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WORKING TITLE: COGNITIVE FAILURES IN DAILY LIFE; exploring the link between Internet addiction and problematic mobile phone use.

Hadlington, L.J.

Email: lhadlington@dmu.ac.uk

Corresponding Address: Nottingham Trent University, 50 Shakespeare Street, Nottingham NG1 4FQ

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Abstract

A questionnaire-based study attempted to explore the link between Internet addiction, problematic mobile phone use and the occurrence of cognitive failures in daily life. Previous research has suggested that individuals who have lower working memory capacity (WMC) and poorer attentional control (AC) maybe poorer at limiting the distraction effect posed by access to communicative digital media such as the Internet and mobile phones (Unsworth, McMillan, Brewer, & Spillers, 2012). 210 participants completed and online questionnaire which comprised of the Online Cognition Scale (OCS; Davis, Flett, & Besser, 2002), the Problematic Mobile Phone Use Scale (MPPUS; Bianchi & Phillips, 2005) and the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982). Both the OCS and MPPUS were significantly positively correlated to scores on the CFQ. Further analysis revealed a significant difference between high and low scoring groups for both the MPPUS and the OCS and scores on the CFQ, with those in the higher groups presenting greater self reported cognitive failures. The results are interpreted as being symptomatic of

individuals in the higher OCS and MPPUS groups as being less resilient to the distractions posed by digital media and technology with a suggested link to lower WMC and AC.

1. Introduction

According to a recent OfCom (2014) computer users now spend an average of 31.4 hours per month browsing the Internet, with the average time spent browsing the Internet via the use of a mobile phone being 5.4 hours. Findings from the same report also demonstrate a trend for individuals moving away from the use of static desktop-based PC to portable devices on which to consume digital media and the Internet. The OfCom report noted that laptop computers were now the most popular mechanism for accessing the Internet, being present in 63% of UK households, closely followed by the smartphone at 61% (OfCom, 2014). This proliferation in the use of mobile devices means that individuals are being afforded the freedom and flexibility to engage in digital media wherever and whenever they like.

The use of such digital technology and high frequency exposure to digital media is historically a recent one and thus the impact of such on human cognition has received very little empirical attention. Although there may be anecdotal links between poor attention and higher levels of Internet and mobile phone use but to date very little is known about such exposure and its affect on human information processing. The importance for exploring the impact of such technology is set alongside the growing population of digital natives, those individuals who have never experienced a world without access to the digital media, the Internet and its associated resources (Prensky, 2001; Tapscott, 1998). If exposure to media such as the Internet and the use of mobile devices such as smartphones is having an impact on cognitive processes in individuals that are going through critical stages in development then this needs to be highlighted and the negative impact of such assessed against the perceived benefits.

1.1 Exploring the effects of Internet use on Cognition.

The notion that the use of the Internet can have an effect on brain activation is something that has been explored in research. A recent study by Small, Moody, Siddarth, & Bookheimer, (2009) presented a series of novel findings which showed differences in the pattern of brain activation according to the level of experience individuals had in searching the Internet for information. The study compared the fMRI patterns of two groups of participants based on their previous exposure to the use of the Internet. The Internet Savvy group were classed as being adept at using the Internet and could perform a variety of tasks using search functions, with the Internet Naïve group having only limited experience in the same area. In the first condition both groups were asked to read normal linear text with the results showing no significant difference in brain activation. In a second condition participants were asked to conduct a simple web-based searching activity with the results demonstrating a distinct difference in the brain activation patterns for the two groups. In the Internet Savvy group there was an increase in the activation of the dorsolateral prefrontal cortex, an area Small et al. (2009) noted to be responsible for cognitive functions related to decision-making, integration of thoughts and sensations as well as elements of working memory. Small et al. (2009) proposed that whereas reading simulated book text is a skill that has been learned by both sets of participants and is something that has become engrained in automatic schemas the use of the Internet to search for information presented a novel process, hence leading to the difference in patterns of brain activation.

