Examination of Addiction and Level of Engagement in Potentially Addictive Activities: Gambling, Video-Arcade Games, Computer Games and the Internet

by

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Abstract

Recent advances in the field of addiction have given greater emphasis to subjective experience and compulsive behaviour. This signifies an important shift from focusing on the object of addiction to acknowledging that behaviours, which can induce changes in physical arousal and subjective experience, have the propensity to be overused and lead to addiction. Gambling, video-arcade games, computer games, and the Internet have therefore been identified as potentially addictive activities, which like drug use, also exist on a continuum of addiction, ranging from no symptoms of addiction to addiction. Researchers have also emphasised the need to distinguish high engagement in activities and addiction (e.g., Charlton, 2002). The aims of the present research are therefore to extend current knowledge on the level of participation and prevalence of addiction to these four activities and to investigate continuum hypotheses of addiction.

Study 1 focused on establishing the level of engagement and prevalence of students endorsing symptoms of addiction due to their involvement in gambling, video-arcade games, computer games, and the Internet. A sample of 1762 (845 female) school students from rural and urban Tasmanian schools (Grades 4 to 12) and 709 (509 female) university students participated in Study 1. Lifetime participation and frequency and duration of engagement in on-line games and the Internet was higher amongst this sample of Australian students compared to previous research conducted on youth (e.g., Tejeiro Salguero & Bersabe Moran, 2002; Wang, 2001). A lower percentage of students met the modified criteria for addiction compared to previous studies, however, the prevalence of sub-clinical computer game and Internet addiction was higher than that reported by past researchers (e.g., Chou & Hsiao, 2000; Johansson & Gatestam, 2004). Risk factors found to predict addiction significantly (e.g., high engagement) were consistent with previous studies (e.g., Chou & Hsiao, 2000; Clarke & Rossen, 2000;

Johansson & Gatestam, 2004). The identification of risk factors associated with sub-clinical and clinical addiction has implications for future prevention programs.

Three continuum hypotheses were investigated in Studies 2, 3 and 4; low engagement through to addiction, continuum of increasing engagement and addiction symptomatology, and continuum of addiction symptomatology. In Study 2 ($N = 80$), the P3a and P3b components of the ERP were examined as these components are proposed to act as a trait marker for substance addiction and index externalizing disorders of disinhibition (P3b only). A difficult discrimination three-stimulus visual oddball paradigm was employed to elicit maximum fronto-central P3a to the non-target distractor stimuli and centro-parietal P3b to targets. It was hypothesized that both P3a and P3b amplitude would be sequentially reduced in participants with progressively greater engagement and symptoms of addiction. In Study 3 ($N = 79$) the mismatch negativity (MMN) component, known to index impulsivity, alcoholism, and CNS disinhibition and hyper-excitability, was examined using a two-stimulus unattended passive auditory oddball task. It was hypothesized that, compared to the P3a and P3b results, the inverse relationship would be reflected in MMN amplitude.

A significant widespread reduction in P3a amplitude was found in Study 2, only among participants with either a sub-clinical or clinical level of addiction compared to those with no symptoms of addiction. Significant results were established for each continuum hypothesis when examining the amplitude of the P3b component. P3b amplitude indexed a dichotomous distinction between lower levels of engagement and/or no symptoms of addiction (non-clinical group), and participants with either a sub-clinical or clinical level of addiction and/or high level of engagement in activity(ies). Findings for both P3a and P3b amplitude indicate that the critical factor was not whether a diagnosis of addiction was met, but rather whether students did or did not experience some symptoms of addiction. These reductions in P3a and P3b amplitude among students with a sub-clinical level of addiction are consistent with suggestions that genetic trait markers for risk of addiction should also be present among sub-clinical populations (Slutske, Eisen, True, Lyons, Goldberg & Tsuang, 2000). In line with past research investigating substance addiction, these findings suggest that participants with lower levels of engagement and/or no addictive symptoms had more resources available to perform the task than participants with either a sub-clinical presentation or diagnosis of addiction. However, in contrast to previous studies of participants with substance addiction, findings from Study 3 revealed that the amplitude of the MMN was not significantly higher among those with addiction, sub-clinical addiction and/or high engagement. In accordance with MMN findings, Study 4 established that the Addicted group were not significantly different to other participants according to extraversion or neuroticism dimensions, suggesting therefore that this sample may not be as impulsive as individuals with substance addiction.

The absence of significant MMN amplitude differences suggests that reductions in P3a and P3b amplitude recorded for groups with a sub-clinical, or above, level of addiction are specifically related to differences in cognitive processing that requires attentional resources and not to pre-attentive automatic processing of incoming stimuli. Furthermore, as the Addicted sample did not display significantly higher traits of extraversion or neuroticism in conjunction with the absence of increased MMN amplitude, it appears that these forms of behavioural addiction are not related to impulsivity, and therefore suggests that they are not externalizing behaviours related to frontal disinhibition. Further research investigating the neurophysiology, psychophysiology and possible existence of a genetic vulnerability to these behavioural addictions is warranted, given that the prevalence of a sub-clinical addiction to computer games and the Internet is increasing among the student population.

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CHAPTER 1

Introduction

Controversy surrounds suggestions that engagement in video-arcade games, computer games, and the Internet can lead to addiction, similar to pathological gambling and substance addiction. To date, no neuroscientific investigation has been conducted to examine addiction to these activities, despite researchers reporting that a small proportion of subjects, particularly youth, experience serious participation-related problems to video-arcade games (e.g., Fisher, 1994), computer games (Tejeiro Salguero & Bersabe Moran, 2002), and the Internet (e.g., Young, 1998). Furthermore, the detrimental effect of experiencing participation-related problems in childhood and adolescence may continue into adulthood or make these young people more vulnerable to developing other maladaptive behaviours. Stemming from the need for further empirical research in the area of behavioural addiction, this thesis aims to investigate the differences between non-clinical, sub-clinical and clinical levels of behavioural addiction to gambling, video-arcade games, computer games and the Internet and to assess whether participation differences are consistent with a continuum of addiction symptomatology. The research project will further examine whether high engagement also belongs on a continuum with addiction.

The thesis has two main sections, an introductory section and empirical section. The introductory section, consisting of five chapters, gives a critical review of the research conducted on the prevalence of engagement and addiction to these activities. Chapters 2 and 3 will provide an overview of the current knowledge about the level of participation and addiction to these activities, and emphasise the importance of the relationship the individual has with the object of their addiction, rather than focusing exclusively on the object as the defining component of addiction. Gender differences have been extensively reported in past research (e.g., Greenberg, Lewis, & Dodd, 1999). As the focus of Chapter 3 is to provide a review of participation in and addiction to each activity, it is beyond the scope of this chapter to also give a critical evaluation of gender differences reported in previous studies. Chapter 4 will illustrate similarities in the neurophysiology of substance addiction and pathological gambling, and in doing so, justify why psychophysiological genetic markers for substance addiction may be able to be used in the study of behavioural addiction (as discussed in Chapter 5). A rationale for future research will be outlined in Chapter 6, with emphasis given to the need to examine a continuum of addiction symptomatology and the role of high engagement in activities. As will be discussed in Chapter 8, it is beyond the scope of this thesis to investigate every point on the continuum of addiction, and consequently the current series of studies will assign participants to three groups corresponding to three incremental stages on this continuum (i.e., non-clinical, sub-clinical and addicted).

The primary aim of Study 1 (Chapter 7) is to examine the prevalence of non-clinical, sub-clinical and addiction to each activity among Australian school-aged and university students, and whether high engagement significantly contributes to a clinical level of addiction. Studies 2, 3, and 4 will investigate the continuum of addiction symptomatology, and whether high engagement in these activities exists prior to clinical addiction. This will be achieved through examining psychophysiological markers for addiction (P3a and P3b) and frontal disinhibition (MMN) associated with a genetic vulnerability to alcoholism, and personality traits and symptoms of psychopathology linked to pathological gambling and substance addiction. Chapter 12 will provide a summary of the findings and discuss their implications in relation to a continuum of pathology, existence of a single syndrome of addiction and addictive personality.

CHAPTER 2

Engagement in and Addiction to Behavioural Activities

Behavioural addiction refers to behaviours that are in excess, compulsive, and associated with a loss of control, where an individual continues to participate in the activity despite experiencing adverse consequences that negatively impinge on their daily functioning (Cox, 1992; Shaffer & Albanese, 2005). In light of West's (2001) review of theories of addiction, addiction appears to be best conceptualised within the context of a biopsychosocial model. The biopsychosocial model acknowledges the interplay between an individual's biological and genetic predisposition to addiction, their psychological functioning including personality, motivation, and values as well as the social context in which they interact (Griffiths, 2005). Emphasis must also be placed on understanding the relationship the individual has with the object of their addiction (Larkin & Griffiths, 1998; Shaffer, 1996). Recognition of these factors is crucial as they collectively influence why some people become addicted while others do not go on to develop addiction (Robinson & Berridge, 2003; Winger, Woods, Galuska, & Wade-Galuska, 2005).

Behavioural Addiction

The terms addiction and dependency are used interchangeably throughout the literature (Maddux & Desmond, 2000). Diagnostic manuals have moved towards using the term dependency rather than addiction, although many in the field agree that addiction relates more to behaviour and infers a disorder of behaviour, compared to dependency which can easily be misinterpreted as physical dependency (Maddux & Desmond, 2000; O'Brien, Volkow, & Li, 2006). Although the term addiction does not feature in the

Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) and is associated with some degree of stigma, the present study will use this term rather than dependency, in an endeavour to emphasise disordered behaviour as opposed to drug use. Many researchers state that addiction is "a perfectly acceptable word" (p. 764) and is less likely to be mistaken for physical dependency which pertains only to physiological adaptation of the central nervous system (CNS), and not to the fundamental components of addiction (O'Brien et al., 2006).

No gold standard definition of addiction exists (Shaffer & Albanese, 2005). The simplistic focus on drug seeking and patterns of drug use (Leshner, 1997) as the defining components of addiction have dominated research over the past 30 years. Such rigidity demonstrates limited understanding of the complexity and variability of addiction (Fuller, Taber, & Wittman, 1988; Ibáñez, Blanco, & Säiz-Ruiz, 2002; Shaffer & Albanese, 2005). Recent studies on addiction have also examined behavioural addiction, with researchers viewing it as sharing similarities with substance addiction (Greenberg et al., 1999; Griffiths, 2005; Leshner, 1997; Marks, 1990; Orford, Morison, & Somers, 1996). An example of the similarities between behavioural and substance addiction is that engagement in behavioural activities can also stimulate the same naturally occurring neurotransmitters induced by drug intake (Hyman & Nestler, 1993). However, the validity of behavioural addiction has been questioned by several sceptics, who propose that drugs are more powerful than natural rewards elicited by engaging in activities (see Holden, 2001).

An early paper by a WHO Scientific Group (Edwards, Arif, & Hodgson, 1981) was the first to make the pivotal point that neuroadaption is only one of several factors involved in drug dependency. The move to addiction as being representative of a compulsive behaviour (Leshner, 1997; 2001) marked by changes in subjective experience (Shaffer, 1999a) emphasises the relationship the person has with the behaviour rather than the object of the addiction per se. De-emphasising the 'object' of the addiction has led to substance addiction being viewed more as a disorder of behaviour, in that drugs merely act as a reinforcer rather than as the essential component of addiction (Winger et al., 2005). Whether induced by behaviour or drug taking, "a reward's a reward, regardless of whether it comes from a chemical or an experience" (Holden, 2001, p. 980). This statement by Holden implies that the nature of the reward is not the critical factor; it appears that the relationship the person has with the behaviour and the desired change in subjective experience that engagement induces, are the critical factors. Greater understanding of the role of subjective experience in addiction has led to less emphasis being given to neuroadaption, tolerance, and withdrawal as defining addiction (Orford et al., 1996).

Substance addiction has been positively associated with impulsivity. A review of the research indicates that impulsivity has also been linked with pathological gambling (such as Blaszczynski, Steel, & McConaghy, 1997; Shapira, Goldsmith, Keck, Khosla, & McElroy, 2000; Steel & Blaszczynski, 1998; Vitaro, Arseneault, & Tremblay, 1999). However, not all pathological gamblers have been shown to be impulsive and it has been argued that they represent more of a diverse group than previously thought (Blaszczynski & Nower, 2002). Pathological gambling is currently defined by the DSM-IV as an Impulse Control Disorder Not Otherwise Specified (NOS) characterised by disturbance in reward motivation and reward-directed activity (Chambers & Potenza, 2003; Sher & Slutske, 2003) along with pyromania, kleptomania, trichotillomania and intermittent explosive disorder (American Psychiatric Association, 1994; Marks, 1990). Despite this diagnosis implying pathological gambling is a manifestation of poor impulse control, the criteria for diagnosis is based on that used to diagnose substance dependency. As researchers in the addiction area now emphasise the role of subjective experience, the relevance of problems of impulse control appears to be less of a defining feature in pathological gambling. The similarities between pathological gambling and substance addiction further challenge whether pathological gambling is correctly classified in the DSM-IV. Neurophysiological evidence for the similarities between pathological gambling and substance addiction will be discussed in later chapters.

Continuum of Addiction Symptomatology

Addiction has been described as a process (Krivanek, 1988) that exists on a continuum ranging in severity from use to abuse (McMurran, 1994). This continuum hypothesis has recently been applied to addiction to behaviours that do not involve substance use, through differentiating non-clinical behaviour from a sub-clinical level of addiction, indicative of experiencing some, but not all, key components of addiction, and clinical addiction (e.g., studies by Greenfield, 1999; Shaffer & Hall, 1996). Past research focusing on addiction has tended to divide subjects into two discrete groups; non-addicted and addicted. Non-addicted samples formed by a dichotomous classification system consist of individuals whose presentations range in severity from no clinical symptoms of addiction though to those with a sub-clinical level of addiction. Multilevel classification systems differentiate non-clinical presentations from sub-clinical addiction and clinical addiction, and thus are more consistent with a continuum of addiction symptomatology than traditional dichotomous models.

Brown (1993) and Griffiths (2005) identified several components common to both behavioural and substance addictions; cognitive, emotional and behavioural salience, tolerance and withdrawal symptoms, relapse and reinstatement, loss of control, change in subjective experience referred to as mood modification and conflict (interpersonal and intrapsychic). Charlton (2002) has found that subjects with high engagement in potentially addictive computer-related behaviour often exhibit some of the characteristic features of addiction, including tolerance, euphoria and cognitive salience, but that other additional negative consequences are exclusive to addiction. In Charlton's study, subjects with high engagement appear to meet a sub-clinical level of addiction, as they report some characteristic symptoms of addiction. Thus it can be suggested that non-pathological engagement in activities and varying levels of addiction may exist on a continuum with clinical addiction, whereby high engagement, and sub-clinical addiction, precede clinical addiction.

Range of Potentially Addictive Activities

Shaffer and Albanese (2005) argue that activities which reliably and profoundly change an individual's subjective state can lead to experiencing problems due to one's involvement in the activity and possibly addiction. For example, Orford et al.'s (1996) pilot study established that gambling was as addictive as alcohol, with pathological gamblers having a similar level of attachment to gambling as individuals with alcoholism have to alcohol. Several behaviours in addition to gambling have been cited as being potentially addictive. These behaviours range from shopping, overeating, sex, and exercise to computer game play and Internet use (Griffiths, 2005; Marks, 1990; Shaffer, 1999b; Shaffer & Albanese, 2005; Young, 1998; 2004).

As engagement in the Internet and video and computer games can induce pleasurable reinforcing effects, it has been proposed that these activities are potentially addictive (Griffiths & Wood, 2004; Griffiths, Parke, Wood, & Parke, 2006; Wood, Gupta, Derevensky, & Griffiths, 2004). Currently, no clear distinction exists between behaviours which are and are not potentially addictive, and what is an addiction as opposed to an obsession and/or compulsion (see commentary by Holden, 2001). Several researchers argue that the association between the aforementioned activities and addiction is premature. This is due to the absence of empirically established diagnostic criteria and the lack of neuroscientific evidence for the existence of underlying aetiology of addiction to activities other than gambling (Beard & Wolf, 2001).

Overlapping Behavioural Addictions: General Tendency to Become Addicted

High comorbidity between several psychopathological phenomena suggests that there may be a common underlying basis for externalizing behaviours, which range from alcohol and substance dependency, ADHD and conduct disorder to pathological gambling (Derevensky & Gupta, 2004; Krueger et al., 2002). Similarly, addictions frequently co-occur, in that a person may have several addictions to different substances and activities (Alexander, 1990). For example, researchers report that pathological gamblers, particularly males (Greenberg et al., 1999), have an increased risk of developing substance addiction and of engaging in risk taking behaviours (Engwall, Hunter, & Steinberg, 2004; Gupta & Derevensky, 1998a; Slutske et al., 2000). Individuals who are addicted to multiple substances and/or activities, or substitute one addiction for another, have been described as having a general tendency to become addicted (Jacobs, 1986). This suggests that different addictions are not independent entities but rather belong to a unified assembly of behaviours or a single underlying addiction syndrome (Shaffer et al., 2004). However, several researchers disagree with the notion that all addictions belong to the same underlying disorder, with for example Briggs, Goodin and Nelson's (1996) study on a clinical population of adults, showing little overlap between gambling and alcoholism.

Only a small body of research has investigated the prevalence of overlapping addictions among university students (Greenberg et al., 1999; Rozin & Stoess, 1993). Rozin and Stoess were first to study the general tendency to become addicted to a range of substances and activities according to four key components of addiction; craving, tolerance, withdrawal, and lack of control. Although Rozin and Stoess only established a weak correlation between activities, a later study by Greenberg et al. supported the conceptualisation of overlapping substance and behavioural addictions, and the tendency to become addicted to multiple activities. The researchers established that the most robust correlations (0.43 to 0.64) for addiction were between television, gambling, Internet use, and video games.

In relation to the proposed general tendency to become addicted (Jacobs, 1986), Sharma's (1995) study established that particular personality traits precede the onset of addiction. Elevated traits of extraversion, neuroticism and psychotocism have been found to differentiate significantly individuals with non-clinical behaviour and those addicted to either substances or behavioural activities (e.g. Blaszczynski, Buhrich, & McConaghy, 1985). Similar to differences in personality dimensions, individuals with behavioural addiction differ from non-addicted populations in relation to degree of psychopathology experienced, with addicted individuals significantly more likely to have greater levels of psychopathology and meet diagnoses of depression and/or anxiety (Blaszczynski & McConaghy, 1988; Shapira et al., 2000; Yang, Choe, Baity, Lee, & Cho, 2005). The association between personality and psychopathology and clinical addiction however, does not indicate whether such traits directly influence the development of addiction or develop as a result of the addiction

Summary

In summary, it appears that pathological gambling is more indicative of addiction than a disorder of impulse control. Given that substance addiction and behavioural addiction (e.g., pathological gambling) often co-occur, are associated with similar personality traits, psychopathology and primary psychiatric disorders, and are often interchangeably the object of one's addiction, it appears that all addictions may be a manifestation of the same underlying disorder. Research is yet to establish whether there is an underlying biological basis for a common addiction syndrome. Similarly, further study is needed to determine whether the personality and psychopathological dimensions associated with addiction would also be present among sub-clinical samples, and whether these dimensions fit on the continuum of addiction, with a greater level of dysfunction present among addicted samples. It is also unknown whether high engagement precedes addiction and whether the level of one's engagement would significantly differ and incrementally increase according to the continuum of addiction.

The majority of empirical research to date has focused only on pathological gambling. Further scientific investigation is needed in the field of behavioural addiction to examine the validity and prevalence of addiction to other activities which have the propensity to be addictive, such as video-arcade games and computer games (Chiu, Lee, & Huang, 2004; Fisher, 1994) as well as the Internet (Young, 1998). Chapter 3 will provide an overview of the research that has examined engagement in these activities, and highlight the importance of distinguishing different levels of engagement in activities and addiction symptomatology.

