential explanations for this discrepancy with our results. First, their participants had not been informed about a memory test before touring the exhibits. Our study has already shown that incidental encoding eliminates the detrimental effect of photographing a content on memory. Another explanation for this discrepancy is that of volition. Participants chose what to photograph, and this variable seems to help focus visual attention and intensify engagement with the experience.

Our study is different from the previous research as it did not take place in a natural setting like a real museum tour but we used a computer-based laboratory paradigm to measure memory accuracies and memory reaction times. Participants of the current study experienced a mock tour in which some important factors (such as RTs of recognition answers, RTs of confidence ratings, time for recognition, and the nature of the cue presented at retrieval) were manipulated. This can have substantial role on the photo-taking-impairment effect.

It must be noted that we investigated the effect of taking photographs on memory when participants did not revisit any photos. In real life, people take photos with the intention to revisit later, the possible effects of revisiting photographs should be tested in future research. Another point is that, in the present study, participants' memory was tested with a relatively short delay. It is important to examine the persistence of the photo-taking-impairment effect in future studies.

As it was discussed above, Barasch and her colleagues (2017) have shown that volitional photography induces a shift in attention toward visual aspects of an experience rather than the auditory aspects, thus picture taking can boost memory recall. If people select which aspects of an experience they want to photograph, memory for these aspects could actually be enhanced from the decision to take a photo in the first place and the increased attention on the photographed features (Diehl et al., 2016). Although our study did not examine the effects of volitional photo taking (the participants were experimentally directed to take pictures), yet it is very likely that volition can increase memory strength. Naturally, the question arises: Would this impairment occur in professional photographers rather than the amateurs? It would be an intriguing subject for future studies to test whether the findings of our study can be extended to different populations such as photographers or in general, individuals devoted themselves to visual arts.

Conclusion

This dissertation has demonstrated that the detrimental effect of photographing a content on recognition memory can be modulated through the manipulation of people's knowledge of an upcoming memory test. This suggests that knowing in advance about a memory task creates itself the impairment by possibly affecting encoding or retrieval strategies. Furthermore, photo groups have given lower confidence judgments compared to no-photo groups, suggesting that photo-taking makes people uncertain about what they remember. In these three experiments we also aimed to test the role of encoding on the photo-taking-impairment effect by presenting retrieval cues as partial details of the original images. Overall, presenting only details impaired memory independent of the different experimental groups. Considered together, these results suggest that taking many photographs (similar to today’s frequent cellphone photo taking habits) does not impair memory encoding, while it seems to affect metacognitive variables at retrieval, such as confidence in memory and retrieval strategies.

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Appendix A

Problematic Mobile Phone Use Questionnaire

	Strongly agree	Agree	Disagree	Strongly disagree
1. It is easy for me to spend all day not using my mobile phone.	1	2	3	4
2. I use my mobile phone while driving.	1	2	3	4
3. I don’t use my mobile phone when it is completely forbidden to use it.	1	2	3	4
4. It is hard for me not to use my mobile phone when I feel like it.	1	2	3	4
5. I try to avoid using my mobile phone when driving on the motorway.	1	2	3	4
6. I don’t use my mobile phone in a library.	1	2	3	4
7. I can easily live without my mobile phone.	1	2	3	4
8. I use my mobile phone in situations that would qualify as dangerous.	1	2	3	4
9. I use my mobile phone where it is forbidden to do so.	1	2	3	4
10. I feel lost without my mobile phone.	1	2	3	4
11. While driving, I find myself in dangerous situations because of my mobile phone use.	1	2	3	4
12. When using my mobile phone on public transport, I try not to talk too loud.	1	2	3	4
13. It is hard for me to turn my mobile phone off.	1	2	3	4
14. I use my mobile phone while driving, even in situations that require a lot of concentration.	1	2	3	4
15. I try to avoid using mobile phone where people need silence.	1	2	3	4

Appendix B

The Smart Phone Addiction Scale Short Version (SAS-SV)

	Strongly disagree	Disagree	Weakly disagree	Weakly agree	Agree	Strongly agree
1. Missing planned work due to smartphone use	1	2	3	4	5	6
2. Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use	1	2	3	4	5	6
3. Feeling pain in the wrists or at the back of the neck while using a smartphone	1	2	3	4	5	6
4. Won't be able to stand not having a smartphone	1	2	3	4	5	6
5. Feeling impatient and fretful when I am not holding my smartphone	1	2	3	4	5	6
6. Having my smartphone in my mind even when I am not using it	1	2	3	4	5	6
7. I will never give up using my smartphone even when my daily life is already greatly affected by it	1	2	3	4	5	6
8. Constantly checking my smartphone so as not to miss conversations between other people on Twitter or Facebook	1	2	3	4	5	6
9. Using my smartphone longer than I had intended	1	2	3	4	5	6
10. The people around me tell me that I use my smartphone too much	1	2	3	4	5	6

Appendix C

Perceived Attachment to Phones Questionnaire

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
1. I would feel uncomfortable if I didn't have my phone with me for a long period of time	1	2	3	4	5
2. I would feel lost if I didn't have a cell phone	1	2	3	4	5
3. I would feel detached from my friends if I didn't have a cell phone.	1	2	3	4	5
4. I feel momentarily distressed if I realize that I am without my phone while I am out and about	1	2	3	4	5
5. I would rather lose my wallet than my phone	1	2	3	4	5

Appendix D

State Trait Anxiety Inventory

Read each statement and select the appropriate response to indicate how you feel right now, that is, at this very moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	**A little**	**Somewhat**	**Very Much So**
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I feel tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel uncomfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I feel jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4