Small et al. (2009) went on to note another interesting finding related directly to the activation of the brain during problem-based activities. In a normal problem-based activity there is a point at which insight into the solution is reached, resulting in the highest level of activation. As further practice takes place and there are subsequent exposures to the same type of problem the activation of these areas reduces from its original peak at the point of insight. However Small et al (2009) noted that this pattern of activity was not consistent with the activation patterns of the Internet Savvy participants in their study. Rather than showing

reduced activation during Internet-based searching activities they still demonstrated a level on a par with that expected at the point of insight. This finding suggests that the activities this group are experiencing continually presents a novel and mentally stimulating activity even in those individuals who have extensive experience in conducting such actions. Such a pattern of activation eludes as to why engaging in activities on the Internet can be so attractive and rewarding, and also highlights a possible pathway to addiction to such activities where the reward remains constantly high. It was also noted that after just a short amount of time practicing the Internet searching activity, those individuals who belonged to the Internet Naïve group began to demonstrate the same level of brain activation as those in the Internet Savvy group. Small et al. (2009) concluded that such a pattern highlighted the sensitivity of the brain to the use of computer-based technologies such as the Internet and cautioned that the use of such could have a detrimental impact in terms of impaired attention and lead to further issues of addiction and dependency as in the cases of substance abuse (Young, 1998).

The deployment of attention in the context of Internet-based activities has garnered some attention from research. Ophir, Nass and Wagner (2009) explored the notion of media multitasking (MMT) an activity which according to the authors has become more prevalent in users of the Internet. They highlight that such a process predominately used in those termed ‘digital natives’ or the age group between 8-18 years . Traditional conceptualisations of attention have noted that even in the most basic environments the human attentional systems is incredibly poor at engaging in multiple streams of information (e.g. Cowan, 1988). The research conducted by Ophir et al. (2009) explored the notion that those individuals using MMT were displaying an enhanced attentional capacity beyond that of a traditional offline capability. Those participants belonging to the high MMT user group had clear difficulties in cognitive functions when engaged in multiple streams of information. In comparison to those in the group who had limited use of MMT, those in the high MMT group has difficulty in filtering out relevant from irrelevant material and were also less likely to be

able to negate unwanted or irrelevant representations within memory. The high MMT group were also less effective at being able to prevent themselves from switch from a relevant task activities to irrelevant task activities, demonstrating easy distraction by multiple streams of irrelevant information. Such research would tend to suggest that those in the higher end MMT group have a lower threshold for exogenous shifts to external stimulus as well as lacking robust inhibitory control to prevent distraction by task irrelevant information. It would appear that elements of Internet use, or indeed the skills that have been developed as a response to its use do impact on underlying human cognition, and such an impact can be seen to alter the capacity of the individual to clearly focus attention and block out unwanted material.

The proclivity of certain individuals to seek out enhanced or increased stimulation also highlights the potential for the Internet and digital media to become a mechanism for aspects of addiction. As the work by Small et al. (2009) has already noted there is a degree of novelty and stimulation that is afforded by the Internet that is seldom experienced elsewhere in the sphere of human activities. Chou, Condron and Belland (2005) provided a useful review of the key consequences for Internet addiction, with the underlying compromise being that of issues related to time-management and time loss. Early studies highlighted failures of time management, disruption to sleep patterns and eating and a failure to attend school or miss classes associated with excessive Internet use Brenner, (1997). Further issues related to academic performance were also noted in Scherer's (1997) study with excessive Internet use being reported as being responsible for poor academic attainment as well as impacting on activities with the workplace. Other work has noted that those engaged in problematic Internet use have issues related to impulse control (Shapira, Goldsmith, Keck, Khosla & McElroy, 2000) and attention deficit hyperactivity disorder (ADHD; Yoo et al. (2004). This selection of research would suggest that underlying behavioural disorders could provide a predictive element for the susceptibility to problematic Internet use. Park et al. (2011) further noted that existing deficits in cognitive function could be related to the prevalence of

excessive Internet use and individuals who possess cognitive functioning deficits are more likely to be addicted to Internet use versus those individuals with intact cognitive functioning. It has however also been noted that aspects of ADHD that have no neurological basis and are born directly out of the demands of the environment are becoming more prevalent. Hallowell (2005) noted a newer form of the disorder that is claimed to be an artefact of the busy digital environments many individuals are spending time immersed in, results in what he terms Attention Deficit Trait (ADT). According to the work by Hallowell, individuals who display the symptoms of ADT have difficulty staying organised, setting priorities and managing time, all of which would fit into the research observations from those exploring excessive Internet use.