CHAPTER 3

Engagement in and Addiction to Potentially Addictive Activities: Gambling, Computer Games, Video-Arcade Games and the Internet

Globalization coupled with changes to public policy and legislation has fostered an environment that accepts gambling (Blaszczynski, Walker, Sagris, & Dickerson, 1999; Griffiths, 2003; Griffiths & Wood, 2000; Stinchfield, 2004; Winters, Arthur, Leitten, & Botzet, 2004). The parallel explosion in accessibility to the Internet, together with the upsurge of mediums available on-line and advances in computer technology, have also led to an exponential growth in the range of Internet activities and computer games available (Griffiths & Wood, 2004). Participation in these activities warrants attention as each has novelty effects that can induce pleasurable changes in subjective experience, which may lead to overuse and addiction (Griffiths, 1998). Furthermore, as technology continues to progress (Stern, 1999), stimulating media such as the Internet and computer games may become more attractive than gambling activities to individuals seeking escapism. This may in turn encourage greater levels of engagement and lead to a greater propensity to experience engagement-related problems to these new technological activities (Shaffer, 1996).

In light of this, the present chapter will provide a critical review of the prevalence of non-clinical behaviour through to addiction, to gambling, video-arcade games, computer games, and the Internet, with reference to the similar structural properties and factors found to predict addiction. The review will focus specifically on research conducted on the most 'at risk' population: youth (Gupta & Derevensky, 1998a). The assembly of school-age and university students represents a unique group, as they are the first generation to be raised in the current technological era with access to potentially addictive activities; slot machines, computer games, and the Internet. However, little attention has been given to the level of engagement or prevalence of addiction within youth, with the most prevailing example being the disparity between the quantity of research conducted on adult gambling compared to youth gambling (Delfabbro & Thrupp, 2003; Lesieur, 2003). Given the contemporary culture in which youth mature, mediated by social and familial influences alike, it would be naïve to assume that the technological advances and thus pending participation-related problems, will bypass children and adolescents, as the proliferation in gambling activities does not exclude youth (Derevensky & Gupta, 2000; Stinchfield, 2004; Stinchfield, Cassuto, Winters, & Latimer, 1997).

In relation to Internet use, researchers state that future investigation is needed to address "Internet addiction among younger users" (Chou, Condron, & Belland, 2005, p. 385), as the student population, particularly those in higher grades of high-school are at the greatest risk of experiencing Internet-related problems (Kandell, 1998; Lin & Tsai, 2002; Nalwa & Anand, 2003; Young, 1998). College and university students, particularly those living away from home (Young, 2004), are more at risk of developing Internet addiction than younger students due to their increased exposure to Internet facilities, educational systems encouraging Internet use and the amount of unstructured time available (Kandell, 1998; Lin & Tsai, 2002; Morahan-Martin & Schumacher, 2000; Young, 1998).

Relationship between Various Potentially Addictive Activities

Slot machine gambling, video-arcade games, computer games, and on-line Internet media share several similarities but are justifiably separate activities. The addictive properties of these activities have been attributed largely to the structural characteristics of each media, as they are fast, have stimulating visual and auditory effects, and rapid event frequency (Griffiths & Wood, 2000; 2004). These structural characteristics collectively make activities such as gambling and video-arcade games potentially more addictive than other activities, and contribute to the development and maintenance of addiction as they interact with the person's predisposing risk factors (Griffiths & Wood, 2000).

Although coin-operated video-arcade games involve the accumulation of points rather than winning money, researchers propose that video-arcade gaming can be viewed as a non-financial form of gambling, akin to slot machines (Griffiths, 1991). Video-arcade games and slot machines share similar structural characteristics, psychological and behavioural features (Griffiths, 1991; Wood, Gupta et al., 2004). In particular, both activities are coin-operated machines that require active participation, encourage prolonged continual play, have variable ratio schedules of reinforcement with the inclusion of near miss opportunities, can be played in solitude, elicit captivating visual and auditory effects (Griffiths & Wood, 2000; 2004) and involve a real (video-arcade games) or perceived (chance-based slot machines) skill component (Gupta & Derevensky, 1996). The following section will address how activities which can induce desired changes in physiological arousal and subjective experience have the propensity to be addictive.

Properties of Gambling, Video-Arcade Games, Computer Games and Internet Media

According to Jacobs (1986), individuals who have an abnormal physiological resting state that is either hyper- or hypo-aroused are vulnerable to the subjective experience induced by potentially addictive media. Arousal based theorists suggest that increases in physiological arousal obtained through engaging in highly stimulating activities or substances, known to elicit an increase in physiological arousal, can temporally relieve an abnormal arousal state. For instance, alcohol use is known to have a normalising effect on hyper-excitability of the CNS (Begleiter & Porjesz, 1999). Temporary changes in physiological arousal therefore act as a positive reinforcer for these individuals and contribute to them being more likely to participate/use in the future (Brown, 1986). Abnormal states of baseline arousal are not a definitive marker for addiction, as the development of addiction is also influenced by other biological, psychological and/or social factors.

Researchers propose that similar to gambling activities, engagement in coin-operated video-arcade games (Griffiths & Wood, 2004) and fruit machines (slot machines) (Moodie & Finnigan, 2005), off-line computer games (Griffiths & Dancaster, 1995) and the Internet (Parke & Griffiths, 2001), can also alter one's state of physiological arousal. More arousing activities have been suggested to be more highly desirable and likely to be sought after and used by individuals with baseline states of hypo-arousal (Griffiths & Wood, 2004) and/or pre-existing emotional vulnerability (Jacobs, 1986).

These highly stimulating activities not only have the ability to increase physiological arousal but can also act as an adaptive coping strategy (Alexander, 1990), as engagement can induce a state of dissociation or escape from reality, which enables the individual to distract themselves from their emotional discomfort or distress (Blaszczynski & Nower, 2002; Griffiths & Wood, 2000; 2004; Gupta & Derevensky, 1998b; Jacobs, 1986; Keepers, 1991; Morahan-Martin & Schumacher, 2000). Researchers argue that, like gambling, video-arcade games, computer games, and the Internet can also induce reliable and robust changes in emotional and subjective experience, have a propensity to be overused, and become the object of an addictive pattern of behaviour (Shaffer, 1996; 1999a). Research also indicates that adolescents who experience more severe participation-related problems compared to those with normal engagement, report greater levels of dissociation while gambling (Gupta & Derevensky, 1998a; Wood, Gupta et al., 2004), playing video-games (Wood, Gupta et al., 2004), and using the Internet (Greenfield, 1999) compared to those who participate infrequently.

The following sections will address the prevalence of engagement and addiction (non-clinical, sub-clinical and clinical) to gambling, video-arcade games, computer games, and the Internet. These activities are known to have novelty effects that can induce changes in physiological arousal and an altered state of reality. Past research indicates that males have a higher level of engagement, frequency of participation and level of addiction to gambling (e.g., Delfabbro & Thrupp, 2003; Engwall et al., 2004; Gupta & Derevensky, 1998a; Moore & Ohtsuka, 1997), video-arcade games (e.g. Fisher, 1994), computer games (Griffiths & Hunt, 1998; Tejeiro Salguero & Bersabe Moran, 2002; Wood, Gupta et al., 2004) and Internet use (e.g., Chou & Hsiao, 2000; Morahan-Martin & Schumacher, 2000; Niemz, Griffiths, & Banyard, 2005; Wang, 2001). As a critical review of differences between male's and female's participation in each activity is not the primary aim of this chapter, gender will only be discussed in relation to risk of developing addiction. Although past studies investigating gambling behaviour have included the study of school-aged students (Gupta & Derevensky; Shaffer & Hall, 1996; Wood, Gupta et al., 2004), the present chapter will focus only on university students' gambling behaviour and level of addiction, as studies conducted on youth abroad do not directly apply to Australia where gambling is illegal for minors.

Prevalence of Gambling and Pathological Gambling

The escalation in gambling opportunities has had a significant impact on youth and young adults (Stinchfield, 2004), with gambling reported to be significantly more popular among young Australians aged 18 to 30 years compared to older adults

(Productivity Commission, 1999). Although the association between increased accessibility and prevalence of problem gambling has not been found to be causational (for review see Raylu & Oei, 2002), it does provide supporting evidence of the impact changes to gambling availability (Productivity Commission, 1999), particularly modern video gambling machines (Raylu & Oei, 2002), have had on contemporary society. The impact of gambling was highlighted by Delfabbro and Thrupp (2003), who reported that 12.9% of Australian adolescents surveyed in their study had strong intentions of increasing their level of gambling involvement, with 14.6% intending to visit gambling venues when they were legally permitted.

In an Australian study conducted by Delfabbro and Thrupp (2003), 505 students from upper high school (mean age 16.5 years) were surveyed and a relatively lower prevalence of gambling involvement was reported. Specifically, a total of 37.5% of Australian students were found to have never gambled in their lifetime, 47.8% infrequently (1-2 times a year to 2-3 times a month) and 14.7% regularly at least once a week (Delfabbro & Thrupp, 2003). Moore and Ohtsuka (1997) established a similar level of participation among their sample of 1017 male and female Australian school students (757) and university students (250) aged 14 to 25 years. The majority were found to have gambled occasionally within the past 12 months, with a lifetime prevalence of approximately 90% (Moore & Ohtsuka, 1997) relative to 80 to 90% of the adult Australian population (Victorian Casino Gaming Authority, 2000; Productivity Commission, 1999).

Similarly, 85% of the 1771 college students from six university campuses located across the United States were found to have gambled in their lifetime, with only 23% engaging in gambling activities at least once a week (Lesieur, Cross, Frank, Welch, White, Rubenstein et al., 1991). Conversely, a later large-scale study (1348 students) across four American campuses reported a lower level of lifetime gambling participation of 67% (Engwall et al., 2004), closer to the prevalence (72%) of gambling involvement reported among Montreal post-secondary students, from Grades 12 and 13, over a year (Derevensky & Gupta, 2000). A retrospective New Zealand study (Clarke & Rossen, 2000) found that 100% of first year psychology students had gambled at least once before the age of 20 years, although only 18% gambled regularly, at least once a week.

University students who classify themselves as gamblers differ from those who classify themselves as non-gamblers according to the type of gambling activity they prefer (Lange, 2001). Lange reported that university students classified themselves as gamblers only if they wagered money on off track betting, dog/cock fights, dice games or frequently bet on dog races, pool, sports, card games and at Casinos, whereas purchasing scratch or lottery tickers was not deemed to be a form of gambling. Slot machines have been identified as the most popular form of gambling activity (54%) amongst American university students, followed by playing cards for money (51%) and gambling at Casinos (49%) (Lesieur et al., 1991). The popularity of slot machine gambling is worrisome, as addiction to slot machines is one of most common activities associated with pathological gambling among older adult gamblers (Griffiths & Wood, 2004).

Pathological Gambling

Addiction to gambling can be viewed as existing on a continuum, ranging from normal 'healthy' engagement to addiction, marked by loss of control over one's behaviour and accompanying negative consequences. Whilst problem gamblers represent only a small, although significant, proportion of the population (Blaszczynski et al., 1999), the majority of research has focused on this pathological sample with little investigation into sub-clinical gamblers who experience some symptoms of addiction

(Shaffer & Hall, 1996) and have been found to share similar genetic predisposing risk factors with pathological gamblers (Slutske et al., 2000).

The prevalence of pathological gambling among university students appears to be relatively uniform across studies, ranging between 3% (Moore & Ohtsuka, 1997) and 5.5% (Lesieur et al., 1991). As assessed by DSM-IV-J criteria, 3.5%, of a sample of 505 adolescent Australian high school students (mean age 16.5 years) were identified as problem gamblers, with a total of 18.8% experiencing at least one gambling related problem, and 4.3% and 1.9% endorsing two and three symptoms of addiction respectively (Delfabbro & Thrupp, 2003). University students have been found to experience levels of sub-clinical and clinical gambling behaviour that are similar to those found in later studies conducted abroad on school-age students. Across their sample of 1017 school-age and university students Moore and Ohtsuka found that 3% met the South Oaks Gambling Screen–Revised for Adolescents (SOGS-RA) criteria for problem gambling, 29.2% chased losses and 13.6% gambled more than intended. Similarly, using the DSM-IV-J criteria 3.4% of post-secondary students from Montreal were identified as pathological gamblers (Derevensky & Gupta, 2000), while 17.8% of New Zealand (Clarke & Rossen, 2000) and 15% of American (Lesieur et al., 1991) university students were found to experience some gambling related problems according to the SOGS measure.

Overall, it can be suggested from past research that the prevalence of pathological gambling among university students has been relatively stable over recent years. Clarke and Rossen (2002) state that the rate of problem gambling will continue to rise with the escalation of available gambling activities, however a review of the literature reveals that the prevalence of student gambling participation and addiction has remained relatively stable over recent years (Stinchfield et al., 1997). For example, research across American university campuses in 2004 reported 5.2% of students surveyed met the short-scale SOGS criteria for pathological gambling (Engwall et al., 2004), which is comparable to the 5.5% recorded in 1991 using the full scale SOGS (Lesieur et al., 1991). Shaffer and Hall (1996) argue that estimated increases are merely due to methodological differences between studies or more reflective of the rise in sub-clinical gamblers, rather than prevalence of pathological gambling.

Researchers have identified pathological gambling as being significantly predicted by gender (male), type of gambling activity (Clarke & Rossen, 2000), high frequency of gambling (Moore & Ohtsuka, 1997), intention to gamble (Moore & Ohtsuka), younger age of onset of gambling participation (Derevensky & Gupta, 2000), and greater number of gambling activities used (Sproston, Erens, & Orford, 2000). Clarke and Rossen found evidence supporting problem gambling as being associated with more continuous forms of gambling, such as scratch tickets, slot machines, track betting, card games, and Casino gambling, which involve fast delivery of reward (Abbott & Volberg, 1992). In addition, pathological gamblers are frequently found to differ from social 'non-disordered' gamblers according to their motives for gambling. Pathological gamblers are more likely to gamble to escape their problems, alleviate feelings of depression and loneliness (e.g., Gupta & Derevensky, 1998b), to make friends, relax, and win money (Gupta & Derevensky, 1998a; Wood, Gupta et al., 2004). Given that a clinically significant proportion of university students experience a sub-clinical level of addiction to gambling, it is imperative that research identifies whether potential predictive risk factors for developing pathological gambling, for example level of engagement, influence whether one progresses from a sub-clinical level of addiction to addiction.

Prevalence of Video-Arcade Game Play and Addiction

Video-arcade games involve the player endeavouring to accumulate as many points as possible as play progresses. They provide a more "continuous and interactive" (Jacobs, 2004, p. 13) interchange between the player and machine compared to slot machine gambling. Past research examining the level of engagement in coin-operated video-arcade games and the prevalence of gaming-related problems, has tended to classify such activities as a form of slot machine gambling due to the structural similarities between these two mediums. In doing so, these shortcomings have influenced the generalization of findings from different geographic locations, which differ according to the legalization of fruit-machine (slot machine) gaming for minors compared to video-arcade games which are legal at all ages across countries (Griffiths, 1991).

Earlier research in the field reported that a high proportion of adolescents spent the majority of their weekly allowance and lunch money on coin-operated video-arcade games (McClure & Mears, 1984). Fisher (1994) was the first to investigate the prevalence of engagement and addiction to coin-operated video-arcade games, as assessed by a modified version of the DSM-IV criteria for pathological gambling. Among a sample of 467 English 11 to 16 year olds, Fisher found 60% had played video-arcade games during the past year, with 21% playing regularly at least once a week. Fisher did not identify the number of hours regular users spent playing video-arcade games. It appears that this group of regular players experienced a sub-clinical level of addiction compared to social players although the extent of their involvement was not reported. Within this sample of adolescents living in close proximity to several video-arcades in their English township, 6% met a classification of addiction, 75% of whom were predominately regular players. Addictive experience was typically attributed to cognitive salience, chasing, and committing illegal acts to obtain money. Forty percent of adolescents with gaming-related problems indicated concern regarding their level of engagement.

Despite past popularity of video-arcade game activity among adolescents (Fisher, 1994), recent studies demonstrate that the prevalence of video-arcade game play has decreased. For example, compared to the 60% engagement rate Fisher reported, current studies indicate that only 10.2% (Johansson & Gatestam, 2004) and 8% (Tejeiro Salguero & Bersabe Moran, 2002) of adolescents are now playing video-arcade games. This move away from video-arcade games has transpired due to the 1990 technology revolution which generated more psychologically rewarding computer games with better graphics, more complex themes, and an increased skill component (Griffiths & Hunt, 1998). Regardless of their current popularity, Fisher's study suggests that video-arcade games, like gambling activities, can be overused and lead to addiction due to their ability to induce desired changes in subjective experience and escapism (McClure & Mears, 1984).

Prevalence of Computer Game Play and Addiction

Similar to coin-operated video-arcade games, home computer games and games played on video consoles require a level of skill, deliver direct feedback to assist performance, and elicit a sense of mastery as the game progresses and skills improve. Little empirical research has been conducted to examine the prevalence of youth computer game play and addiction to computer games, as they are a relatively new phenomena compared to more traditional gambling activities (Griffiths & Hunt, 1998). Although further empirical research is needed on the aetiology of computer game addiction, it has been tentatively proposed that an individual can become addicted to computer games (Griffiths & Hunt, 1998), characterised by a loss of control over computer game play, cognitive salience and preoccupation, as well as intrapsychic and interpersonal conflict (Tejeiro Salguero & Bersabe Moran, 2002).

Research to date is yet to differentiate definitively computer and video-arcade games, despite computer games generally not requiring a monetary outlay to continue play. Brown and Roberston (1993) were the first to differentiate and separately investigate normal levels of youth home computer game play, video game play outside the home (for example arcade games), and gambling in a sample of 807, 11 to 18 year olds from Greater Glasgow. Overall, a greater percentage of adolescents were found to play home computer games (68%) than video games in public venues (42%). A similar study from the UK reported 77% of their sample of 868 adolescents (mean age 13.66 years) had played home video games in their lifetime, 75% played for over one hour per session and 24% played daily (Phillips, Rolls, Rouse, & Griffiths, 1995). A higher lifetime prevalence of home computer game play (99%), typically to both hand-held consoles and television computer games (64%), was reported by Griffiths and Hunt (1998) in their sample of 387 adolescents, with 31% of the sample playing daily and 7% playing for more than 30 hours a week.

Compared to earlier studies examining 'old generation' games, the prevalence of normal computer gaming has remained relatively constant since the mid 1990 upsurge in computer games. Consistent with earlier research, Tejeiro Salguero and Bersabe Moran's (2002) study on 223 Spanish adolescents (mean age 15.1 years) established that 93% had played computer games over the past year with 57% playing regularly at least once a week. Specifically, 73% of adolescents had played console games, 37% offline computer games, 8% arcade video games, and 7% on-line games (Tejeiro Salguero & Bersabe Moran, 2002). Similarly, a large study of 1913 Norwegian adolescents reported a 99% lifetime, and 63% weekly, prevalence of computer game play, with data/CD-ROM games the most popular weekly activity played by 83% of those surveyed, compared to TV/video games (50%) and video-arcade games (10%) (Johansson & Gatestam, 2004).

Research indicates conclusively that normal use for adolescent computer game play is between two hours per week (Chiu et al., 2004) and thirty minutes to an hour a day (Phillips et al., 1995). Indicators of problematic use appear to relate to interference with homework and interpersonal relationships due to computer game play, with Phillips et al. reporting that the majority of adolescents (73%) self-report that gaming has no impact on their homework despite often playing longer than intended. Recent studies have demonstrated that computer games are more likely to be overused and lead to addiction due to their ability to induce an altered sense of reality, escapism from negative feelings (Tejeiro Salguero & Bersabe Moran, 2002), and greater salience effects than video-arcade games and gambling activities (Brown & Roberston, 1993).