As highlighted above the research on Internet addiction and problematic Internet use has explored a variety of consequences for the disorder but most have focused on elements related to social functioning and fewer exploring the impact on cognition. Sun et al. (2009) explored the link between excessive Internet use in the context of decision-making and response inhibition. The research demonstrated that those who were placed in the higher Internet use group were more likely to have diminished decision-making skills. More specifically, the authors noted that this deficit is not related to incorrect decisions being made but more so a delay in being able to implement the correct strategy. Variety of more general research has also highlighted a link between the use of electronic media and issues related to poor academic attainment . Jacobsen and Forste (2011) specifically noted that a significant negative correlation between time spent engaged in electronic media (e.g. mobile phones, texting, Social Networking Sites (SNS), online gaming) and academic attainment. There is an obvious caveat in terms of using academic attainment as a metric of cognitive functions as such a measure is clouded by a variety of other factors. However even with this caveat accepted it does provide a useful context against which to view the effects of such activities.

Although not specifically an aspect of Internet use but more general use of computer in the context of a learning environment, Risko, Buchanan, Medimorec, & Kingstone (2013) present an interesting study worthy of inclusion in the current context. They based their research on a previous study by (Hembrooke & Gay, 2003) which compared two groups of students, one group which had access to a laptop computer and the Internet and another group that did not. They were tested to see if the access to the laptop computer and the Internet influenced their retention of lecture-based material, with the computer group demonstrating poorer recall of information. Risko et al (2013) extended this study and included the ability for students in the computer-access group to have an email account and a Facebook. Participants were asked to watch a 1-hour long recorded lecture, during which they were presented with a series of ten tasks to complete in their own time throughout the lecture. The research demonstrated that individuals in the computer-access group spent less time attending to the lecture versus those in the control condition and also retained less information about the lecture content. Further analysis also revealed that participants in the computer-access condition performed more poorly as a direct result of the computer taking away attention from the lecture material. The consequences of technology use in teaching environments is a current source of debate and given the findings from research such as that by Risko et al. (2013) demonstrates the importance of further research exploring the ramifications on cognition.

1.2 Problematic Mobile Phone use

A variety of studies have explored the effects of problematic mobile phone use from a number of perspectives. For instance the work by Bianchi and Phillips (2005) highlighted a series of psychological predictors for problematic mobile phone use by using the Mobile Phone Problematic Use Scale (MPPUS). They concluded that aspects of extraversion and lower self-esteem served to explain higher problematic mobile phone use. Problematic mobile phone use has also been explored in terms of the psychological and health consequences indicating links to higher anxiety and insomnia . Ha et al. (2008) also

documented a variety of depressive symptoms for excessive mobile phone use as well as an element of higher interpersonal activity and also lower self-esteem.

The various studies that have explored the link between cognition and excessive mobile phone use have focused on the exposure of individuals to the electromagnetic radiation (EMF) as a source of cognitive impairment. Besset, Espa and Dauvilliers (2005) explored the effect of daily exposure to EMF and found no effect of mobile phone use on cognitive function after a 13hr rest period. The exposure to EMF did have an effect on attention and vigilance with reduced reaction times and increased vigilance when under exposure to EMF. Smythe and Costall (2003) also reported effects of mobile phone exposure on short-term and long-term memory in male and female participants. Surprisingly the results showed that males exposed to an active phone made fewer spatial errors compared to an inactive mobile phone suggesting some form of facilitation effect. It should be noted that in this instance the participants simply held the phone against their left ear during the experiment with no requirement to interact with it and the sample size was relatively small (15 males). However to date there appears to be no systematic exploration of the impact the excessive use of mobile phones is impacting on human information processing capabilities.

The apparent absence of a clear behavioural mechanism through which to explore the impact of excessive Internet and electronic media on cognition could explain the dearth of research in this area. However in the context of the present study a self-report measure is employed as an alternative mechanism for exploring the impact of engaging in digital media and the Internet on cognition. The Cognitive Failures Questionnaire (CFQ) originally developed by Broadbent, Cooper, FitzGerald and Parkes (1982) explores cognitive-based errors on everyday activities an individual should be able to perform (Martin, 1983; Wallace, Kass, & Stanny, 2002). In the original work by Norman (1981) it was noted that cognitive failures could be viewed in terms of 3 key categories, namely errors in the formulation of intentions, the faulty activation of schemas and the false triggering of actions (Wallace, Kass, Stanny, 2002). The underlying causes of cognitive failures have been posited to be

conditions of boredom, worry and divided attention (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). Further research noted that aspects of overloaded STM, reductions in attentional capacity, vigilance and incidental learning (Broadbent et al., 1982; Pollina, Greene, Tunick, & Puckett, 1992). The CFQ offers a useful self-report measure for an initial exploration for how excessive Internet use and problematic mobile phone use maps onto underlying failures in cognition. Broadbent et al. (1982) originally concluded that the CFQ was not sufficiently reliable as a predictor for behavioural measures. However additional research has noted that the CFQ can provide a good predictor for aspects of measures of sustained attention (Robertson et al., 1997) as well as proneness to boredom, ADHD and type A behaviours (Wallace et al. 2002).

Aspects of cognitive failure in daily life are viewed as a common occurrence and in most cases present as a lapse of attention. Such attentional failures can direct the individual away from the task in hand via exogenous mechanisms such as a distracting stimuli or endogenous processes such as ruminations or daydreaming (Unsworth et al., 2012). Unsworth et al. (2012) noted a variety of previous work that has linked such failures in attention to accidents (Reason, 1990; Reason & Mycielska, 1982) as well as problems in educational achievement (Brown, 1927; Lindquist & McLean, 2011). Early work conducted by Reason (1984) explored the nature of attentional failures in undergraduate students and proposed that such lapses occurred due to a preoccupation with either internal thoughts or distraction from external stimuli (Unsworth et al., 2012). Unsworth et al.'s (2012) study further highlighted a link between individual differences and lapses in attentional failures noting a significant role for poor attentional control (AC) and low working memory capacity (WMC). These individuals appear to be lacking the capacity to prevent shifts away from the current focus of attention therefore being prone to significant lapses in tasks particularly where sustained attention is required (Kane et al., 2007).

The aims for this current study are to explore the link between excessive Internet use and problematic mobile phone use and associated links to cognitive failures. It is hypothesized

that those individuals scoring highly a measure of excessive Internet use (Online Cognition Scale, OCS: Davis, Flett, & Besser, 2002) will demonstrate a higher score on the CFQ in comparison to those who scored lower on the OCS. Similarly it is further hypothesized that those individuals who demonstrate higher levels of problematic mobile phone use as identified on the MPPUS (Bianchi & Philips, 2005) will also demonstrate a higher level of cognitive failures as identified via the CFQ.

2. Method

2.1 Participants

210 participants were recruited via an online survey with the sample comprising of 107 males and 103 females. The age range for participants was 18-65 with a mean of 23.19 (*SD* = 7.47). The age groups for participants can be broken down as follows; 88% were aged between 19-29, 6% were aged between 30-39, 5% were aged between 40-49 with 1% were aged 65+. All participants reported prior experience of using the Internet and had owned a mobile phone for over 4 years prior to the commencement of the survey. The amount of time spent on the Internet was self-reported by participants, giving a mean of 22.95 hours over the period of a week.