The prevalence of computer game addiction varies considerably between studies (Tejeiro Salguero & Bersabe Moran, 2002). For example, Griffiths and Hunt (1998) identified 19.9% of their sample of 387 adolescents as meeting the modified DSM-III-R criteria for pathological gambling. This rate greatly surpasses other findings on youth computer game addiction, which range from 7.5% (Phillips et al., 1995) to 2.7% (including arcade games) and 9.8% deemed at risk (Johansson & Gatestam, 2004). Similar to studies investigating youth gambling and video-arcade game play, the most common consequences of computer game play pertain to playing for longer than intended (28%), being preoccupied with playing (16%), and playing to escape problems (16 %) (Johansson & Gatestam, 2004).

Risk factors found to predict computer game addiction significantly include gender (male), younger age of onset of participation, playing on-line games, number of hours spent playing (higher engagement), and regular weekly participation (Johansson & Gatestam, 2004). The average time spent playing per session and longest single playing time have also been reported to be significantly associated with clinical addiction (Griffiths & Hunt, 1998). Computer game addiction has been found to occur more frequently in youth who commence playing at an earlier age than non-problem gamers who on average start play at approximately nine years of age (Griffiths & Hunt, 1998). Common motivating factors to playing computer games are typically for enjoyment and to use up spare time (Phillips et al., 1995), with addictive behaviour usually, but not always (Wood, Gupta et al., 2004), uniquely attributed to playing as a means of escapism from negative feelings (Phillips et al.1995; Tejeiro Salguero & Bersabe Moran, 2002).

Prevalence of Internet Use and Addiction

On-line Computer Games

A comprehensive representation of gaming behaviour requires examination of the complete breadth of possible gaming media, ranging from video-arcade game and off-line home computer/video games to participation in on-line Internet games. In recognition of the technological differences between off-line and on-line games, researchers have begun to differentiate these two (Ng & Wiemer-Hastings, 2005), acknowledging the superior interactive three-dimensional visual graphics of on-line games and opportunity to compete against, and interact with, other virtual gamers (Griffiths, Davies, & Chappell, 2004). Additionally, subscription to on-line games provides unlimited access thereby promoting continual high engagement. Relative to coin-operated video-arcade games subscription to on-line games is inexpensive (Whang & Chang, 2003).

Massive multiplayer on-line role playing games (MMORPGs) are the new generation of on-line gaming. These run in real time and unlike off-line video games are endless and involve continuous goals and advancing levels (Ng & Wiemer-Hastings, 2005). Globally, the most popular MMORPGs are Everquest, World of War Craft, and Lineage. An on-line study by Ng and Wiemer-Hastings examined differences in the engagement of on-line MMORPG game players compared to off-line gamers. The researchers concluded that on-line gamers preferred gaming than spending time with friends and felt happier when playing, spending considerably longer periods of time playing, with 11% gaming over 40 hours a week relative to 2% for video game players. Despite this on-line study being based on a biased sample of Internet users (Wood, Griffiths, & Eatough, 2004), Ng and Wiemer-Hastings highlighted that on-line gamers have a higher level of engagement and similar to findings reported by other studies, preferred on-line reality over their 'real life' relationships (e.g., Morahan-Martin & Schumacher, 2000; Pratarelli, Browne, & Johnson, 1999; Young, 1998).

On-line gaming has been deemed to be potentially addictive, with adolescents possibly more vulnerable to experiencing negative consequences from their engagement than adults (Griffiths et al., 2004). Griffiths et al. investigated participation in the MMORPG Everquest across a sample of 540 on-line adolescent and adult gamers. The on-line questionnaire yielded a biased age and gender sample, surveying more males and adults (84%; mean age 30 years) than adolescents aged 12 to 19 years. The underlying philosophy of encouraging continued participation was illustrated by adolescents and adults on average spending 25 and 23 months playing the game, for an average of 26 hours and 25 hours a week respectively, with a smaller sample of adults (2.5%) compared to adolescents (9%) spending over 50 hours a week playing Everquest. The researchers reported that many players had sacrificed sleep, work and education, and socialising with friends, family, and partners in order to continue playing (Griffiths et al., 2004). Frequent editorial letters by treating physicians (for example Sattar & Ramaswamy, 2004) discuss the treatment of patients with on-line disordered gaming involvement, who play continuously for up to 52 hours at a time, as a vehicle of escape from unpleasant emotions (Allison, Wahlde, Shockley, & Gabbard, 2006).

Use of Internet Media

The Internet provides remote access to a breadth of information and high quality multimedia resources. It enables communication between people situated on either side of the globe at a low cost and ever increasing speed (Chou et al., 2005). The Internet can serve as a communication vehicle, research and educational tool and leisure activity (Beard & Wolf, 2001; Young, 2004). In the case of on-line gambling, the Internet provides 24-hour global, anonymous, unregulated access to gambling activities (Griffiths, 2003; Griffiths & Wood, 2004; Griffiths et al., 2006; Griffiths & Parke, 2002). Through the Internet, gambling is now available in the home, school, and workplace environment as opposed to only in regulated gambling venues (Griffiths, 2003).

Studies examining Internet behaviour have focused largely on samples with Internet addiction rather than on those with normal Internet use. The prevalence of Internet use varies considerably across studies, particularly between studies using off-line compared to on-line data collection. Researchers report on-line data collection increases accessibility to large samples of heavy Internet users, reduces socially desirable responding, and ensures anonymity, however in doing so, it creates a biased sample of Internet users (Wang, 2001; Wood, Griffiths et al., 2004).

Scherer's (1997) off-line study of 531 Southern American college students reported similar prevalence of Internet use across genders, with 73% of the sample using the Internet at least once a week. The majority of students perceived their engagement in the Internet positively, spending on average eight hours on-line per week, including fours hours of leisure time. Of the students surveyed, 98.7% used email, 85.2% performed World Wide Web (WWW) searches, 54% used library services, 37.7% accessed new groups, 11.7% played games, 9% used chat rooms, and 1.8% engaged in multi-user domains (MUDs). Off-line studies of university students from regional Australia (Wang, 2001) and the United States (Morahan-Martin & Schumacher, 2000; Pratarelli et al., 1999) also report similar levels of Internet use among non-disordered participants. Wang's study of 217 students (mean age 25 years, 66% female) found that most students accessing the Internet via university (41%) or home computers (34%), typically engaged in WWW searches and emailing, with less time spent using discussion forums, and MUDs compared to college students from the United States (Wang, 2001).

In relation to the amount of time spent on-line by students, Morahan-Martin and Schumacher (2000) reported that 98% of undergraduate United States university students (mean age of 21 years) spend on average 3.45 hours per week engaging in Internet-related activities. Pratarelli et al. (1999) further reported that within a sample of 341 college students from Oklahoma, 26% of students use the Internet between 10 to 20 hours per week, and 3% for over 40 hours (Pratarelli et al., 1999). The majority of students use the Internet as a vehicle for obtaining relaxation, excitement (Morahan-Martin & Schumacher, 2000), entertainment and enjoyment (Chou & Hsiao, 2000), and change in mood (Morahan-Martin & Schumacher, 2000; Pratarelli et al., 1999).

Addiction to the Internet

The exponential growth in Internet use over the last decade has given rise to questions regarding problematic use of the Internet (Greenfield, 1999; Morahan-Martin, 2005) with Mark's (1990) review of behavioural addiction including the Internet as a potentially addictive medium. The conceptualisation of problematic Internet use is highly debated in relation to whether the Internet itself is construed as being potentially addictive, that is, whether the interactive Internet media is considered to be the object of addiction rather than the activity(ies) accessed on the Internet (Shaffer et al., 2000). This seemingly controversial area within the research is further highlighted by Griffiths' argument that individuals with excessive Internet gambling are addicted to gambling rather than the Internet, and are distinct from users who are addicted to interactive on-line gaming or chat rooms. It has thus been hypothesised that due to the diversity of Internet activities one may become addicted to, 'Internet addicts', like pathological gamblers (Blaszczynski & Nower, 2002), represent a heterogeneous group of consumers (Niemz et al., 2005).

An on-line study by Niemz et al. (2005) employed the Pathological Internet Use (PIU) scale (Morahan-Martin & Schumacher, 2000) to examine comprehensively the range of dysfunctional Internet use within a sample of 371 British university students. The results of the study indicated 30.5% of the sample experienced no symptoms of addiction, 51.2% limited symptoms (sub-clinical addiction) and 18.3% a clinical level of Internet addiction. However, this level of Internet addiction was deemed to be inflated due to the low cut-off score for dysfunction built-in in the PIU scale (Niemz et al., 2005). A lower prevalence was reported by Whang, Lee and Chang's (2003) large scale on-line survey which sampled 13,588 users (58% males, mean age 27 years) accessing a popular Korean portal site. Young's Internet Addiction Scale classified 3.47% of the sample as having Internet addiction (58% males), 21.67% a sub-clinical level of addiction, and 43.11% no symptoms of addiction (Whang et al., 2003). Similarly, an off-line questionnaire study of Australian university students conducted by Wang (2001) identified 4% as meeting the criteria for Internet addiction, 27.9% as having a sub-clinical level indicated by having one to three symptoms, and 68.2% as having no Internet-related problems. A higher percentage than that reported by Wang was established in Morahan-Martin and Schumacher's off-line US study; 8.1% were pathological Internet users, 64.7% had a sub-clinical level, and 27.2% no symptoms of addiction (non-clinical). Variations in the prevalence of sub-clinical Internet use reported in these two later studies are possibly due to the different methodology employed and the different samples surveyed.

Through cross-analysing two diagnostic measures, the Chinese Internet-Related Addictive Behaviour Inventory and Young's (1998) Diagnostic Questionnaire (DQ) for Internet Addiction, Chou and Hsiao (2000) established that a 6% prevalence of Internet addiction was a conservative estimate. In comparison to studies conducted on university students, Simkova and Cincera (2004) found that 16% of on-line chat users met a diagnosis of addiction. This higher prevalence rate among on-line younger group of chat users suggests therefore that university students either have a lower prevalence of addiction than younger players, or that surveying university students off-line does not attract as many disordered users.

Studies investigating adolescent and university students' Internet use have consistently reported that, compared to normal users, those with Internet addiction perceive their behaviour as causing functional impairment and as negatively affecting their interpersonal relationships, work, and academic performance (Chou & Hsiao, 2000; Lin & Tsai, 2002; Morahan-Martin & Schumacher, 2000; Nalwa & Anand, 2003; Niemz et al., 2005; Scherer, 1997; Young, 1998). This further emphasises functional impairment as an essential component of Internet addiction (Beard & Wolf, 2001; Chiu et al., 2004). Additionally, research consistently portrays individuals with Internet addiction as differing from those with normal Internet usage in relation to amount of time spent online, applications used, and gender distribution (Young, 1998). Students meeting the criteria for Internet addiction spend significantly longer (Simkova & Cincera, 2004), between 20 and 100 hours per week for non-essential purposes (Young, 1998), often double the amount of time spent on-line compared to normal users (Scherer, 1997). Shapira et al. (2000) found that of their sample of 20 problematic Internet users, on average 2.8 hours were spent per week on essential use and 27.9 hours on non-essential use such as chat lines, email, surfing the web, MUDs, and gaming.

While researchers agree that it is incorrect to propose high engagement in activities signifies addiction (e.g., Charlton, 2002), some past research has mistakenly assumed that time spent online is indicative of Internet addiction, despite studies showing a proportion of normal users spend 20 hours or more a week on-line (Chih-

Hung, Ju-Yu, Cheng-Chung, Sue-Huei, & Cheng-Fang, 2005). Although studies have frequently reported that number of hours online and/or frequency of participation significantly predicts or is significantly associated with Internet addiction (e.g., Chih-Hung et al., 2005; Chou & Hsiao, 2000), excessive use is not equivalent to Internet addiction (Lin & Tsai, 2002; Morahan-Martin & Schumacher, 2000; Young, 1998). Studies vary greatly according to the average amount of time addicted compared to normal users spend on-line per week (Chou & Hsiao, 2000; Niemz et al., 2005; Simkova & Cincera, 2004; Wang, 2001; Young, 1998). The levels of engagement students dedicate to using the Internet ranges considerably between studies, from 13 to 44 hours (Simkova & Cincera, 2004), 9 to 17.5 hours (Lin & Tsai, 2002) and 5-10 to 20-25 hours per week (Chou & Hsiao, 2000). Studies collectively show however that the amount of time spent on-line (i.e., level of engagement) increases sequentially from non-clinical through sub-clinical to a clinical level of addiction (Morahan-Martin & Schumacher, 2000; Niemz et al., 2005).

In relation to applications used on-line and motives for participation, it has generally been found, but not conclusively (Nalwa & Anand, 2003; Wang, 2001), that specific applications are related to the development of Internet addiction (Chou & Hsiao, 2000; Griffiths & Wood, 2000; Morahan-Martin & Schumacher, 2000; Scherer, 1997; Young, 1998). People with Internet addiction are significantly more likely to engage in interactive two-way communication media such as chat rooms, virtual role-playing (MUDs), and fantasy games than other Internet media (Chou & Hsiao, 2000; Griffiths & Wood, 2000; Lavin, Marvin, McLarney, Nola, & Scott, 1999; Morahan-Martin & Schumacher, 2000; Whang et al., 2003; Young, 1998). In comparison, individuals with non-clinical Internet use are more likely to use the Internet as an information and communication tool than for recreational purposes (Whang et al., 2003; Young, 1998).

In studies in which gender has been investigated as a predictive factor of Internet addiction, regression analyses have identified gender (male) as being a significant predictor of addiction (e.g., Chou & Hsiao, 2000). In contrast, Niemz et al. (2005) found that gender was not a significant predictor of Internet addiction. Age at which Internet activity starts has also been associated with Internet addiction, with those commencing at a younger age more likely to develop problems related to Internet use (Lin & Tsai, 2002).

Summary

This review of the literature on youth gambling, video-arcade game and computer game play, and Internet use, shows that the majority of students have participated in these activities at least once in their lifetime, with fewer students now playing video-arcade games. Empirical investigation into the incidence of normal engagement in these activities is relatively lacking, compared to research conducted on average and recommended alcohol consumption (Currie et al., 2006). Computer games, especially on-line games, and interactive Internet media are becoming increasingly popular activities that youth engage in, compared to more traditional gambling activities and older generation video-arcade games (Shaffer, 2004). It could thus be argued that as all four of these activities have the ability to induce changes in physiological arousal, subjective experience and emotions, they are potentially addictive. It appears that more continuous forms of gambling, on-line compared to off-line computer games, and on-line interactive compared to research based Internet media, are more addictive to youth.

Studies examining addiction to gambling, video-arcade games, computer games, and the Internet, show fluctuations in the prevalence of addicted samples due to varying theoretical frameworks employed by studies, diagnostic tools used, data collection methods and demographic differences between the samples investigated; target age group, clinical status, locality of the study, culture and accessibility to each respective activity. Fluctuations in the prevalence of addiction reported among studies highlight the necessity to develop standardized, reliable and valid instruments to assess each behavioural addiction (Chih-Hung et al., 2005; Derevensky & Gupta, 2004). The year in which the study was conducted also dramatically influences prevalence of participation and addiction to these activities, due to the continually advancing technology behind slot machines, video-arcade games, computer games and on-line games (Griffiths & Wood, 2004). For example, Internet participation is influenced by speed of information delivery, which is continually increasing due to greater broadband width and associated unlimited Internet access, compared to past years in which time-incurred charges applied (Chou et al., 2005; Morahan-Martin & Schumacher, 2000).

Overall research shows that approximately 5% of university students are addicted to gambling, 7% of students to computer games and 6% to the Internet, with no recent studies reporting the current prevalence of video-arcade game addiction. The emergence of potentially addictive patterns of video-arcade games, computer games and Internet use, further challenge redundant definitions of addiction that focus on the object of addiction rather than the process of addictive experience. This highlights the increasing need to investigate the "role that new and emerging technology plays in initiating, expediting and sustaining addictive patterns" (Shaffer, 1996, p. 462). The critical element to addiction is therefore not the object of addiction per se, but rather the relationship the individual has with the object of their addiction.

There is currently insufficient evidence to draw definitive conclusions as to the validity of behaviour addiction to video-arcade games, computer games and the Internet (Beard & Wolf, 2001; Tejeiro Salguero & Bersabe Moran, 2002). The possible existence of addiction to the aforementioned activities therefore requires empirical examination. More recent research has employed multilevel classification models to differentiate non-clinical samples from those with a sub-clinical level of addiction, and from those with clinical addiction. Past research shows that several variables including regular participation and high engagement significantly predict addiction. Research is yet to establish whether such predictors of addiction in fact exist on the continuum of addiction symptomatology and whether youth with a sub-clinical level of addiction also have these risk factors. Distinguishing sub-clinical populations from non-clinical samples is important as it enables further examination of this potentially ‘at risk’ population and examination of possible protective factors to addiction. Greater understanding of potential protective factors is required to assist the development of effective treatment prevention programs. The development of efficacious prevention programs is imperative as Shaffer and Hall (1996) propose that the percentage of sub-clinical youth “will increase until informal [and] formal social controls emerge to help young people better regulate their behaviour” (Shaffer & Hall, 1996, p. 212).

Further research is needed in the area of behavioural addiction to examine whether video-arcade game, computer game and Internet addiction share similar neurophysiological deficits and psychological and personality traits, associated with both substance addiction and pathological gambling. Similarities in the neurophysiological basis of substance addiction and pathological gambling will be discussed in Chapter 4.

CHAPTER 4

Neurophysiology of Substance Addiction and Behavioural Addiction: Evidence for the a Single Underlying Syndrome of Addiction

Debate regarding the conceptualisation of behaviour and substance addiction as being indicative of the same syndrome (Shaffer et al., 2004) has until recently lacked empirical validity (Charlton & Manowitz, 1987). Current research which provides supporting evidence for the relationship between behavioural and substance addiction, shows that each share similar pathology ascribed to addiction and aetiological determinants (Charlton & Manowitz, 1987; Slutske et al., 2000), common molecular pathways (Reuter et al., 2005) and neurobiology (Ibáñez et al., 2002). Separate biological and behavioural explanations of substance and behavioural addiction is outdated, as research now supports the integration of these components (Leshner, 1997; 2001) in the context of a biopsychosocial model of addiction (Griffiths, 2005). Thus, the move away from physical withdrawal and tolerance as defining features of addiction, has accentuated the significance of behaviour and subjective experience underlying addiction, particularly the compulsive nature of addiction, craving, and loss of regulatory inhibitory control (Leshner, 1999; Shaffer, 1999a; Tavares, Zilberman, Hodgins, & el-Guebaly, 2005).

Neurophysiology of Substance Addiction

Maintenance of the homeostatic balance of the CNS is essential for optimal cognitive functioning and a stable state of arousal (Begleiter & Porjesz, 1999; Franken, Nijs, & Van Strien, 2005). Neuroadaptation of the body's reward system occurs after prolonged drug abuse as a direct result of the body attempting to restore this critical homeostatic balance (Franken et al., 2005). Drug-induced neuroadaptation of the CNS denoted by changes to the functioning of excitatory neurons and larger neuronal substrates (Lubman, Yucel, & Pantelis, 2004; Nestler & Aghajanian, 1997), and accompanying brain dysfunction and neurological deficits, underlies several key symptoms of addiction; craving, tolerance, and withdrawal. The effect of repeated drug use on the brain has been extensively investigated, with research identifying dysfunction of a common neuronal circuit associated with substance addiction, irrespective of the class of drug administered (Leshner, 1997; Nestler & Aghajanian, 1997; Robinson & Berridge, 2000). The neuronal circuitry involved in addiction primarily involves the functioning of the prefrontal and orbitofrontal cortex and the mesolimbic dopamine system.

Substance addiction alters the functioning of the frontal and prefrontal cortex, which are responsible for compulsivity and drive (Goldstein & Volkow, 2002; Lubman et al., 2004; Volkow & Fowler, 2000) and goal selection and goal directed behaviour (Hyman, 2005). The down-regulation of the "supervisory functions" (p. 1643) of the frontal cortex alter dopaminergic activity in the mesolimbic system, leading to impaired response inhibition and salience attribution related to drug seeking behaviour (Goldstein & Volkow, 2002). Specifically, changes to the functioning of the orbitofrontal cortex and stiato-thalamo-orbitofrontal circuit are responsible for loss of control over behaviour, with compulsive repetitive behaviour occurring even when a level of tolerance has been reached and the drug no longer delivers a pleasurable reward (Lubman et al, 2004.; Volkow & Fowler, 2002).

Drug use also activates the mesolimbic dopamine system (Leshner, 1997; 2001), with long-term use producing subsequent incremental neurological changes and sensitization of this reward system (Robinson & Berridge, 2000). The mesolimbic dopamine pathway, also referred to as the mesolimbic reward pathway, comprises a diverse array of dopamine neurons extending from the midbrain ventral tegmental area in the brainstem to the nucleus accumbens in the basal ganglia, and through broader dopaminergic projections to the limbic system (amygdala and hippocampus) and prefrontal and orbitofrontal cortex (Hyman, 2005; Robinson & Berridge, 2003; Self, 2004; Tamminga & Nestler, 2006). Changes to the mesolimbic reward pathway produce a craving response and loss of control over drug taking due to increases in the level of synaptic dopamine (Robinson & Berridge, 2003), in particular dopamine from projections within the ventral tegmental acting on the nucleus accumbens (Hyman, 2005). Researchers however argue that such differences in brain functioning may reflect pre-exising differences present prior to drug abuse.

Neurophysiology of Pathological Gambling

In spite of the prevalence and severity of pathological gambling, little neuroscientific research has been conducted to investigate the underpinning physiology of this behavioural addiction (Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002; Potenza, Leung, Blumberg, Peterson et al., 2003; Regard, Knoch, Gatling, & Landis, 2003), despite research demonstrating that pathological gamblers report intense craving experiences (Tavares et al., 2005) and mild symptoms of withdrawal and physical dependency (Orford et al., 1996). As gambling is non-toxic and does not produce brain damage per se, Regard et al. highlighted the importance of examining whether the psychophysiology of cognitively 'healthy addicts' would also show impairment in frontal and limbic functioning. If impairment were shown, it would suggest that neuroadaptation is either a symptom of both behavioural and substance addiction or a pre-existing deficit. Consistent with research investigating substance addiction (Robinson & Berridge, 2000; Volkow & Fowler, 2000), pioneering researchers have recently reported decreased inhibitory regulation of the frontal cortex (Cavedini et al.,

2002) and reductions in the activation of the mesolimbic reward pathway in pathological gamblers (Reuter et al., 2005).

The ventromedial prefrontal cortex responsible for impulse inhibition and decision making was examined by Potenza et al. (2003a). The Stroop paradigm employed differentiated the 13 adult male DSM-IV diagnosed pathological gamblers and 11 matched controls, with functional magnetic resonance imaging (fMRI) detecting reduced activation in the ventromedial prefrontal cortex of pathological gamblers upon presentation of infrequent incongruent stimuli. Differences in signal changes in the left ventromedial prefrontal cortex were attributed to activation of the left middle and superior frontal gyri, lateral superior frontal sulcus, and superior orbitofrontal cortex, with pathological gamblers having overall decreased activity compared to controls. These findings suggest that pathological gamblers experience dysfunction in decision making processes due to deregulation of the ventromedial prefrontal cortex and deficiencies in processing rewards and suppressing responses linked to the operation of the orbitofrontal cortex. No significant differences were found between the performance of pathological gamblers and controls for accuracy or reaction time to incongruent stimuli (Potenza et al., 2003a).

A similar level of dysfunction of ventromedial prefrontal cortex was established by Cavedini et al. (2002). The researchers examined the decision-making processes, mental flexibility, and executive functioning of 20 pathological gamblers and 40 controls; however, controls were not matched for variables known to affect neuropathology, therefore limiting the generalisability of the findings. The results of the study indicated that pathological gamblers showed specific deficits in decision making and executive functioning due to dysfunctional ventromedial prefrontal cortex as opposed to a more general frontal lobe deficit (Cavedini et al., 2002). An additional fMRI study further established that the activation of the frontal (paralimbic and limbic) and orbitofrontal cortex, caudate/basal ganglia and thalamus of male pathological gamblers was significantly reduced compared to controls at the onset of trials (Potenza et al., 2003b). As engagement in gambling activities is often preceded by an urge to participate, Potenza et al. (2003b) proposed that gambling cue-presentations elicit a craving response to gamble through deactivation of the frontal and prefrontal cortices and limbic structures responsible for impulse control.

Beyond the inhibitory function of the prefrontal cortex, the mesolimbic dopaminergic reward system of pathological gamblers is disrupted in accordance with the aetiology of substance addiction. Functional magnetic resonance imaging (fMRI) was used by Reuter et al. (2005) to measure the level of activity in the ventral striatum of 12 male DSM-IV diagnosed pathological gamblers addicted to slot machines and 12 matched male controls screened for variables known to affect fMRI recordings. Recordings were taken while subjects performed a monetary reward based guessing task which has been found to produce greater activation in the ventral striatum during winning compared to losing outcomes. An unpredictable cash balance reward was given at completion of the task, with the probability of predicting a win set at approximately 50% as research indicates that reward uncertainty and magnitude of reward influence dopaminergic activation (Fiorillo, Tobler, & Schultz, 2003). In accordance with data relating to substance addiction, Reuter et al. established that pathological gamblers had reduced activation of the ventromedial and ventrolateral prefrontal cortex compared to controls, and thus require stronger reinforcers (i.e., gambling outcomes) than non-gamblers to compensate for reduced levels of cortical dopamine. Regression analysis revealed that hypo-activity in these areas was significantly and negatively correlated with gambling severity (Reuter et al., 2005), highlighting the need to assess gambling as existing on a continuum of severity, ranging from non-clinical, to sub-clinical, to clinical pathology.

As seen in goal directed gambling tasks, video games have also been found to increase the release of endogenous dopamine and dopaminergic neurotransmission in the human striatum (Koepp et al., 1998). This suggests that subjects with reduced mesolimbic functioning may engage in video game play to increase deficient dopamine levels. In turn this further supports the notion that engagement in behavioural activities can, like substance use, influence the release of dopamine (Koepp et al., 1998). Although not empirically tested, it appears that those with behavioural addictions other than pathological gambling may also show similar reductions in ventral striatum, accounting for why they access greater stimulation through computer games and Internet use.

Summary

The repetitive, uncontrollable, compulsive nature of substance and behavioural addiction can be seen as a manifestation of the disinhibition of the brain's overarching regulatory system controlled by the frontal and prefrontal cortex (Cavedini et al., 2002; Goldstein & Volkow, 2002; Lubman et al., 2004; Potenza et al., 2003a; Potenza et al., 2003b; Volkow & Fowler, 2000) and consequential adaptation of the dopaminergic functioning of the mesolimbic system (Reuter et al., 2005; Robinson & Berridge, 2003). Examining neurophysiological deficits of addicted samples does not however indicate whether these deficits existed prior to addiction, or whether they are a by-product of being addicted. Research has also failed to examine whether those with a sub-clinical level of addiction exhibit similar neurophysiological deficits as those meeting a diagnosis of addiction, as neuroscientific research has tended only to examine addicted samples compared to controls (collectively grouping non-clinical and sub-clinical individuals).

Research on substance addiction and pathological gambling suggests that predisposing factors mediate the development of addiction, including a genetic risk factor to addiction (Begleiter, Reich, Hesselbrock, Porjesz et al., 1995; Bierut et al., 2002; Comings et al., 1996; Goodwin, 1986; Shah, Eisen, Xian, & Potenza, 2005; Slutske et al., 2000), a deficiency in the reward dopaminergic system contributing to pleasure seeking behaviour (for review see Ibáñez, Blanco, de Castro, Fernandez-Piqueras, & Säiz-Ruiz, 2003) and a pre-existing disinhibition of the CNS (Begleiter & Porjesz, 1999; Blum et al., 2000). If a continuum of addiction symptomatology exists whereby one progresses from a sub-clinical to clinical level of addiction, it would be expected that sub-clinical samples would share genetic risk factors ascribed to addiction. A more integrative model of behavioural addiction is needed which broadens the scope of potentially addictive behaviours beyond gambling. Such an integrative, biopsychosocial model of behavioural addiction requires an understanding of the underlying psychophysiology, as well as psychological and social determinants of a greater range of behavioural addictions. Chapter 5 will focus largely on the psychophysiology of alcoholism and predisposing genetic markers for addiction and other disinhibitory disorders, with reference to genetic vulnerability to pathological gambling and sub-clinical addiction to gambling.

CHAPTER 5

Event-Related Potentials as an Index of Addiction and Disinhibition

Neuroscientific research has established a similar neurophysiological basis for substance addiction, pathological gambling and other disorders of disinhibition. As the majority of research in the area has focused on alcoholism as opposed to other addictions, the following chapter will discuss the underlying psychophysiology associated with alcoholism and genetic vulnerability to developing alcoholism.

Psychophysiology is defined as the "study of relations between psychological manipulations and resulting psychological responses" (Andreassi, 1995, p. 1). Psychophysiological measures have been used in conjunction with behavioural measures to examine the effect of substance addiction on brain functioning, particularly in relation to changes in the operation of the CNS (Polich, 2003). Unlike behavioural measures, psychophysiological techniques provide a quantifiable index of cognitive functioning and psychological processes such as sensation, attention, and perceptual processing that occur between stimulus presentation and response execution.

Electroencephalographic (EEG) activity is the summation of electrical charge generated from the homeostatic balance between the activity of excitatory pyramidal neurons and inhibitory interneurons within the CNS (Porjesz & Begleiter, 2003). Voltage changes in neuronal rhythmic activity are detected at the scalp by electrodes and sequentially magnified before being recorded as neuronal oscillations (frequency of wave cycles per second) (Empson, 1986). Compared to the spontaneous and random firing of cortical neurons which occur at rest, neuronal activity within the excitatory association pathways become synchronised when an individual engages in a task (Empson, 1986; Porjesz et al., 2005).

Event-related potentials (ERPs) are derived from EEG brain activity through the use of signal averaging methods and provide a unique, non-invasive approach to understanding the functional operation of different anatomical structures involved in the cognitive processing of sensory, motor, or cognitive events (Andreassi, 1995; Duncan-Johnson & Donchin, 1982; Friedman, Cycowicz, & Gaeta, 2001; Picton et al., 2000; Porjesz & Begleiter, 2003). ERPs are time locked to a stimulus event and therefore provide a stable index of an actual or anticipated event, dependent on the physical and psychological characteristics of the stimulus (Donchin, McCarthy, Kutas, & Ritter, 1983; Porjesz & Begleiter, 1995). The resulting ERP waveform consists of a sequence of positive and negative voltage deflections which are labelled according to their polarity and onset following stimulus presentation (Duncan-Johnson & Donchin, 1982; Rugg, 1992). The scalp distribution, amplitude, and latency of each component in the ERP waveform provides an insight into the information processing mechanisms occurring within the brain (Friedman et al., 2001).

ERP components are classified as either exogenous or endogenous according to whether the subject is responding to the stimulus or evaluating the stimulus, respectively (Empson, 1986). Earlier EEG activity has been labelled exogenous as it is evoked by external events and thus reflects neuronal detection attributed to the physical parameters of the stimulus (e.g., sensory modality, intensity, quality and frequency), independent of stimulus evaluation or the subject's state of alertness. Exogenous activity is generated by cortical areas consistent with the eliciting task's sensory modality, for example visual stimuli evoke activity in the occipital lobe within the visual cortex (Baudena, Halgren, Heit, & Clarke, 1995; Halgren et al., 1995; Satomi, Horai, Kinoshita, & Wakazono, 1995). In contrast, endogenous ERP components are generated by extrinsic events and therefore index psychological variables thought to be involved in stimulus processing. Endogenous activity is unrelated to the physical parameters for the stimulus (Low, 1987). Researchers have identified several endogenous ERP components, including P2, N2, and P300.

Previous clinical research has employed psychophysiological measures as an index of cognitive dysfunction associated with neurological and psychiatric disorders such as substance addiction, pathological gambling and other disinhibitory disorders related to reduced neuronal inhibition of the CNS and cortical hypo-arousal. It has been proposed that ERPs provide a more sensitive measure of neurological changes underlying addiction that are overlooked by gross changes detected by imaging techniques (Porjesz & Begleiter, 2003). Imaging techniques (e.g., fMRI) are more suited to gauging pronounced neurological impairment present in clinical samples while more subtle deficitis can be detected by psychophysiological measures (Charlton & Manowitz, 1987). The following section of this chapter will discuss two ERP components proposed to represent potential markers for addiction and disorders of disinhibition; the P300 component and mismatch negativity (MMN).

Event-Related Potentials: P300 and MMN

P300 Component: Definition and Theories

The late positive P300 component of the ERP was first measured by Sutton, Braren, Zubin and John (1965) in response to task-relevant stimuli and has since been employed broadly as an index of cognitive functioning in both clinical and non-clinical populations (Polich, 2003). The definition of P300 as the maximum positive peak of neuroelectrical activity occurring approximately 300 ms post stimulus onset has become redundant due to an increasing body of research citing positive ERP waveforms occurring between 300 to 900 ms as signifying ‘P300’ (Donchin et al., 1983). In Andreassi’s (1995) review of the P300, the scepticism of Donchin et al. was discussed not in terms of the reliability of P300 as a late ERP component, but rather in relation to the array of cognitive functions proposed to be reflected in the electrical activity it indexes; encompassing attention allocation, stimulus discrimination and task difficulty, decision making, stimulus probability and stimulus relevance (Polich & Kok, 1995; Pritchard, 1981).

Due to the array of variables associated with P300, the formulation of a theoretical definition of this endogenous component is a complex undertaking (Pritchard, 1981), complicated further by the array of nomenclature used to denote the P300 component including the 'late positive component' (Sutton et al., 1965) and more recently the 'P3b component' (Squires, Squires, & Hillyard, 1975). Several hypotheses that have been proposed to account for the functional significance of the P300 component are outlined in this chapter, including P300 as a measure of resource allocation, the triarchic model which suggests that the P300 reflects the amount of stimulus processing required (Johnson, 1986; 1988), the hypothesis that P300 represents an updating of working memory (Douchin, 1981), and that it is a process of context closure (Verleger, 1988).

Johnson's (1986, 1988) triarchic model provides a comprehensive taxonomy of experimental variables associated with P300 amplitude, accounting for the combined effect of three areas of task manipulation on underlying cognitive processing; subjective probability, stimulus meaning, and information transmission. Subjective probability reflects information regarding the relative expectedness of an event based on the sequential structure of preceding stimuli. Johnson proposed that variations in P300 amplitude are associated with the unexpectedness of an event, such that the lower the *a priori* probability of an event's occurrence, the larger the P300 amplitude elicited. In relation to stimulus meaning, P300 amplitude has been proposed to index the task-relevance of the information conveyed by the stimulus. Specifically, stimulus meaning includes information pertaining to task complexity and stimulus complexity (perceptual demand) and stimulus value (stimulus significance), with for example, increases in

P300 amplitude associated with greater task complexity. Subjective probability and stimulus meaning collectively relate to distinct information processes and hence distinct neuronal generators. However, they are dependent on how effectively information about the stimulus is transmitted for further processing. Information processing in turn is modulated by the allocation of attention and amount of information lost, due to the subject's uncertainty about having correctly perceived the event.

The context updating model proposed by Donchin (1981) addresses the role stimulus context, particularly stimulus probability, plays in the modulation of P300 amplitude. Specifically, the P300 component is conceptualised as indexing processes involved in updating or revising stimulus representations in working memory, and the depth of processing required to create an enduring memory trace. Accordingly, the model suggests that P300 amplitude is proportional to the expectancy of the task-relevant stimulus and its variability from the pre-existing schema model, and thus its latency represents the processing time required to update neuronal representations of the stimulus context (Duncan-Johnson & Donchin, 1982). Additionally, the model suggests that P300 latency indexes both stimulus evaluation time and the time taken to categorise the stimulus according to cognitive schema representation. In contrast to P300 latency, the researchers suggest that choice reaction time increases in proportion to decreases in stimulus probability and increased stimulus evaluation time and response production (Duncan-Johnson & Donchin, 1982; Sommer, Leuthold, & Matt, 1998). As opposed to the context updating model, Verleger's (1988) context closure hypothesis claims that P300 does not index working memory activity, but rather indexes events that close the internal template of the stimulus context that has been maintained through repeated presentations of the expected stimulus. In this model, the P300 is postulated as occurring only when expectancies of stimulus events are met rather than when updating is required due to the mismatch between the current event and the pre-existing neuronal trace.

Overall, several theories have been proposed to account for the functional significance of the P300 component. Of the paradigms utilizing infrequent target stimuli with unexpected event probability, P300 amplitude appears to represent underlying cognitive processes and memory updating, and therefore the amount of cognitive resources required to perform the task. P300 latency is indicative of the time taken to evaluate and categorise target stimuli (Douchin, 1981; Duncan-Johnson & Donchin, 1982; Johnson, 1986; Pritchard, 1981). It has however, been postulated that the late positive P300 component comprises two separate subcomponents (Squires et al., 1975), the P3a evoked by non-target distractor stimuli and later P3b, representative of classic P300, evoked by task-relevant infrequent target stimuli requiring a covert or overt response (for review see Kok, 1997; Polich, 2003). Spencer, Dien and Donchin (1999) confirmed the presence of these two subcomponents using componential analysis. The P3a and P3b components will be discussed in the following section in reference to stimulus context, task manipulation, scalp topography, and underlying neurobiology. P3a and P3b have been given various labels by researchers, and this research project will follow the convention of referring to the component elicited fronto-centrally by non-target distractor stimuli as the P3a, and centro-parietal activity elicited in response to target stimuli as the P3b component.

P300 Component: P3a and P3b Components

Studies employing three-stimulus visual and auditory oddball paradigms have shown that P3a amplitude is sensitive to both target discrimination and the degree of deviation between the non-target and standard stimulus, while P3a latency is affected by the deviation in magnitude between the non-target and standard stimuli. Correspondingly, the magnitude of the P3b has been found to be negatively dependent on task difficulty and independent of the configuration of other stimuli (difference between standard and non-target stimuli). Importantly, this body of research has established that difficult target discrimination tasks with highly discrepant non-target stimuli evoke greater P3a amplitude at frontal sites, compared to that elicited by the target stimulus. P3b amplitude has been found to be maximum at parietal sites in difficult target to standard discrimination tasks (Comerchero & Polich, 1999; Goldstein, Spencer, & Donchin, 2002; Katayama & Polich, 1998; Katayama & Polich, 1999; Simons, Graham, Miles, & Chen, 2001) and when the presentation of the target stimulus is unpredictable (Suwazono, Machado, & Knight, 2000).