2.2 Measures

2.2.1. Online Cognition Scale (OCS).

Davis, Flett & Besser (2002) presented the 36-item OCS as a mechanism that explores aspects of excessive Internet use. The key to the OCS is that it focuses directly on cognitions rather than behaviours so is therefore useful to map against issues related to cognitive failures. The OCS contains four key subscales including:

1. Loneliness/depression (items 2, 22, 23, 24, 25, 35) associated to feelings of worthlessness and depressive cognitions about the Internet. This aspect is consistent with previous research indicating a strong relationship between

loneliness and problematic Internet use (Kraut, Patterson, & Lundmark, 1998) as well as depressive cognitions playing an important role in problematic Internet use (R. Davis, 2001)

2. Diminished impulse control (items 4, 5, 10, 11, 12, 15, 17, 21, 34, 36) that relates to obsessive cognitions about the Internet and the inability to reduce Internet use despite the desire to do so. DIC is seen as a clear indicator of the more severe levels of problematic Internet use and is associated with impulsivity related to risk taking and other dangerous behaviours (McCoul & Haslam, 2001)
3. Social comfort (items 1, 3, 6, 7, 8, 9, 13, 14, 16, 18, 19, 26, 31) and associates to the notion that individuals that are lonely have a tendency to use the Internet for the purpose of social comfort. This involves aspects of feelings of safety and security of being part of a social network.
4. Distraction (item 20, 27, 28, 29, 30, 32, 33) involves the use of the Internet as a mechanism for avoidance. This could be avoidance from a stressful event, task or stream of thought (an important component in the context of the CFQ measure). This avoidance-orientated form of coping has negative implications for personal adjustment (Enoler & Parker, 1994) with distraction being highly correlated to procrastination and a history of improper Internet use.

In the study by Davis et al. (2002) the OCS demonstrated a high level of internal consistency as a measure for problematic Internet use with a Cronbach's alpha of 0.94. Scores on the OCS are between 36 to 252.

2.2.2. Mobile Phone Problem Usage Scale (MPPUS)

Bianchi & Philips, (2005) created a 27-item questionnaire which explored aspects of behavioural and technological addiction focusing on problematic mobile phone use. All of the questions in this section were responded to on a 10-point Likert-type scale with 1 (not at all true) and 10 (very true). Bianchi & Philips reported a Cronbach's alpha of 0.93

demonstrating a high level of internal consistency and that the items are related to the underlying construct of problematic mobile phone use. Scores on the MMPUS can range between 27 to 270.

2.2.3. Cognitive Failures in Daily Life (CFQ).

As discussed briefly in the introduction to this study Broadbent et al. (1982) developed the CFQ to assess lapses in cognition for 3 key areas, namely perception, memory and motor function. Later researchers have noted the CFQ comprises of several other factors, with the most recent presented by Wallace, Kass & Stanny (2002) who present a four-factor solution accounting for 54% of variance. The four factors they identified are:

Factor 1: Memory made up of 8 items (3, 6, 12, 13, 16, 17, 18, 23) and is related to memory errors and forgetfulness. Wallace et al. (2002) noted that this factor accounted for 37.39% of variance.

Factor 2: Distractibility made up of 9 items (1, 2, 3, 4, 15, 19, 21, 22, 25) and is identified as a disturbance in the individuals' ability to focus attention. This factor accounted for 6.06% of the variance.

Factor 3: Blunders made up of 7 items (5, 8, 9, 10, 11, 14, 24) and accounted for 5.36% variance. Blunders are defined either in terms of lapses in social concentration or issues related to motor control.

Factor 4: Names was made up of just 2 items (7 & 20) and accounted for 4.34% of variance. This factor relates directly to issues with acquisition of or remembering names.

Scores on the CFQ can fall within the range between 0 and 100.

2.3 Procedure.

The questionnaires outlined above were used to create an online survey which was posted in a variety of research related forums with data collection taking place from May 2014 until

November 2014. Participants were invited to take part in the survey and were given a brief introductory statement about the nature of the experiment detailing an exploration of key aspects related to behaviour online, mobile phone use and daily cognitive failures. Participants were told that they did not need to complete the questionnaire if they did not wish and that they could withdraw at any point during the process. Upon completion of the survey participants were thanked for their time and given fuller details of the aims for the experiment. As this was an online survey informed consent was taking at the point of participation and the right to withdraw was deemed as participants not completing the questionnaire fully. All incomplete responses to the survey were deleted before the final analysis took place.