The nature of P3a is ill-defined (Simons et al., 2001). Ambiguity has arisen due to the diversity of deviant stimuli found to elicit frontal activation, including non-target distractor stimuli (Squires et al., 1975) and unrecognizable 'novel' stimuli (Courchesne, Hillyard, & Galambos, 1975), and the use of interchangeable terminology to classify early frontal P300 (i.e., P3a and novelty P3). Simons et al. employed factor analysis and principal component analysis to examine the P3a component elicited by distractor and novel stimuli. The researchers revealed that both P3a and novelty P3 were highly correlated and questioned the distinctiveness of these two frontal P300 components. Regardless of the nomenclature applied, research frequently reports that the earlier P3a occurs maximally at frontal and central sites approximately 250 to 400 ms post stimulus onset in response to the infrequent distractor or novel stimulus elicited within a three-stimulus oddball paradigm. Researchers postulate that P3a generation reflects an initial orienting response and only occurs in difficult target to standard discrimination tasks, through attention being involuntarily redirected (reallocated) to the non-target stimulus through frontal lobe activation (Comerchero & Polich, 1999; Friedman et al., 2001; Katayama & Polich, 1998; Katayama & Polich, 1999; Simons et al., 2001; Suwazono et al., 2000).

The later target P3b component is positive maximally at central and parietal sites (Katayama & Polich, 1998; Kok, 2001). In accordance with the context updating model, studies have demonstrated that the latency of the P3b component corresponds to stimulus evaluation time and cognitive processing, reflecting the speed at which the stimulus is identified and processed as task relevant, independent of response selection and execution (Duncan-Johnson & Donchin, 1982; Pritchard, 1981). P3b latency is therefore negatively correlated with individual processing capacity and speed, and positively associated with task difficulty and degree of stimulus discrimination (Katayama & Polich, 1998). Although reaction time (RT) and P3b latency are both influenced by stimulus evaluation processing and hence stimulus complexity, studies have shown that RT is also reflective of the time taken to respond to the specific event, including response selection and initiation (Andreassi, 1995).

The origins of the P3a and P3b are highly debated, with general agreement that they reflect the cortical activation of multiple neuronal substrates (for review see Kok, 2001; Polich, 2003). Research utilizing scalp topography methods, intracranial depth electrode recordings (Baudena et al., 1995; Halgren et al., 1995) and clinical samples of lesion patients (Knight, 1997) indicate that both limbic and anterior and posterior cortical regions are involved in the maintenance of neuronal models in working memory (frontal lobe) and context updating and memory storage (hippocampus formation and temporal-parietal region), and thus P3a and P3b generation respectively (Friedman et al., 2001; Polich, 2003). Furthermore, Knight established that only demanding categorization tasks, involving the activation of the association cortex between prefrontal and posterior cortices, elicit the P3b component. Additionally, P3a generation is not limited to frontal lobe functioning, but rather widespread cortical activation of prefrontal and posterior cortices. In fact, hippocampal and limbic regions are also involved in the orienting response to novel events (Baudena et al., 1995; Halgren et al., 1995; Knight, 1997). In addition to P3a, MMN acts as another index of underlying processing in fronto-central neuronal substrates and will be discussed in the following section.

MMN: Definition and Theories

MMN occurs 150-250 ms from stimulus onset in response to an unexpected change in ongoing auditory input (Näätänen, Jacobsen, & Winkler, 2005; Näätänen, Simpson, & Loveless, 1982). As MMN is elicited within a passive oddball paradigm which does not require focused attention, it reflects an underlying pre-attentive discrimination of stimulus change. Explicitly, MMN generation occurs when a mismatch is detected between the neuronal sensory model of a recently rehearsed and expected standard stimulus and an incoming new, unexpected 'deviant' stimulus (Näätänen et al., 1982). It has been proposed that the detection of stimulus deviance signifies the working of the orienting reflex, indicative of an automatic memory-based, change-detection process or 'attention-switch' mechanism exclusive to the physical properties of stimuli (Näätänen, 1992). Detection of stimulus change relates to the overlap of exogenous, automatic brain processes related to the parameters of the presenting stimulus (i.e., N1, N2a) and endogenous processes associated with detection of stimulus deviance (i.e., N2b) (Empson, 1986; Näätänen, 1990; Näätänenet al., 1982).

MMN amplitude and latency act as a measure of neuronal-mismatch processing and are proportionate to the probability of the presentation of the deviant stimulus and degree of stimulus deviation, with increased MMN amplitude signifying greater discrepancy between the standard and deviant stimulus (Beauchemin & De Beaumont, 2005). MMN can be elicited by various changes in the physical properties of the presenting tone, including differences in the intensity of successive tones, frequency, duration, timing or periodicity of stimuli, inter-stimulus interval, and the locus of the origin of the sound and spectra patterns (Näätänen, 1982; 1992; Schrager, Tervaniemi, Wolff, & Näätänen, 1996). Additionally, MMN latency is indicative of the time taken to distinguish deviant stimuli from the neuronal trace of the standard stimulus.

Näätänen (1982) proposed a theory of selective attention to explain the differences between ERP components elicited by attended compared to unattended stimuli, and unexpected and expected stimuli. In doing so, Näätänen criticized previous research claiming that earlier ERP components were associated with lapses in attention, and went on to suggest that larger ERP components to attended stimuli are not reflective of selective attention, but rather index non-specific general cortical arousal in response to anticipated relevant stimuli. The irrelevance of attention in the generation of the MMN makes it a "unique measure of auditory discrimination accuracy" (Näätänen, 2001, p. 1). As demonstrated in passive reading tasks, MMN does not disappear when the subject is not attending to the auditory input stimulus (Näätänen et al., 1982). Neither does it disappear when attention is withdrawn, as demonstrated in studies showing MMN activity in coma patients (Kane, Curry, Butler, & Gummins, 1993) and in participants who are in a sleep state (Sams, Hari, Rif, & Ji, 1993). Other researchers confirm that selective attention does not affect the processing indexed by MMN, demonstrating that analysis of auditory stimuli occurs regardless of the level of attention employed (Sussman, Winkler, & Wang, 2003) or the degree of stimulus discrimination required (Paavilainen, Tiitinen, Alho, & Näätänen, 1993).

Woldorff, Hackley, and Hillyard (1991) were first to question whether MMN is an entirely pre-attentive process. They demonstrated that tasks which redirect attention to another input stream produce a reduction in afferent input to MMN generators and hence reduce MMN amplitude (Woldorff et al., 1991). The researchers argued that past studies had not used the level of attentional shift employed in their study, but rather a slower stimulus presentation rate such as that employed by Näätänen et al. (1982). In response, Näätänen (1991) acknowledged the possible existence of a modulating effect of attention on MMN, yet provided strong argument for the automaticity of MMN generation and its independence from attention modulation. It has also been proposed, and demonstrated (Woldorff et al., 1991), that MMN generation comprises two discrete types of neuronal generator systems; computational (informational) neurons that are stimulus specific and fully independent of attentional processing, and amplifying (modulating) neurons that strengthen the input from computational neurons dependent on attention and subjective state (Näätänen, 1992; Näätänen, Paavilainen, Tiitinen, Jiang et al., 1993). Research therefore demonstrates the importance of the distinction between factors which influence the generation compared to those factors influencing the magnitude (intensity) of MMN, as attentional focus does influence the voltage intensity, but not elicitation, of this auditory ERP. Kropotov et al. (2000) and Laufer and Pratt (2005) state that, unlike other ERP activity, MMN occurs only within the auditory cortex and association cortex.

The critical involvement of the frontal lobes and fronto-temporal circuit in pre-attentive processing, and hence the formation of auditory sensory memory, has been consistently reported in the literature (Kropotov et al., 2000). Researchers have hypothesized that MMN generation firstly occurs in the temporal cortices change detection mechanism, which initiates frontal lobe activation causing an involuntary attention switch to the deviant stimulus (Rinne, Alho, Ilmoniemi, Virtanen, & Näätänen, 2000). The activation of the temporal lobe has been found to precede the elicitation of the bilateral activation of frontal MMN, with significant differences recorded in the right hemisphere only (Rinne et al., 2000), and maintained by input from the dorsolateral prefrontal cortex (Alain, Woods, & Knight, 1998). The neuronal generators responsible for frontal MMN have been shown to be different from those eliciting earlier temporal activity, suggesting that these different structures carry out different functional operations in change-detection processing (Deouell, Bentin, & Giard, 1998;

Opitz, Rinne, Mecklinger, von Cramon, & Schröger, 2002). Reduced MMN has been reported in subjects with dorsolateral prefrontal lesions when stimuli are presented to either the ipsilateral or contralateral ear (Alain et al., 1998; Alho, Woods, Algazi, Knight et al., 1994). Patients with lesions to the temporal-parietal association cortex have also been found to have selective deficits in processing deviance when stimuli are presented to the ear contralateral to the damaged hemisphere (Alain et al., 1998). Alain et al. further suggest that the hippocampal formation contributes little to the processing of deviance, as subjects with unilateral lesion to the hippocampus region show no significant reduction in MMN amplitude.

Summary of P300 Component and MMN

Overall, psychophysiological research indicates that activity from neuronal generators within the prefrontal and frontal cortices and limbic region responsible for attentional processing, can be indexed by P3a (Holguín, Porjesz, Chorlian, Polich, & Begleiter, 1999; Katayama & Polich, 1999; Knight, 1997) and MMN (Kropotov et al., 2000; Opitz et al., 2002), whilst P3b indexes activity in the parietal and temporal-parietal region and association cortex (Knight, 1997; Polich, 2003). These findings relate to the neurophysiological deficits that underpin substance addiction (Goldstein & Volkow, 2002; Lubman et al., 2004; Robinson & Berridge, 2003) and pathological gambling (Cavedini et al., 2002; Potenza & Winters, 2003; Reuter et al., 2005), as discussed in Chapter 4. The following section will discuss the research examining alcoholism and risk of substance addiction as indexed by the endogenous P300 components and exogenous MMN.

Event Related Potentials and Addiction Research

Few ERP studies have examined the biological basis of pathological gambling, despite researchers showing significant differences between the psychophysiology of pathological gamblers compared with matched controls (Goldstein, Manowitz, Nora, Swartzburg, & Carlton, 1985). Pathological gamblers have been shown to exhibit reduced hemispheric switching and a reversal of hemispheric differentiation (Charlton & Goldstein, 1987; Goldstein & Carlton, 1988). Findings from Charlton and Goldstein's study led the researchers to tentatively conclude that pathological gambling was similar to alcoholism, as the pathological gamblers in their study appeared to have a predisposing dysfunctional attentional mechanism seen in alcoholics and other impulsive behavioural disorders such as ADHD.

Neuronal disinhibition of the CNS has been identified as underlying a broad spectrum of disinhibitory disorders and externalising behaviours, including alcoholism and substance addiction, characterised by problems with disinhibition, loss of control, and compulsiveness, and exemplified by a pattern of responding to achieve immediate gratification and short-term rewards at the expense of long-term gains (Gorenstein & Newman, 1980; Iacono, Malone, & McGue, 2003; Krueger et al., 2002; Porjesz et al., 2005). The P3b component of the ERP is known to index CNS disinhibition (Begleiter & Porjesz, 1999) and is implicated as a psychophysiological measure of such pathology. Changes in P3b amplitude have been shown across a range of addictions, including addiction to tobacco (Anokhin et al., 2000) and alcoholism (Holguín et al., 1999; Porjesz & Begleiter, 1995).

Porjesz and Begleiter's (2003, 2005) reviews note that studies employing visual oddball paradigms consistently demonstrate reductions in parietal P3b amplitude among alcoholics when responding to target stimuli, however findings are less consistent within the auditory modality. The majority of past research has largely focused on male samples, however female alcoholics in parallel with their male counterparts have also been found to display P3b amplitude deficits (smaller reduction) and no significant latency differences across both visual and auditory modalities (Hill & Steinhauer, 1993;

Prabhu et al., 2001). Although delayed P3b latency has been associated with alcoholism, findings are inconsistent across modalities with longer latency reported for auditory (Steinhauer, Hill, & Zubin, 1987), but not visual targets (Hill & Steinhauer, 1993; Pfefferbaum, Ford, White, & Mathalon, 1991). P3b latency differences do not appear to index alcoholism, but rather the ease with which auditory targets can be discriminated from non-target events (Porjesz & Begleiter, 1995).

Findings on P3a amplitude also vary between studies employing auditory and visual modalities. Some researchers have established supporting evidence for reductions in P3a amplitude among alcoholics compared to controls (Holguín et al., 1999; Prabhu et al., 2001), while others disagree with such claims (Pfefferbaum, Ford, White, & Mathalon, 1991). Holguín et al. attempted to resolve this disparity in the literature by suggesting that more robust P3a results could be achieved through using a visual three-stimulus oddball paradigm with difficult target to standard perceptual discrimination and low target and non-target stimuli probability. Later studies employing difficult discrimination three-stimulus oddball tasks, as suggested by Hill et al. (1999), have somewhat resolved previous disparity in the literature with more profound P3a deficits established among the majority of addicted samples

In addition to studying the P3a and P3b components of the ERP, greater understanding of CNS functioning and vulnerability to addiction can also be achieved by examining auditory MMN as an index of pre-attentive automatic processing (Realmuto, Begleiter, Odencrantz, & Porjesz, 1993). Of importance to future research on addiction, cortical hyper-excitability underlying alcoholism and other disinhibitory disorders, has been associated with impulsivity. Specifically, MMN amplitude acts as an index of impulsivity, such that individuals with higher levels of impulsivity display larger negative MMN amplitude (Franken et al., 2005). MMN amplitude has also been found to be positively correlated with other factors linked to substance addiction and disorders of disinhibition; CNS disinhibition, extraversion and differences in frontal and temporal functioning (Franken et al., 2005; Sasaki, Campbell, Gordon Bazana, & Stelmack, 2000; Tsai, Gastfriend, & Coyle, 1995; Zhang, Cohen, Porjesz, & Begleiter, 2001). Researchers further indicate that MMN is delayed and its generation compromised following alcohol consumption (Jääskeläinen, Pekkonen, Alho, Sinclair et al., 1995; Jääskeläinen, Pekkonen, Hirvonen, Sillanaukee, & Näätänen, 1996). MMN recordings of alcoholics may also be impaired as a result of the neurotoxic effects of prolonged alcohol exposure (for review see Porjesz et al., 2005).

Genetic Vulnerability to Alcoholism

P300 Component

The last two decades have seen growing evidence that the vulnerability to alcoholism (Steinhauer, Hill, & Zubin, 1987) and the amplitude of the P3b are partially mediated by genetic factors (Almasy et al., 1999; O'Connor, Hesselbrock, & Tasman, 1986; Porjesz et al., 1998). Researchers suggest that reduced P3b amplitude acts as a potential phenotypic marker for risk of alcohol dependency, present prior to the onset of alcohol dependency and irrespective of the effects of alcohol on the brain (Begleiter & Porjesz, 1995; Begleiter, Porjesz, Bihari, & Kissin, 1984; Pfefferbaum et al., 1991; Porjesz & Begleiter, 1990; Porjesz et al., 1998). The proposal of a genetic basis for alcoholism was first investigated in a hallmark study by Begleiter et al. (1984). These researchers investigated the P3b component of offspring of alcoholic fathers deemed to be at a high-risk of developing alcoholism.

Using a visual head-orientation task, Begleiter et al. (1984) were the first to report reduced P3b amplitude and no latency or RT differences, among children at risk of developing alcoholism compared to controls. Later studies adopting a similar two-stimulus visual oddball paradigm confirmed the presence of reduced P3b amplitude at centro-parietal, parietal and occipital regions among sons of alcoholics with no personal history of alcohol use (Berman, Whipple, Fitch, & Noble, 1993; Steinhauer et al., 1987; van der Stelt, Geesken, Gunning, Snel, & Kok, 1998). P3b amplitude reductions (no latency differences) have also been reported at parietal leads (Pz) for high-risk college students with mild alcohol use compared to students who had no first or second degree relative with alcoholism (O'Connor et al., 1986; Porjesz & Begleiter, 1990). Later research showing similar deficits in P3b amplitude were also present in abstinent alcoholics (Porjesz & Begleiter, 1995). A comprehensive meta-analysis by Polich et al. (1994) of the P3b in high-risk male and female offspring of alcoholics further supports the existence of a genetic risk to alcoholism. The researchers established significant reductions in target P300 (P3b) amplitude elicited by those at risk while performing difficult visual discrimination tasks.

Family history studies also report a relationship between density of familial alcoholism and abnormalities in P3b amplitude (Pfefferbaum et al., 1991). Moreover, research by Carlson et al. (1999) established that P3b amplitude also indexed a level of disordered alcohol use and externalizing behaviours. The researchers measured P3b amplitude prior to assessing degree of substance use and disinhibitory behaviour and grouped subjects according to P3b amplitude (small, average, large) as opposed to clinical symptomatology. This community-based study by Carlson et al. established that a smaller P3b was elicited in significantly more people with alcohol dependency, illicit drug dependency, and externalising disorders. Males with average P3b amplitudes were also found to be more likely to have alcohol dependency or accompanying symptoms of alcohol dependency, compared to males with larger P3b amplitude but fewer symptoms than participants with smaller P3b amplitude. Evidence therefore suggests that P3b amplitude may act as a pre-existing trait marker, indexing not only clinical addiction, but also a sub-clinical level of dysfunction.

Hill, Steinhauer, Lowers, and Locke (1995) two-stimulus auditory oddball ERP study evaluated the P3b as a predictor of early onset of substance abuse. The researchers examined a sample of 11 high-risk and 9 low-risk female and male offspring of alcoholic fathers over an eight year timeframe, at approximately 10 and 18 years of age. The high-risk sample comprised children who had approximately four first- or second-degree relatives with alcoholism and the low-risk sample had no relative with alcoholism. More high-risk offspring were found to have developed alcoholism at age 18 years (4 out of 11) compared to the absence of reported alcohol abuse in the control sample. Reduction in P3b amplitude at Pz was reported among more high-risk offspring while no significant group differences were recorded for P3b latency at Pz (Hill et al., 1995). Berman et al. (1993) reported that age, lower P300 amplitude and also prolonged latency accounted for one quarter of the variance in predicting later adolescent substance use, with P3a and P3b amplitude significant predictors at Cz only.

It is important to note there is a lack of consensus across studies regarding the utility of P3b amplitude as a specific biological marker (e.g., Polich & Bloom, 1987) as several other factors can account for ERP differences. For example, the disparity in the literature may reflect differences in the methodological approaches employed by studies, including age differences, differences in the modality of the task (Ji, Porjesz, Begleiter, & Chorlian, 1999), or differences in the perceptual discriminability of target stimuli (Polich, Pollock, & Bloom, 1994). Additionally, Berman et al. (1993) suggested that the inconsistencies in reported P3b latency differences between studies may be related more to differences in the alcoholism aetiology of subjects.

Examination of the psychophysiology underlying the risk of substance addiction, primarily alcoholism, has largely focused on the P3b component of the ERP. The P3a provides information regarding one's ability to inhibit responding to irrelevant task information, indicative of the action of inhibitory neurons within prefrontal and frontal cortical structures (Chorlian, Porjesz, & Cohen, 1995; Friedman et al., 2001; Holguín et al., 1999). Little investigation has been conducted on the sensitivity of frontal P3a as a biological trait marker for alcoholism and addiction. Of the few studies employing difficult discrimination three-stimulus visual oddball tasks to examine this proposition, significant differences in the P3a amplitude, but no latency differences, have been established between high-risk offspring compared to matched control children, adolescents, and adults (Hada, Porjesz, Chorlian, Begleiter, & Polich, 2001; Holguín, Porjesz, Chorlian, Polich, & Begleiter, 1999). In a younger sample of high-risk children however, reductions in P3a amplitude to novel stimuli were found to be restricted to the occipital area, and no differences in peak latency were established (van der Stelt et al., 1998). Holguín et al. (1999) further propose that the absence of P3a differences in children may be indicative of age acting as a confounding variable, as clear fronto-central P3a does not emerge until adolescence.

Mismatch Negativity

The pre-attentive auditory MMN as a measure of cortical disinhibition and genetic vulnerability to alcoholism has also been investigated (Holguín, Corral, & Cadaveira, 1998; van der Stelt, Gunning, Snel, & Kok, 1997; Zhang et al., 2001). The function of MMN as a trait marker for alcoholism remains unclear, as the MMN dysfunction established among alcoholics has not been consistently reported among samples of abstinent alcoholics and high-risk offspring of alcoholics (Fein, Whitlow, & Finn, 2004). It is unclear however whether MMN is only a state marker for alcoholism, indexing the toxic effects of long term use on the brain, or whether it also acts as a trait marker of addiction, similar to the P3b component (Porjesz et al., 2005). If this were true, impairment in MMN amplitude should also be found in abstinent alcoholics, as trait markers remain stable over time regardless of environmental changes. Realmuto et al. (1993) attributed reduced automatic processing among abstinent alcoholics (abstinent 4 to100 days) to a deficiency in the neuronal template of the repetitively presented standard stimulus. Although the researchers established significant decreases in N2 amplitude and increased latency, differences were unsubstantiated when age effects were controlled, and MMN was not assessed directly. Likewise, no association between MMN and alcoholism has been established in alcoholics abstinent for short periods of time (Grau, Polo, Yago, Gual, & Escera, 2001) and over six months (Fein et al., 2004). Research in which MMN has been used to investigate genetic vulnerability to alcoholism has also shown inconsistent results, with larger MMN amplitude only present in samples of older high-risk offspring (Zhang et al., 2001) and not among samples of younger children (van der Stelt et al.,1997; Holguín et al., 1998).

Summary

The P3a and P3b components and MMN of the ERP have been found to index alcoholism and other disinhibitory disorders. It has been postulated that a reduced P3b component may act as a genetic predisposing risk factor for alcoholism and CNS disinhibition. Reductions in P3b amplitude have been well documented among the offspring of alcoholics, prior to personal alcohol use and addiction (Begleiter & Porjesz, 1999; Porjesz et al., 2005). In contrast, abnormalities in MMN amplitude appear to index the neurotoxicity of alcohol abuse rather than a pre-existing vulnerability to addiction. Increased MMN amplitude has however, been found to act as a reliable index of other factors associated with addiction; impulsivity, extraversion, frontal and temporal functioning and CNS disinhibition (Franken et al., 2005; Sasaki et al., 2000).

Despite researchers stating that the P300 is the most useful biological marker for examining predisposing risk for developing disorders of inhibition and addiction (Porjesz et al., 2005), few studies have examined the underlying psychophysiology of pathological gambling and no study has examined the P300 components of individuals addicted to video-arcade games, computer games or the Internet. This is surprising as neuroscientific research has already established that pathological gambling shares a similar neurobiological and neurophysiological basis as substance addiction, and that there is also a genetic basis for pathological gambling (e.g., Slutske et al., 2000).

Only a small body of psychophysiological research has investigated pathological gambling and no study has looked at the P300 component or MMN of individuals with a sub-clinical level of pathological gamblers. Further research needs to be conducted to determine whether similar deficits in the P300 and MMN amplitude of participants with a sub-clinical level of substance addiction and externalizing disorders, or genetic vulnerability to alcoholism, are also present among individuals with a sub-clinical level of behavioural addiction. Psychophysiological examination of a broader range of behavioural addictions is needed, given that activities such as computer games and the Internet have been found to elicit changes in physiological arousal and subjective experience, similar to those induced by alcohol. As gambling activities, video-arcade games, computer games, and the Internet can all induce physiological changes and escapism from reality, a small proportion of people engaging in these activities has been found to experience participation-related problems. If similar psychophysiological deficits ascribed to substance addiction and the genetic vulnerability to alcoholism are also present among participants with a sub-clinical and clinical level of addiction to these activities, it could be suggested that both behavioural and substance addiction are a manifestation of the same disorder.

CHAPTER 6

Rationale for Further Research

Similar to the progression from drug taking to drug addiction (Robinson & Berridge, 2003), only a small proportion of people who participate in gambling and other potentially addictive activities go on to develop behavioural addiction. Researchers typically categorise subjects into two dichotomous groups on the basis of whether or not they are addicted to an activity. In doing so, researchers have failed to acknowledge the diversity of this non-addicted group which may differ in relation to their level of engagement and addiction symptomatology. More comprehensive multilevel classification systems (e.g., Shaffer & Hall, 1996) than traditional dichotomous models differentiate this heterogeneous group of non-addicted subjects according to the number of symptoms of addictions they experience. Multilevel classification systems are based on a continuum of addiction symptomatology, with increasing increments on the continuum indicative of more symptoms of addiction; non-clinical (no symptoms), sub-clinical (some symptoms) or clinical level of addiction.

Support for the continuum of pathological gambling was established by Slutske et al. (2000) in a genetic twin study. Slutske et al. found that co-twins of men with either a pathological or sub-clinical level of gambling, as defined by experiencing some DSM-III-R diagnostic symptoms of pathological gambling, were found to be significantly more at risk of developing the disorder; those with co-twins with pathological gambling most at risk compared to co-twins of men who did not fulfil any of the given DSM-III-R criteria. Examination of sub-clinical populations enables greater depth of understanding of the continuum of addiction and shared aetiology between sub-clinical and clinical addiction (Shah et al., 2005).

In addition to the level of addiction an individual may experience, high engagement in an activity can also have a substantial impact on daily functioning, education and employment, and interpersonal relationships. Charlton (2002) established that subjects with high engagement in computer-related behaviour often experience some characteristic features of addiction, but that they are distinctly different from those meeting a diagnosis of addiction. Unfortunately Charlton did not examine the level of addiction experienced by subjects with lower levels of engagement. Despite this shortcoming, Charlton's study highlights the importance of research which does not imply that high engagement is the same as addiction. That is, samples of subjects with high engagement and those diagnosed with addiction should not be amalgamated into a unified clinical group.

When viewed in relation to the continuum of addiction, findings from Charlton's (2002) study suggest that high engagement in activities may precede behavioural addiction. To date, researchers have not investigated whether high engagement in activities exists on a continuum with addiction symptomatology before clinical addiction, despite results from previous studies showing that high engagement significantly predicts addiction to gambling (Moore & Ohtsuka, 1997) and computer games (Johansson & Gatestam, 2004). The absence of research in the area may be partially due to lack of uniformity regarding what constitutes low engagement and high engagement, and that some studies fail to differentiate excessive use from addiction, incorrectly implying that high engagement signifies addiction (Beard & Wolf, 2001). In addition, research is yet to examine empirically whether experiencing some symptoms of addiction to these activities manifests prior to the development of behavioural addiction.

The aim of the following empirical studies is therefore to employ a multilevel classification system to investigate the continuum hypothesis of addiction to gambling and these other potentially addictive activities, and secondly to examine whether high engagement also belongs on a continuum with addiction. The present research project will empirically evaluate the continuum of addiction symptomatology (non-clinical, sub-clinical, clinical) to gambling, video-arcade games, computer games, and the Internet, rather than using a dichotomous classification (i.e., not addicted vs. addicted).

This primary aim will be achieved through examining the prevalence of non-clinical, sub-clinical and addiction to each activity, and whether high engagement significantly contributes to a clinical level of addiction (Study 1). Studies 2, 3 and 4 will investigate this continuum of addiction symptomatology, and further whether high engagement in these activities exists on the proposed continuum prior to clinical addiction. As the sample of high engagers in Charlton's (2002) study experienced some symptoms of addiction, representative of a sub-clinical level, these later studies will also examine whether a combination of both high engagement and a sub-clinical level of addiction exist on a continuum of addiction symptomatology.

As discussed throughout the earlier literature review, substance addiction and pathological gambling share similar neurophysiological deficits (Cavedini et al., 2002; Goldstein & Volkow, 2002; Lubman et al., 2004; Potenza et al., 2003a; Potenza et al., 2003b; Volkow & Fowler, 2000) and genetic risk markers (Eisen et al., 1998; Slutske et al., 2000). It can therefore be hypothesised that deficits in P3b, suggested to index genetic vulnerability to alcoholism and neuronal dysfunction, may also be present in gamblers with sub-clinical addiction, with a proportionately greater deficit among those with clinical addiction. Stemming from this premise it could be proposed that the study of the P3b component may establish subtle differences between participants with varying levels of addiction symptomatology to other potentially addictive activities (i.e., video-arcade games, computer games and the Internet). It would be expected that P3a and P3b deficits associated with alcoholism and substance addiction would also exist among participants addicted to gambling, video-arcade games, computer games, and the Internet, and to a lesser extent among those with a sub-clinical level of addiction.

Engagement in gambling activities has been found to increase sensory stimulation and alleviate the abnormal baseline state of arousal present among pathological gamblers. As discussed in earlier chapters, video-arcade games and off-line computer games (Griffiths & Dancaster, 1995) and the Internet (Parke & Griffiths, 2001) also have the propensity to alter one's state of physiological arousal. Empirical support for the presence of CNS disinhibition among participants with behavioural addiction is however currently lacking, despite researchers proposing that higher levels of extraversion, impulsivity and psychopathology are experienced by these individuals compared to non-addicted samples (Charlton & Manowitz, 1987; Eisen et al., 1998; Greenberg et al., 1999; Petry, 2001; Shapira et al., 2000; Vitaro et al., 1999). As discussed in Chapter 5, increased MMN amplitude indexes pre-attentive activity of the frontal lobes and is known to be influenced by impulsivity, addiction and CNS disinhibition. If participants addicted to the aforementioned activities are impulsive and have frontal disinhibition, it would be expected that samples of participants with sub-clinical and clinical addiction would show increased MMN amplitude (highest amplitude for the clinical sample).

CHAPTER 7

Study 1

Level of Engagement and Prevalence of Addiction to Gambling, Video-Arcade Games, Computer Games and the Internet among School-age and University Students

The environment in which youth of today are being raised makes them more vulnerable to developing behavioural addiction to gambling, video-arcade games, computer games, and the Internet due to their level of exposure to these ever evolving forms of recreation and entertainment. The re-focus of addiction research to the youth population is important as one's experience and development during childhood and adolescence can be negatively influenced by the consequences of addictive behaviour (Chambers, Taylor, & Potenza, 2003; Gupta & Derevensky, 1998b). Experiencing participation-related problems in childhood or adolescence can continue into adulthood and disadvantage their progression to 'healthy' adulthood (Derevensky & Gupta, 2004; Jacobs, 2004). Youth who participate in video-arcade and computer games may perceive that they have a control over gambling outcomes (Griffiths & Wood, 2004) and be more vulnerable to seek forms of gambling that have a greater level of perceived skill and reinforcement (Brown & Roberston, 1993; Griffiths, 1991).

A review of the literature on the behaviour of youth suggests that there has been a move away from participation in video-arcade games and traditional forms of gambling to computer games, on-line Internet games and continuous gambling activities (e.g., slot machines). Compared to older video-arcade games and non-continuous forms of gambling these newer activities have greater salient effects, stimulating visual and auditory effects, rapid event frequency and they also encourage continuous play (Brown & Roberston, 1993; Griffiths & Hunt, 1998; Ng & Wiemer-Hastings, 2005). This is worrisome as continuous gambling and gaming activities and interactive on-line media are proposed to be more addictive than video-arcade games and non-continuous forms of gambling (Chou & Hsiao, 2000; Griffiths et al., 2004; Whang & Chang, 2003). These potentially addictive activities have also been found to alter physiological arousal (Brown, 1986; Moodie & Finnigan, 2005; Parke & Griffiths, 2001) and induce changes in subjective experience (i.e., mood modification) (Griffiths & Wood, 2000; Gupta & Derevensky, 1998b; Shaffer, 1996). Similarly, a greater proportion of addicted youth report that they are motivated to participate in such activities in order to escape depression and loneliness (Gupta & Derevensky, 1998b; Tejeiro Salguero & Bersabe Moran, 2002).

It is unknown whether the level of participation in gambling, video-arcade games, computer games ,and the Internet has changed among Australian school-aged and university students, as the majority of research in the area has been conducted abroad. In studies based in Canada, the United Kingdom and United States it has been shown that increasing proportions of youth participate in computer game play and the Internet, and that they also experience more problems due to their involvement in these activities (Griffiths & Wood, 2004; Griffiths et al., 2006; Morahan-Martin & Schumacher, 2000; Niemz et al., 2005). Additionally, students addicted to gaming and Internet media report that their engagement takes precedence over spending time with friends and family and also impacts on the amount of time allocated to homework (Griffiths et al., 2004; Ng & Wiemer-Hastings, 2005; Phillips et al., 1995).

Researchers investigating behavioural addiction have typically employed dichotomous models to classify students into two discrete groups on the basis of whether or not they were addicted to a particular activity. This simple differentiation between non-addicted and addicted samples does not account for the diversity of the non-addicted population; the frequency and duration of their engagement or prevalence of sub-clinical addiction symptomatology. Of the limited research that has examined a continuum of behavioural addiction, most has focused on gambling (Clarke & Rossen, 2000; Shaffer & Hall, 1996; Slutske et al., 2000) with the exception of more recent studies conducted on Internet-related problems (e.g., Greenfield, 1999; Morahan-Martin & Schumacher, 2000; Niemz et al., 2005; Wang, 2001; Whang et al., 2003). Further examination of sub-clinical populations is needed as the prevalence of students with a sub-clinical level of addiction will continue to increase in line with the increasing sophistication of the technology behind these activities (Shaffer & Hall, 1996). Greater understanding of this sub-clinical population of Australian students will also assist in identifying protective factors to addiction and whether a sub-clinical level of addiction precedes the development of clinical addiction.

Researchers suggest that potential risk factors for addiction to the aforementioned activities include being male, younger age of onset, regular participation at least once a week, high engagement (number of hours per week), and type of activity media; on-line interactive media, continuous forms of gambling and on-line compared to off-line computer games (Chou & Hsiao, 2000; Derevensky & Gupta, 2000; Johansson & Gatestam, 2004; Moore & Ohtsuka, 1997). Gender differences have been well documented in past research, with males' level of engagement, age of onset and prevalence of addiction significantly exceeding their female counterparts' gambling (e.g., Delfabbro & Thrupp, 2003; Engwall et al., 2004; Gupta & Derevensky, 1998a; Lesieur et al., 1991; Moore & Ohtsuka, 1997), video-arcade game (e.g., Fisher, 1994), computer game (e.g., Griffiths & Hunt, 1998; Phillips et al., 1995; Tejeiro Salguero & Bersabe Moran, 2002; Wood, Gupta et al., 2004) and Internet use (e.g., Chou & Hsiao, 2000; Morahan-Martin & Schumacher, 2000; Niemz et al., 2005; Wang, 2001). As the effect of gender on engagement and addiction has been extensively examined in previous studies, the present study will only investigate whether gender is a potential predictor of addiction to these activities.

Only a small body of research has investigated differences in the behavioural involvement of youth according to the continuum hypothesis of addiction symptomatology. Multilevel classification systems based on this continuum hypothesis enable examination of participants with a non-clinical (no symptoms), sub-clinical (some symptoms) and clinical level of addiction. In response to gaps in the literature, the present study will employ a similar multilevel classification system, to examine the continuum of addiction to a broad range of potentially addictive activities; gambling, video-arcade games, computer games, and the Internet.

This study has three aims. The first aim is to examine the level of participation in these activities among students from Australian primary and secondary schools, college institutions, and university campuses. To do so, the motivating factors behind participants' engagement, diversity of media used, frequency (per week) and duration of participation (hours per week for students in secondary education and above, and hours per day for primary students), and current prevalence of addiction and symptoms of addiction experienced will be investigated. Gambling will only be examined among university students as it is an illegal activity for minors in Australia. A diagnosis of addiction to the aforementioned activities will not be made among primary school students given the young age of this sample, however key components of addiction will be investigated.

The second aim of this study pertains to investigating participation differences between groups with increasing levels of addiction, to determine whether such factors belong on a continuum with addiction symptomatology. In order to achieve this aim, the study will identify the proportion of students with a non-clinical, sub-clinical and clinical level of addiction to each of the activities assessed. Group differences in relation to the type of media used and the impact participation has on homework and interpersonal relationships will be examined. The study will also investigate whether significant group differences exist for frequency participation (regular participation) and duration of engagement (high engagement), and whether these factors are significantly associated with addiction.

The third aim of the study is to investigate potential risk factors identified by previous research. It is predicted that being male, type of activity, younger age of onset, regular participation, higher engagement, and participating to achieve a desired change in subjective experience (escapism), will significantly predict addiction to gambling, video-arcade games, computer games, and the Internet (Chou & Hsiao, 2000; Clarke & Rossen, 2000; Griffiths & Hunt, 1998; Johansson & Gatestam, 2004; Lin & Tsai, 2002; Moore & Ohtsuka, 1997).

Method

Participants

University Sample

A total of 709 university students from the three (south, north, and northwest) campuses of the University of Tasmania, Australia, voluntarily participated in Study 1. Participants were recruited from the first year Psychology cohort during semester one in 2004 (n = 466) and 2005 (n = 230), and from first year Engineering in semester two 2005 (n = 9).

After the exclusion of participants with incomplete data the overall sample (N = 705) consisted of 191 male (M = 21.01 years, SD = 5.32) and 509 female (M = 21.69 years, SD = 7.00) students, aged 17 to 54 years. Students were from 37 different countries, with Australia (84.4%) the most common, followed by England

(2.6%), Malaysia (1.4%) and Singapore (1.3%) (see Appendix A, Table A1). The percentage of students living with family members (57.3%) was greater than that of students in shared accommodation (17.3%), at residential colleges (10.5%), living with their partner (9.5%), living alone (5%) or in a home stay arrangement (0.1%).

Students were enrolled in 24 different university courses, including single and combined degrees (see Appendix A, Table A2). Arts (51.2%), Arts Law (11.9%) and Science (10.9%) had the highest levels of enrolment, with the majority of the sample completing their first year of university study (81.7%) (see Appendix A, Table A3). A greater percentage of students (83.9%) spent less than 15 hours on average studying per week (non-contact hours); 26.2% studied between "0 to 5 hours per week", 38.9% between "6 to 10 hours", and 17.7% studied "11 to 15 hours a week" (see Appendix A, Table A4). The majority of university students reported having access to a computer (93.2%) and the Internet (80.9%) at home.

School Sample

A total of 1762 primary, secondary, and college students from southern, northern, and northwest Tasmanian State Schools were included in Study 1 during 2004 ($n = 623$) and 2005 ($n = 1139$). In 2004, four primary, six secondary, and three colleges volunteered to participate in the study, however, two secondary schools and one college failed to return questionnaires. The return rate from the four primary schools was 52.13%, 34.94% for secondary schools, and 17.14% for colleges. In 2005, two primary schools, four secondary schools and three colleges volunteered to be included in the study. Return rate of questionnaires in 2005 was higher than in 2004. Primary schools' return rate was 99.17%, 69.31% from the four secondary schools and 70% for the three colleges.

Socioeconomic status and regional locality varied between participating schools (see Appendix B, Table B1). Socioeconomic status was gauged by the median weekly family income of each participating schools' suburb or township, according to the 2001 census (Australian Bureau of Statistics, 2001). Participating primary schools were from five urban suburbs and one rural region, secondary schools were located in four urban and four rural areas, and the five participating colleges were from three urban suburbs and two rural locations. Of the five urban primary schools, three schools were above, one was below and one school was equivalent to the median weekly family income for Tasmania, whilst the one rural primary school fell below the median income bracket. The four urban secondary schools were above and the four rural secondary schools fell below the median family income for Tasmania. Colleges in urban and rural areas were all above the median Tasmanian weekly family income.

The overall sample ($N = 1706$) consisted of 380 primary, 990 secondary, and 335 college school students following the exclusion of students with incomplete data. Appendix B (Table B2) gives a breakdown of the total number of students, and males and females, included in the study from each grade. The majority of primary, secondary and college students had computer access at home (90.3%, 90.5%, and 98% respectively) and at school (94.5% of primary and over 98% of secondary and college students). Similar to computer accessibility, a greater proportion of college students had Internet access at home (87% vs. 70% of primary, 73% of secondary) while the Internet was readily accessible to the majority of all school students (approximately 98%) (see Appendix B, Table B3).