Data Analysis

All statistical analyses were conducted using SPSS (version 22, IBM Corp.). Data across all participants was collated with one item from the OCS (Item 12) being reversed scored. A median split technique was employed to obtain the groups for high and low OCS and MMPUS groups. For the OCS groups the median was set at 118.5, with all participants scoring higher than this being placed into the high OCS group. For the MPPUS the median was set at 108.5, with all participants scoring higher than this being classified as being in the high group.

3. Results

Preliminary exploration of data revealed a significant correlation between OCS and Daily Cognitive Failures, r = .341 (n=210) p =.000. There was also a significant correlation between MMPUS and Daily cognitive failures, r = .452 (n=210) p =.000 and a further significant correlation between MPPUS and OCS, r = .593, (n=210) p = .000.

3.1 Sex, OCS, MPPUS and CFQ.

The mean score for males on the CFQ questionnaire was 66.32 (*SD* = 16.58) and for females it was 54.90 (*SD* = 18.57). Preliminary analysis for sex and CFQ questionnaire totals revealed that Levene's Test of Equality of Error Variances was not significant (*F* (1, 208) = .465, *p*. = .496) indicating that the assumption for homogeneity of variance had been upheld. A one-way between subjects ANOVA revealed a significant difference between sex groups and total score on the CFQ (*F* (1, 208) = 22.125, *p*. = .000, η_p^2=0.92).

The mean score for males on the OCS questionnaire was 121.31 (SD = 32.53) and for females it was 117.53 (SD = 34.66). Levene's Test of Equality of Error Variances was not significant (F (1, 208) = .096, p. = .757) for sex and OCS questionnaire total indicating that the assumption for homogeneity of variance had been upheld. A one way between subjects ANOVA revealed no significant difference for sex groups and total scores in the OCS questionnaire (*F* (1, 208) = .663, *p*. 417, η_p^2=0.003).

The mean score for males on the MPPUS questionnaire was 113.17 (*SD* = 44.02) and for females it was 113.46 (*SD* = 44.26). Levene's Test of Equality of Error Variances was not significant (*F* (1, 208) = .121, p. = .728) for sex and MPPUS scores indicating that the assumption for homogeneity of variance had been upheld. A further one-way between subjects ANOVA revealed no significant differences for sex and scores on the MPPUS (*F* (1, 208) = .002, *p.* .962, η_p^2 = .000).

3.2 OCS and Daily Cognitive Failures.

The mean score for low online cognition groups on the daily cognitive failures questionnaire was 53.790 (*SD* = 16.68). The mean score for high online cognition groups on the daily cognitive failures questionnaire was 67.650 (*SD* = 17.57). Levene's Test of Equality of Error Variances was not significant (*F* (1, 208) = .330, *p*. = .566), indicating that the assumption of homogeneity of variances had been upheld.

One-way between subjects ANOVA revealed a significant difference between high and low Online Cognition Scale groups and scores on the Daily Cognitive failure scale (F (1, 208) = 34.350, p. = .000, η_p^2 = .142 indicating a large effect size.

3.3 MPPUS and Daily Cognitive Failures.

The mean score for those in the low problematic mobile phone use on the daily cognitive failures questionnaire was 53.438 (SD = 15.99). The mean score for those in the high problematic mobile phone use group on the daily cognitive failures questionnaire was 67.000 (SD = 18.66). Levene's Test of Equality of Error Variances was not significant (F (1, 208) = .330, p. = .566) therefore indicating that the assumption of homogeneity of variances had not been violated.

A one-way between subjects ANOVA revealed a significant difference between high and low groups for the mobile phone misuse scale and the scores on the daily cognitive failures scale F (1, 208) = 34.350, p. = .000; N^2 = .142 indicating a large effect size.

The means for the CFQ according to both high and low OCS and MMPUS are displayed in figure 1.

[Insert Figure 1 Here]

4. Discussion

The results suggest a link between both higher problematic mobile phone use and excessive Internet use on self-reported cognitive failures in daily life. In the context of the present study problematic Internet use was highly positively correlated to higher scores on the CFQ alongside a similar strong positive correlation between the CFQ and problematic mobile phone use. There was also a strong relationship between the scores on the OCS and MPPUS scales, suggesting that there is a proclivity for one to be associated with the other. Further analysis demonstrated a significant difference between high and low scoring groups

on both the MPPUS and OCS and scores on the CFQ, with those in the higher groups scoring significantly more than those in the lower groups.

In the absence of clear comparison data form previous research this study is the first formal exploration of the impact of both excessive Internet use and mobile phone use has on cognitive failures individuals experience in daily life. Previous work exploring the nature of lapses in attentional failures in daily life has highlighted a variety of links to individual differences in measures of working memory and attentional control (Unsworth et al., 2012; Kane et al., 2007). In this context one possible mechanism that could serve to explain the results is the impact of reduced cognitive resources, where competition arises between the need to conduct those activities an individual conducts on a daily basis and the draw of both excessive Internet and mobile phone use. This competition for resources, potentially the need to direct attention and encode task relevant information could be a clear mechanism for the propensity to commit blunders, memory errors and components of distraction.

The research conducted by Ophir et al. (2009) also provides further basis for this assertion where those engaged in excessive use of digital media are engaged in high levels of media multitasking. The individuals belonging to this group in the Ophir et al. (2009) study were less likely to be able to filter out relevant from irrelevant material and also be less likely to be able to identify those memory representations which are also directly relevant to the task. As noted in the work by Unsworth et al. (2012) at the core of this is the inability for participants to be able to prevent exogenous shifts towards task irrelevant material. This would suggest a common mechanism related to a deficit in attentional control and limited working memory capacity. This premise also links into work conducted by (Shapira, Goldsmith, Keck, Khosla, & McElroy, 2000) and Yoo et al. (2004) who noted that those who were viewed to have elements of problematic mobile phone use also had issues directly related to impulse control. Such a premise also has a link to the work reviewed by Chou et al. (2005) which highlighted the results of addiction to the Internet as being aspects of behaviour that would

also suggest poorer levels of attentional control, include issues with time management and disrupted academic performance due to such behaviour.

From this background research it is suggested that individuals with higher level of problematic mobile phone use and Internet addiction have a lower WMC therefore leading to poorer AC, limiting their capacity to prevent distraction from these types of media. This pattern of individual differences could in turn serve to explain the higher levels of daily cognitive failure observed in these groups. On the basis of the current design there is no capacity to determine if aspects of Internet addiction and problematic mobile phone use serve to have a causal influence on aspects of daily cognitive failures but there is a distinct link between these factors. Whether this is symptomatic of an individual who is highly distractible due to lower levels of WMC and poor attentional control or more fundamental shift in the processing of information due to the use of such types of digital media remains a point of conjecture and a route for further empirical research in the area.

4.1. Limitations

A variety of limitations exist in the current study and again highlight the issues related to exploration of cognitive failures in any given context. The collection of data on mind wandering and cognitive failures is replete with issues as suggested by Unsworth et al. (2012) and of course this study provides no exception. The CFQ is a self-reported measure, with obvious issues related to the participant's capacity to recall exact incidences of failures in their daily life. As always, given the inherent fallibility of memory there is the propensity for participants to forget, exaggerate or ignore such incidences in daily life. In the context of current developments in mobile phone technology and the rise of the Smartphone, the use of the MPPUS as a measure may also provide a further limitation. The MPPUS as a scale essentially focuses on the use of the mobile phone as a mechanism for communication rather than a tool for engaging with digital media. From this regard it is argued that the scale now overlooks a great deal of the functionality afforded to such a device, including the

capacity for the individual to use it as a means to consumer more digital media. In light of this current limitation it is recommended that further research is needed to explore the link between potential Smartphone addiction and aspects of cognitive failures with the development of an appropriate scale to assess the former.