From the six Primary schools surveyed, 188 male ($M = 10.67$ years, $SD = 1.01$) and 188 female ($M = 10.58$ years, $SD = 1.00$) students (four unknown) aged between eight and 13 years participated in the study from Grades 3, 4, 5 and 6. Across Grades 7, 8, 9 and 10 a total of 519 male ($M = 13.83$ years, $SD = 1.21$) and 471 female ($M = 14.41$ years, $SD = 1.22$) students aged between 12 and 17 years participated in the study from the eight secondary schools surveyed. The College sample of 148 male ($M = 17.01$

years, *SD* = .75) and 186 female (*M* = 17.02 years, *SD* = .74) students (one unknown) from Grades 11, 12 and 13, ranged in age from 15 to 19 years.

Materials

University Questionnaire

The questionnaire given to university students (see Appendix C) comprised five sections; first demographic information and then a separate section for each activity: computer games, video-arcade games (coin operated gaming machines), the Internet, and gambling. Participants completed a section if they had, in their lifetime, participated in the given activity.

Demographic information. Questions relating to demographic information and University course and study requirements were included in this section of the questionnaire. Items related to participants' age, sex, current living arrangements, University course, number of years studying at university, average number of hours spent studying per week, and country of origin. Consistent with previous studies, accessibility to a computer and the Internet at participants' place of residency was also assessed (Greenfield, 1999; Wang, 2001).

Activity sections. Sections allocated to each activity were divided into three segments: participation, characteristics of engagement, and addiction.

Items assessing participation. For each activity, participation was measured by three items pertaining to lifetime participation, frequency of participation, and level of participation (Tejeiro Salguero & Bersabe Moran, 2002). Lifetime participation was assessed by a yes/no response to whether the student had engaged in the activity in their lifetime. Frequency of participation per week was measured by five response options, ranging from "less than once a week" to "7 or more times a week". The item examining level of participation was measured across eight consecutive time increments (each block representing five hours) from participating "less than one hour a week" to "more than 30 hours a week".

Characteristics of engagement. For each activity, participants' engagement in the respective activity was measured in four segments; reason for engagement, age of onset, impact on study/relationships, and diversity of the behaviour. Nine response items adapted from past research (Moore & Ohtsuka, 1997; Morahan-Martin & Schumacher, 2000) assessed the reason(s) behind students' engagement in each activity, including fun and excitement, thrill of winning, recreation and relaxation, entertainment, boredom or loneliness, to test skills, to try new things, to use up spare time, an 'other' option (the 'other' option was omitted for video-arcade games). Additional response options, "to meet people" (Internet and gambling) and "to win money quickly" (gambling) were added as reasons to engage in the respective activities (Gupta & Derevensky, 1998a; Wood, Gupta et al., 2004).

Age at which participation commenced (age of onset) was measured over six time increments ranging from "younger than 5 years" to "25 years or older", with each increment equivalent to five years. Age of onset of gambling was not assessed as gambling is illegal in Australia under the age of 18 years.

Impact of engagement on study (Chou & Hsiao, 2000; Griffiths, 1998; Young, 1998) and relationships (Pratarelli et al., 1999; Young, 1998) was assessed by yes/no response items pertaining to whether students engaged in the activity in time allocated for study (impact on study) and preferred to engage in the activity over spending time with friends/family (impact on relationships).

Diversity of engagement was examined separately for each activity (exclusion of video-arcade games), with students asked to provide a tick-box response to the different types used. A total of ten gambling activities were assessed, based on studies by Gupta and Derevensky (1998a) and Lesieur et al. (1991) examining the gambling behaviour of university students. Activities assessed ranged from playing cards for money, betting on animals, betting on sport, playing dice games for money, Casino gambling, lottery, bingo, playing the stock/commodities market, slot machines or poker machines, playing games of skill for money (for example, pool), and an 'other' option. An inventory of five different computer game platforms assessed diversity of computer game use; PlayStation or PlayStation 2, Microsoft XBOX, PC Games or MAC Games, Nintendo (GameCube, GameBoy, SuperNintendo), games on the Internet, and an additional 'other type' option. A yes/no response item were also included to ascertain whether students were currently playing a new computer game. Internet diversity was measured across nine different Internet mediums adapted from past research (Scherer, 1997; Wang, 2001). Activities included WWW searches/surfing, FTP downloading of software, newsgroups/discussion forums, Email, Chat rooms and Internet relay chat (IRC), playing games, gambling, university related work, cyber sex or adult resources, and an additional 'other' option.

Items assessing addiction. Four screening checklists modelled on the DSM-IV criteria for pathological gambling (American Psychiatric Association, 1994) were used to assess present addiction to (a) computer games, (b) video-arcade games, the (c) Internet and (d) gambling. These measures were selected to reduce time constraints posed by other inventories measuring such behavioural addictions and for practicality, as questionnaires were completed in class time and by a large sample.

(a) Young's (1998) eight-item DQ for Internet addiction was adapted to assess addiction to computer games, as criteria assessing video-arcade games could not be applied to computer games given the absence of a financial component (Johansson & Gatestam, 2004; Tejeiro Salguero & Bersabe Moran, 2002). Past researchers have modified these eight criteria measuring computer game addiction from the 10 DSM-IV criteria for pathological gambling (Griffiths & Dancaster, 1995). Components of addiction assessed were salience, mood modification, tolerance, withdrawal, loss of control, conflict, relapse, and escape. The eight-item checklist required yes/no responses, with a score of five indicative of addiction.

(b) Video arcade game addiction was assessed by nine criteria (DSM-IV-JV) developed by Fisher (1994) to assess addiction to coin-operated video game machines in youth populations. The measure was based on the DSM-IV criteria for pathological gambling (nine of the 10 criteria) in adult populations, and DSM-IV-J criteria assessing youth pathological gambling (Fisher, 1994). The internal consistency reliability was 0.71 (Fisher, 1994) across the nine dimensions of addiction assessed. The nine items were answered with a yes/no response; with a score of four endorsed items indicating addiction.

(c) Internet addiction was measured across eight yes/no response items on the same questionnaire adapted to assess for computer addiction: Young's DQ for Internet addiction (Young, 1998), with five or more endorsed items classified as Internet addiction. Item 8 was revised to "Do you use the Internet as a way of escaping from problems or relieving [a dysphoric mood] feelings of helplessness, guilt, anxiety or depressions" by the omission of dysphoric mood. A score of five or more (range 0-8) indicates the presence of Internet addiction (Chou & Hsiao, 2000).

(d) Nine items on a yes/no response checklist were used to measure gambling addiction in the adult population (Lesieur & Rosenthal, 1991). A score of four or more is representative of the presence of gambling addiction (Delfabbro & Thrupp, 2003). These nine items were adapted from Fisher's (1994) DSM-IV-J scale for pathological youth gambling. The dimensions of addiction assessed included; progression and preoccupation, tolerance, withdrawal, loss of control, escape, chasing, lies and deception, illegal acts, disruption to study/family/education, and financial bail-out. Items were adapted using Lesieur and Rosenthal's (1991) review of the DSM-III and

DSM-III-R criteria for the American Psychiatric Association taskforce on DSM-IV. Delfabbro and Thrupp (2003) state that there is little evidence to suggest that the outcome of multi-response versions of the DSM-IV-J differs to scores derived from checklists with dichotomous yes/no response options.

School Questionnaires

Separate questionnaires were developed for primary, secondary, and college school age students (see Appendices D, E, and F). Each questionnaire was modified from the University Questionnaire. The major modification was the exclusion of gambling as an activity option. Other modifications made to each questionnaire are detailed below. Age-related adjustments were made to ensure suitability for the given education sample, and each questionnaire was piloted on the proposed sample to verify age-appropriate changes.

Primary questionnaire. The following modifications were made to the Primary Questionnaire: level of participation was changed to assess engagement per day (from "less than one hour a day" to "10 or more hours a day"), "relaxation" and "other" response options were omitted from the item examining reason(s) for engagement, Internet diversity was refined to five activities (WWW searches, Email, Chat rooms, playing games, school work, 'other'), and the prevalence of addiction was not assessed. Four items assessing components of addictive experience outlined by Greenberg et al. (1999) and Rozin and Stoess (1993), were assessed: craving, withdrawal, lack of control, and tolerance, across three response options ("no", "a little bit", and "yes").

Secondary questionnaire and College questionnaire. All items from the computer game, video arcade game, and Internet sections on the University Questionnaire were included in the Secondary Questionnaire and College Questionnaire after age-appropriate changes were made. On the Secondary Questionnaire, Internet diversity was refined to the same five activity options as for the Primary Questionnaire.

Procedure

University

Approval to conduct Study 1 was obtained from the Northern Tasmania Social Sciences Human Research Ethics Committee in 2004. Psychology students were given an information sheet (see Appendix G) and consent form to read and complete. In 2005 the Ethics Committee approved an amendment to discontinue consent forms, as informed consent was implied by the participant choosing to complete the questionnaire. Students were issued the University Questionnaire and instructed to answer and return it face-down to the investigator within the 10-15 minute allocated time period.

Primary and Secondary Schools and Colleges

Study 1 was conducted during 2004 and extended to 2005. Only public schools were included. Approval to conduct this study in schools was obtained from the Northern Tasmania Social Sciences Human Research Committee and the Department of Education's Departmental Consultative Research Committee. In 2004, 17 primary schools, 13 secondary schools and five colleges from the six school districts across Tasmania were approached. School principals were sent letters of invitation to participate in Study 1 with an accompanying consent form (see Appendix H) to be completed and returned to indicate their anticipated involvement in the study. Following school consent, the investigator sent or delivered materials needed to conduct the study. Teachers were asked to give information sheets and consent forms to students to be complete by their parents (see Appendix H). Parental consent forms were returned to the class teacher and placed in an allocated envelope. Teachers were asked to administer and collect questionnaires according to the 'Administration Instructions' provided (see Appendix I). Students with parental consent and who volunteered to participate were given an outline of the purpose of the study and format of the 20-minute questionnaire.

The investigator was notified when the study had been completed and arranged for the return of materials. Ethics approval was granted to repeat Study 1 in 2005 due to the poor return rate in 2004. Twenty eight schools were approached in 2005 following the procedure used during 2004 (with the exception of parents giving passive consent).

Design and Data Analysis

Analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 14.0 for Windows. Separate analyses were performed on each educational sample investigated (primary, secondary, college and university) for each activity; video-arcade games, computer games, and the Internet. Gambling was only assessed within the university sample. After lifetime participation was assessed, data analysis was limited to students who had taken part in an activity at least once in their lifetime.

The results section is divided into four parts, one section per activity. Each activity section reports analyses on the participation and engagement characteristics of each education sample (first aim), participation and engagement differences between students with a non-clinical, sub-clinical and clinical level of addiction (second aim), and risk factors of addiction (third aim). Breakdown analysis according to gender will not be discussed as this is beyond the scope of the study however these statistics are included in the Appendices.

Participation and Engagement in Activities

Percentages were calculated for the proportion of primary, secondary, college and university students endorsing one or more possible reason(s) for why they participated in the activity, choice of media type used, frequency of participation per week, and duration of engagement. The percentage of students endorsing items of addiction and percentage of students addicted to each activity (excluding primary students) was calculated for each sample.

Continuum of Non-clinical Engagement to Addiction

Samples were collapsed to form one large sample of students (excluding primary students) who had participated in the activity at least once in their lifetime. Students were divided into three groups according to the number of symptoms of addiction endorsed; non-clinical (no symptoms), sub-clinical (at least one symptom but below the cut-off score for addiction), clinical group who meet the cut-off score for a diagnosis of addiction. For each group the percentage of students endorsing each behaviour variable (e.g., frequency of participation) and who reported that their engagement impacted on their homework and took precedence over spending time with their friends and/or family, was calculated. Two-way contingency table analyses were performed to examine the association between level of addictive experience (i.e., number of symptoms of addiction) and frequency and duration of participation. The Cramér's V was used as a measure of effect size. Significant Pearson's chi-square tests were followed by pairwise comparisons. The occurrence of Type 1 error was controlled by applying Holm's sequential Bonferroni method to all pairwise comparisons (Green, Salkind, & Akey, 2000). Assumptions underlying chi-square tests were assumed for all analyses reported. Given the large sample size of the study, analyses with up to 20% of expected frequencies falling below five were reported. Results were deemed to have insufficient statistical power if any expected frequency was below 1. Given that a small number of participants were found to be addicted to gambling, Pearson's chi-square analysis was not able to be performed between participation and engagement variables and level of addiction to gambling (group).

To rectify problems with expected frequencies, for all analyses reported in this chapter, the variables assessing frequency of participation and duration of engagement were collapsed to form dichotomous categories; regular participation (at least once a week) and high/medium engagement (at least 11 to 15 hours per week), respectively.

The terms regular engagement and high/medium engagement will be used throughout this chapter.

Analysis of the Risk Factors of Addiction

Separate binary logistic regression analyses with Backward Wald stepwise exclusion criteria were performed to determine which nominated variables contributed to gambling, video-arcade game addiction, computer game addiction and Internet addiction. As this was a purely exploratory exercise to establish which variables significantly contributed to addiction, only the main effects of predictor variables were examined and not the interactions between variables.

The present study was exploratory in nature, and hence not concerned about reaching a parsimonious solution, the focus of Study 1 was to find what predictor variables made a contribution to the accurate prediction of addiction. Regression analyses were therefore stopped earlier than that dictated by the strict entry and exclusion criteria of SPSS. Instead the following criteria were applied to the decision of whether to report an earlier model; the removal of a non-significant predictor variable did not significantly contribute to improving the former model, the log likelihood of the step increased, and there was no improvement (or decrease) in the percentage of correctly predicted individuals with addiction. Only models with a non-significant Hosmer and Lemeshow's goodness-of-fit test statistic were reported to ensure that the model did not differ significantly from observed data.

Participants with missing values on any predictor variable were excluded from analysis. Multicollinearity assumptions for each model were controlled through examination of classification plots and tolerance and VIF collinearity statistics (Tabachnick & Fidell, 1996).

Results

Gambling

Participation and Engagement in Gambling

Data on the gambling behaviour of students was collected from the university cohort. A total of 54.9% of the sample had gambled at least once in their lifetime. The thrill of winning was the most highly endorsed reason why students chose to gamble (56.1% of gamblers), secondly for fun and excitement (54.8%), and entertainment (53.2%). Gambling to meet people (3.2%) and alleviate feelings of boredom and loneliness (5.2%) were the least common motivating factors reported. Ten percent of the sample gambled to test their skills and 28.2% gambled to make money, implying that they perceived gambling outcomes were not based on chance (Appendix J, Table J1).

Gambling activities are either continuous with rapid event frequency or non-continuous with a delay between participation and outcome. Table 1 shows that a higher proportion of students engaged in more continuous forms of gambling (e.g., slot machines) compared to non-continuous media (e.g., lotteries). The most common gambling media were, slot machines, gambling at the Casino, lotteries and betting on animals. Betting on dice and stock and commodities were the least popular activities.

Table 1

Percentage of University Students (n = 387) Participating in Each Gambling Activity

Gambling activity	% Students	Gambling activity	% Students
Slot machines	76.2	Skill games	27.6
Casino	70.0	Bet on sport	22.7
Bet on lotteries	53.7	Bingo	21.7
Bet on animals	49.9	Other	9.6
Cards	37.2	Stock/commodities	5.9
Skill games	27.6	Bet on dice	5.4

Of the university students who gambled the majority did so infrequently, that is, less than once a week (89.4%). A small percentage of students (1.3%) were found to gamble in excess of three times a week (five participants) (see Appendix J, Table J2). Consistent with the frequency at which students gambled, over 90% of gamblers spent less than one hour per week gambling. Only one student was found to gamble between 11 and 15 hours and no student reported that their gambling behaviour exceeded 15 hours a week (see Appendix J, Table J3).

In addition to examining the frequency of participation and level of engagement in gambling activities, the type of gambling-related problems (symptoms of addiction) experienced by students was also assessed (see Appendix J, Table J4). A total of 2.3% of university students (1.8% male, 2.6% female) were found to meet the criteria for pathological gambling. Symptoms of addiction that were more commonly reported included returning to gamble to chase money lost (8.5% of the gamblers), cognitive salience and preoccupation with past and future games (6.7%), the need to gamble with more money to achieve the desired excitement (tolerance: 5.4%), and deception to concealment of ones involvement in gambling (4.1%). Few students gambled as a means to escape negative feelings (3.1%).

Continuum of Non-clinical Engagement to Addiction

The sample of university students who gambled ($n = 387$) were analysed according to number of symptoms of addiction they experienced. Overall, 316 (81.7%) gamblers did not endorse any of the eight symptoms of addiction (non-clinical level), 62 (16%) endorsed one to three symptoms (sub-clinical level), and nine (2.3%) experienced at least four symptoms of pathological gambling (addicted) (see Appendix J, Table J5 for a breakdown by gender). Caution must be taken when discussing the behaviour of the addicted sample as it is only representative of nine students.

The non-clinical group was consistently found to have the lowest percentage of students engaging in each type of gambling activity. Although percentages of students differed, all groups showed a similar preference for particular gambling media (see Appendix J, Table J6). The greatest portion of students in the non-clinical, sub-clinical and addicted sample played slot machines (73.4%, 88.7%, 88.9%, respectively), and casino gambling (66.5%, 83.9%, 100%, respectively) betting on the lotteries (50%, 69.4%, 77.8%, respectively) and animals (47.8%, 58.1%, 77.8%, respectively). Gambling on stock and commodities was the least popular activity for the non-clinical (4.7% of sample), sub-clinical (11.3%) and addicted (11.1%) groups.

In relation to gambling frequency, Table 2 shows that the majority of those with a non-clinical level of addiction gambled less than once a week while a greater percentage of addicted gamblers participated regularly. Fewer sub-clinical gamblers were found to gamble regularly (32.3%) compared to those who were addicted (77.8%).

Table 2

Frequency University Students Gambled per Week (Irregular or Regular Participation) according to whether they had a Non-clinical, Sub-clinical or Clinical Level of Addiction to Gambling

Weekly frequency	Non-clinical[a]	Sub-clinical[b]	Addicted[c]
< 1	95.6	67.7	22.2
1 - 2 times	4.1	30.6	44.4
3 - 4 times	0.3	0	11.1
5 - 6 times	0	0	22.2
7 or more	0	1.6	0

Note. Values represent percentage of students.
[a]*n = 316.* [b]*n =62.* [c]*n = 9.*

Table 3 depicts the level of engagement of each group of gamblers. As can be seen, no student in the non-clinical group had a high/medium level of engagement with all participants gambling below six hours per week. The addicted sample gambled for longer periods of time, with over half engaged for at least two to five hours per week compared to only approximately 20% of those with a sub-clinical level of addiction.

Table 3

Number of Hours Spent Gambling per Week by University Students[a] with a Non-clinical, Sub-clinical or Clinical Level of Addiction to Gambling

Hours per week	Non-clinical (n = 316)	Sub-clinical (n = 62)	Clinical (n = 9)
< 1	97.8	80.6	44.4
2 - 5	2.2	17.7	33.3
6 - 10	0	1.6	11.1
11 - 15	0	0	11.1

Note. Values represent percentage of students. Clinical group meet the criteria for addiction. High/medium engagement equates to gambling at least 11 – 15 hours per week
[a]n = 383.

In relation to the impact of gambling on other aspects of a student's life, a greater proportion of students meeting the criteria for addiction (22.2%) reported that they gambled during homework time compared to students with a sub-clinical (8.1%) and non-clinical (0.3%) level of addiction. Similarly, gambling involvement that takes precedence over wanting to spend time with friends or family appears to be characteristic of clinical addiction, with 22.2% of the addicted sample reporting this compared to no student with a sub-clinical level and 0.3% of non-clinical gamblers.