5. Conclusion.

The avenues of exploitation for this current stream of research are broad should be viewed as being of critical importance if the effect of digital technology on human cognition is to be understood. There are a series of obvious links to education, particularly where individuals are being encouraged to engage with learning via Virtual Learning Environments (VLEs) as well as a proliferation of digital technology in many aspects of teaching (e.g. use of mobile devices in lectures). Following the results from the current study and those from researchers such as Hembrooke and Gay (2003) and Risko et al. (2013) it is obvious that more needs to be done in order to understand how individual differences in cognitive capacity influence technology use in such settings. One suggestion could be to focus on individual differences in WMC and AC and how these interact with the antecedents of Internet addiction and problematic mobile phone use. The pathway to aspects of Internet addition and problematic mobile phone use is still poorly evidenced with findings from this study suggesting that some aspect of attentional control could be at the heart of both issues. Similarly, a more focused exploration of how these individual differences could impact accidents in daily life should also be considered within the wider context of access to digital devices in the workplace. With the growing culture of Bring-Your-Own Device to work (BYOD) the propensity for distraction from primary tasks towards the communicative, entertainment and social networking elements offered by such devices is still an unknown. If a clear link can be demonstrated to exist between levels of engagement with digital media and daily lapses in attention it is possible that suitable preventative measures could be taken to ensure that such errors are negated or limited.

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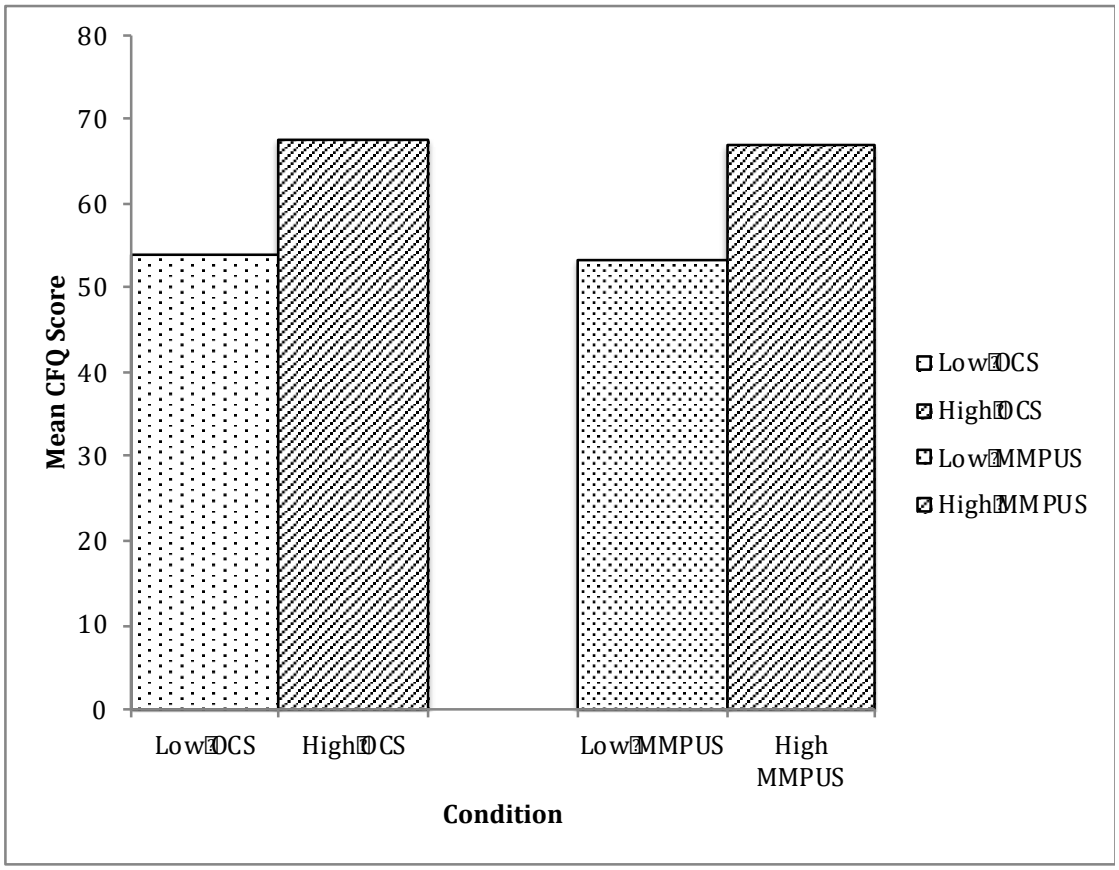
Figure 1: Means for CFQ Scale according to condition



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