Risk Factors for Addiction to Gambling

Given that only nine participants were addicted to gambling, logistical regression was not able to be performed due to the inadequacy of expected frequencies.

Summary of the Gambling Behaviour of University Students

Approximately 54.9% of the sample gambled, primarily due to the thrill obtained by winning, for fun and excitement and as an entertainment outlet. The majority of the sample experienced no gambling-related problems (non-clinical; 81.7%), with only a small proportion of gamblers found to be addicted to gambling (2.3%). It was established that this sample of students (regardless of level of addiction experienced) preferred more continuous forms of gambling, including slot machines and Casino activities. In relation to gambling participation, the majority of the sample (approximately 90%), including both non-clinical and sub-clinical gamblers, gambled infrequently and for short periods of time compared to the addicted sample. Overall, only a small proportion of gamblers, typically those who were addicted to gambling, found that gambling impacted on study (2.1%) and took precedence over the time they wanted to devote to their relationships (0.8%).

Video-Arcade Games

Participation and Engagement in Video-arcade Games

Approximately 60% of the total sample of students investigated had played video-arcade games at least once in the lifetime; 63.7% of primary, 68.1% secondary, 61.2% college and 55.6% of university students. Engagement was more popular among younger cohorts of students compared to those in tertiary education. As shown in Table 4, students from each of the three school samples most commonly reported that fun and excitement was a motivating factor behind their engagement. In comparison the highest proportion of university students reported that they played video-arcade games as a source of entertainment. A higher proportion of students from each sample played video-arcade games to test their skills (especially primary students), try new things and use up their spare time.

Table 4

Reason(s) Primary Secondary, College and University Students gave for Engaging in Video-Arcade Games

Reason	Primary [a]	Secondary [b]	College [c]	University [d]
Fun / excitement	64.0	71.7	61.5	58.4
Entertainment	54.1	63.2	60.0	66.6
Test skills	46.3	36.8	22.4	21.9
Try new things	44.2	30.7	19.0	17.9
Spare time	39.3	36.5	28.8	23.0
Thrill of winning	34.3	31.9	22.0	25.8
Boredom / loneliness	28.5	17.4	8.8	7.1
Recreation / relaxation		20.9	18.0	23.0

Note. Values present percentage of students.
[a]$n = 242$. [b]$n = 674$. [c]$n = 205$. [d]$n = 362$.

Table 5 shows that the majority from each education sample played video-arcade games for less than once per week. Primary and secondary students had a higher rate of participation, with more students playing at least one to two times a week or more (23.6% and 20.5%, respectively) compared to college (5.4%) and university students (4.4%).

Consistent with the frequency at which students engaged in video-arcade games, Table 6 shows that the majority from secondary, college and university played for less than one hour a week. Secondary students played for longer than college students, followed by university students. Similar to older samples of students, approximately 84% of primary school participants spent less than one hour a day engaging in this activity (refer to Appendix K, Table K1).

Table 5

Frequency Primary, Secondary, College and University Students Spent Playing Video-Arcade Games per Week

Weekly frequency	Primary[a]	Secondary[b]	College[c]	University[d]
< 1	76.4	78.8	94.6	95.7
1 - 2 times	14.0	12.8	3.9	3.3
3 - 4 times	6.2	5.0	1.0	0.8
5 - 6 times	1.7	1.2	0	0
7 or more	1.2	1.9	0.5	0.3

Note Values present percentage of students.
[a]$n = 242$. [b]$n = 674$. [c]$n = 205$. [d]$n = 362$.

Table 6

Number of Hours per Week Secondary, College and University Students Spent Playing Video-Arcade Games

Hours per week	Secondary [a]	College [b]	University [c]
< 1	82.9	94.6	96.2
2 - 5	10.1	3.9	3.3
6 - 10	3.0	0	0.3
11 - 15	1.5	0.5	0
16 - 20	0.7	0	0
21 - 25	0.6	0	0
26 - 30	0	0.5	0
> 30	1.0	0.5	0

Note. Values present percentage of students.
[a]$n = 674$. [b]$n = 205$. [c]$n = 362$.

A higher percentage of secondary students who played video-arcade games (7%) were found to be addicted compared to those from college and university (1.5% and 0.3%, respectively) (see Appendix K, Table K2 for a breakdown by gender). The most frequently experienced aspect of addiction to video-arcade games reported across student cohorts was returning to play to chase a higher score; 19% secondary, 9.3% college and 12.8% university gamers. Other highly endorsed aspects of addiction were tolerance and playing to escape problems or unpleasant feelings (see Appendix L, Table L1). Four key components of video-arcade game addiction were also investigated among primary school students. As shown in Table 7, over one quarter of students reported that they felt their behaviour was 'a bit', and 11.6% stated that it 'was', out of control. In comparison to other problems, experiencing some level of tolerance was endorsed by a higher proportion of primary students.

Table 7

Percentage of Primary School Students Endorsing Aspects of Video-Arcade Game Addiction

Symptom of addiction	No	A little bit	Yes
Withdrawal	85.5	10.7	3.7
Strong desire	79.8	17.8	2.5
Tolerance	73.1	19.0	7.9
Lack of control	62.4	26.0	11.6

n = 242.

Continuum of Non-clinical Engagement to Addiction

The sample of secondary, college, and university students who had played video-arcade games was collapsed to examine the second aim of the study. Of the total sample of 1271 students (excluding primary students), 73.2% (*n* = 931) did not experience any symptomatology (non-clinical level), 22.4% (*n* = 287) one to three symptoms (sub-clinical level), and 4.2% (n = 53) met the modified DSM-IV-JV criteria for video-arcade addiction (see Appendix L, Table L2 for breakdown by gender).

The majority of students with non-clinical and sub-clinical levels of addiction play irregularly, less than once a week, as shown in Table 8. In comparison to other students, those addicted to video-arcade games reported playing regularly at least once a week (65.4%), with approximately 15% having seven or more sessions per week.

Table 8

Frequency at which Students[a] Played Video-Arcade Games per Week (Irregular or Regular Participation) according to whether they had a Non-clinical, Sub-clinical or Clinical Level of Addiction to Gaming

Weekly frequency	Non-clinical (n = 931)	Sub-clinical (n = 287)	Addicted (n = 53)
< 1	93.0	75.3	34.6
1 - 2 times	5.5	16.7	15.4
3 - 4 times	1.0	5.9	25.0
5 - 6 times	0.2	0.3	9.6
7 or more	0.3	1.7	15.4

Note The sample includes students from university, secondary schools and colleges but excludes those from primary schools.
[a]n = 1270.

Overall, frequency of gaming participation increases sequentially across non-clinical, sub-clinical and addicted samples. A two-way contingency table analysis established that regular participation and level of addiction were significantly related, Pearson χ^2 (2, N = 1271) = 182.767, p < .001, Cramér's V = .38 (see Appendix L, Table L3). Follow up pairwise comparisons were conducted to examine differences in the proportions of regular gamers with a non-clinical, sub-clinical and clinical level of addiction (group). Significant differences existed between the proportions of regular gamers in each group, with significantly fewer having a non-clinical (7%) level of addiction compared to sub-clinical (24.7%), χ^2 (1, N = 1218) = 69.74, $p < .001$, Cramér's V = .24, or clinical level (64.2%), χ^2 (1, N = 984) = 181.12, $p < .001$, Cramér's V = .43. The proportion of regular players in the sub-clinical group was significantly lower than in the addicted group, χ^2 (1, N = 340) = 32.56, $p < .001$, Cramér's V = .31 (see Appendix L, Table L4). Review of Cramér's V values for each comparison suggests that the relationship between regular participation is consistent with the continuum of addiction symptomatology.

Consistent with differences in the frequency of participation amongst groups, the number of hours spent playing video-arcade games per week also appears to be a differentiating factor between students with varying levels of addiction symptomatology. Results regarding the duration students spent playing video-arcade games are reported in Table 9. As expected the non-clinical group had the lowest level of engagement. The majority of students with non-clinical and sub-clinical addiction engaged for less than one hour per week, whereas over 64% of the addicted sample played in excess of two to five hours per week.

A two-way contingency table analysis established that the proportion of students with a high/medium level of engagement significantly differed amongst groups with varying levels of addiction, Pearson χ^2 (2, N = 1271) = 128.36, $p < .001$, Cramér's V = .32 (see Appendix L, Table L5). Follow up pairwise comparisons were conducted to evaluate the differences among groups, however due to violations to the assumption of expected frequencies analyses were deemed invalid (Appendix L, Table L6).

A higher percentage of addicted gamers reported playing video-arcade games during time allocated for homework (47.2%) compared to students with sub-clinical (10.8%) and non-clinical (3%) levels of engagement. Preferring to play video-arcade games over spending time with family and friends was found to be a function of addiction rather than of sub-clinical involvement. A total of 32.1% of the addicted sample endorsing that video-arcade gaming took precedence over relationships compared to only 4.2% sub-clinical and 0.8% non-clinical gamers.

Table 9

Number of Hours Spent Playing Video-Arcade Games per Week by Students[a] with a Non-clinical, Sub-clinical or Clinical Level of Addiction to Gaming

Hours per week	Non-clinical ($n = 931$)	Sub-clinical ($n = 287$)	Addicted ($n = 53$)
< 1	94.6	80.8	35.8
2 - 5	4.1	12.9	26.4
6 - 10	0.5	3.1	13.2
		High/medium engagement	
11 - 15	0.2	1.7	7.5
16 - 20	0.2	0.3	3.8
21 - 25	0.1	0.3	3.8
26 - 30	0.1	0	0
> 30	0.1	0.7	9.4

Note. Values represent percentage of students. High/medium engagement represents playing for at least 11 – 15 hours per week.
[a]n =1269.

Risk Factors for Video-Arcade Game Addiction

A binary logistic regression analysis was conducted to determine whether individual differences (sex) and participation variables, regular participation, high/medium engagement, onset of gaming involvement (before age five) and playing to escape negative emotions, significantly contribute towards predicting addiction. In comparison to the constant-only model the full model with all five predictor variables was significant, χ^2 (5, N = 1267) = 199.30, $p < .001$, indicating that the predictors, as a set, were able to differentiate participants who did or did not meet the criteria for video-arcade game addiction reliably.

The variance in video-arcade game addiction accounted for by the full-model was 45.3 percent (R^2 = .45, Nagelkerke R = .49). When the model was run without the age of onset variable (step 2) it was found to be significantly superior to the constant-only model at predicting addiction, χ^2 (4, N = 1267) = 197.86, p < .001, however it did not make a significant contribution when compared to the full model and therefore was not reported. The classification of addiction by the full-model was still poor with only 39.6% of those with video-arcade game addiction correctly predicted while 98.7% of those with no clinical diagnosis were correctly classified, resulting in an overall success rate of 96.2 percent.

The significant predictor variables, in sequential order from most to least Wald chi-statistic and hence variance, were playing video-arcade games to escape negative emotional states (R = 19.61% variance), regular participation (R = 3.32% variance) and high/medium engagement (R = 0.52% variance). Addiction was significantly predicted by playing to escape negative emotional states, χ^2 (1, N = 1267) = 88.33, p < .001, regular participation χ^2 (1, N = 1267) = 16.64, p < .001, and a high/medium level of engagement in video-arcade games, χ^2 (1, N = 1267) = 4.28, p < .05 (see Appendix L, Table L7). Overall, these results suggest that youth who have greater engagement (frequency and duration) and seek desired changes in subjective experience are more likely to become addicted to video-arcade games.

Summary of Video-arcade Game Behaviour

Sixty percent of the sample had played video-arcade games at least once in their lifetime, with the majority playing infrequently (higher frequency of participation among younger samples). The most highly endorsed reason why students from each education level chose to play video-arcade games was for fun and excitement, and entertainment. The majority of the overall sample had a non-clinical level of addiction (73.2%) and 4.2% met a diagnosis of addiction according to the DSM-IV-JV. A greater proportion of secondary school students (7%) were found to be addicted compared to other samples, and of concern, a proportion of primary school students also reported experiencing problems due to their gaming behaviour, mainly in relation to having a lack of control over reducing their activity (11.6% of the sample). Results suggest that frequency and duration (hours per week) exist on a continuum with addiction, with significantly more students from the non-clinical group, followed by sub-clinical group, having an infrequent and lower level of engagement compared to the addicted sample. Pearson chi-square tests revealed that those addicted to video-arcade games were significantly more likely to play regularly (i.e., 65.4% of the sample) however, not for a long period of time (i.e., the majority played 2 - 5 hours per week). These participation differences were supported by logistical regression analysis, as both regular participation and high/medium engagement made a significant contribution to predicting addiction.

Computer Games

Participation and Engagement in Computer Games

Over 90% of school students (98.4% of primary, 95.6% secondary and 91.3% college) and 82.7% of university students had played computer games at least once in their lifetime. Participants were asked to identify the one or more reasons why they played computer games to determine motivating factors behind their engagement. Fun and excitement were found (see Table 10) to be the most frequently endorsed reasons why primary students played computer games, and entertainment was the most common reason given by older students. It appears that the proportion of students reporting playing computer games for fun, the thrill of winning, to alleviate boredom and loneliness, to test skills and try new things, decreases as age increases. A greater proportion of older students report playing to relax compared to younger cohorts.

Table 10

Reason(s) Students gave for Playing Computer Games

Reason	Primary [a]	Secondary [b]	College [c]	University [d]
Fun / excitement	66.6	64.5	52.0	34.6
Entertainment	61.5	69.5	66.3	57.6
Boredom / Loneliness	53.5	36.7	34.6	32.8
Spare time	48.4	60.9	52.9	37.0
Test skills	36.9	28.4	22.5	13.2
Try new things	33.2	27.7	14.1	8.7
Thrill of winning	28.3	23.7	12.7	13.0
Recreation / Relaxation		32.8	47.1	44.9
Other Reason		14.6	5.9	7.7

Note. The values represent percentages of students.
[a]n = 374. [b]n = 946. [c]n = 306. [d]n = 583.

Table 11 presents the percentage of students engaging in each type of computer game media. PlayStation, PC or Mac games, and games on the Internet were the most frequently played computer games across all education samples. A similar proportion of primary, secondary, college and university students play PC or Mac games. The popularity of PlayStations, Xbox, Nintendo and Internet on-line games decreases after adolescence.

Table 12 shows that the majority of university students played computer games less than once a week. Approximately 47% and 40.5% of secondary and college students, respectively, played three to four or more times a week compared to 21.6 percent of university students.

Table 11

The Percentage of Primary, Secondary, College and University Students who have Participated in Various Computer Games

Computer Game	Primary [a]	Secondary [b]	College [c]	University [d]
Internet games	66.8	74.7	61.8	31.6
PC / MAC Game	65.2	70.3	75.5	67.6
PlayStation	64.7	72.2	59.5	56.1
Nintendo	37.4	36.4	31.0	23.0
Other	30.2	24.1	12.7	8.6
X BOX	25.7	30.1	28.1	19.0

Note. The values represent percentages of students playing each type of computer game activity at least once in their lifetime.
[a]$n = 374$. [b]$n = 946$. [c]$n = 306$. [d]$n = 583$.

Table 12

Frequency at which Students Engage in Computer Games per Week

Weekly frequency	Primary[a]	Secondary[b]	College[c]	University[d]
< 1	22.2	27.6	41.2	59.0
1 - 2 times	28.3	25.9	18.3	19.4
3 - 4 times	28.9	22.0	16.0	12.7
5 - 6 times	9.1	10.8	8.2	4.1
7 or more	11.5	13.6	16.3	4.8

Note The values represent percentages of students
[a]$n = 374$. [b]$n = 946$. [c]$n = 306$. [d]$n = 583$.

A greater percentage of all students spent less than one hour per week playing computer games, with more secondary students playing over two hours a week compared to college and university students (70.3% compared to 58.2% and 38.4% respectively). As shown in Table 13, the majority of university students played for fewer hours compared to secondary and college students. A higher proportion of college students (13.5%) played computer games for longer periods of time on average (over 16 hours per week) than secondary students (7.6%) and university students (3.1%). Comparatively, approximately 43% of primary students reported playing computer games in excess of one hour per day (see Appendix K, Table K1).

Table 13

Number of Hours per Week Secondary, College and University Students Spend Playing Computer Games

Hours per week	Secondary [a]	College [b]	University [c]
< 1	29.7	41.8	61.6
2 - 5	29.5	27.8	23.3
6 - 10	23.4	13.4	8.6
11 - 15	9.6	3.6	3.4
16 - 20	3.7	5.6	1.2
21 - 25	1.3	2.6	0.7
26 - 30	0.7	2.0	0.3
> 30	1.9	3.3	0.9

Note. The values represent percentages of students
[a]*n* = 946. [b]*n* = 306. [c]*n* = 583.

The prevalence of addiction and symptoms of addiction was assessed within the secondary, college and university samples. The secondary students had the highest proportion of addicted gamers (7%) compared to college (3.3%) and university students (2.6%) (for a breakdown of gender refer to Appendix K, Table K2). Playing for longer than intended was the most frequently experienced consequence endorsed by secondary (48.5%) college (51.3%) and university (52.7%) students. Salience of playing and anticipating future engagement was the second mostly highly experienced consequence reported by approximately one quarter of the secondary and college sample, followed by playing as a means to escape problems or to induce mood modification. The reverse was found for university students, with the second highest percentage of students reporting that they played to escape problems or unpleasant feelings (15.3%) and third that they experienced cognitive salience and anticipatory affects (12.3%) (refer to Appendix M, Table M1).

Key components of addiction to computer games were also assessed among primary school students. As can be seen in Table 14 over half the sample reported experiencing some degree of loss of control over their behaviour and approximately 30% needed to play for longer periods of time to get the same amount of satisfaction or enjoyment.

Table 14

Percentage of Primary School Students Endorsing Aspects of Computer Game Addiction

Symptom of addiction	No	A little bit	Yes
Withdrawal	76.7	17.9	5.1
Tolerance	67.9	19.8	12.0
Strong desire	57.2	37.2	5.1
Lack of control	46.0	37.7	15.8

n = 374.

Continuum of Non-clinical Engagement to Addiction

Of the sample of students who played computer games (excluding primary students), a total of 39.8% (*n* = 731) did not experience any symptoms of addiction due to their engagement (non-clinical level of addiction), 55.2% (*n* = 1013) reported one to four symptoms (sub-clinical level) and 5% (*n* = 91) met a diagnosis of addiction (see Appendix M, Table M2 for a breakdown by gender). Lifetime participation was examined within each group, separately for on-line Internet games and games played off-line games (see Appendix M, Table M3 for a breakdown of participation per activity). As shown in Table 15 the majority of students, regardless of the level of addiction they experienced, had played both off-line and on-line computer games at least once in their lifetime, with a higher proportion having played off-line.

Table 15

Participation in Off-line and O-line Computer Games by Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to Computer Games

Type of game	Non-clinical[a] ($n = 731$)	Sub-clinical[b] ($n = 1013$)	Addicted[c] ($n = 91$)
Off-line[d]	93.4	98.1	96.7
On-line[e]	51.1	62.7	79.1

Note. The values represent percentages of students (secondary, college, university only) playing each type of computer game activity at least once in their lifetime. Off-line games include PlayStation, Xbox, PC and Mac games, and Nintendo media. On-line games are defined as any game played on the Internet. [d]$n = 1835$. [e]$n = 1743$.

As can be seen in Table 15, on-line computer games are less popular among samples with less addiction symptomatology. A two-way contingency table analysis examined this relationship between the proportion of students who had participated in on-line games and level of addictive experience; non-clinical, sub-clinical and addicted. A significant association was established between these two categories, with Pearson χ^2 (2, $N = 1834$) = 39.73, $p < .001$, Cramér's $V = .15$ (see Appendix M, Table M4). All follow up pairwise comparisons were significant (see Appendix M, Table M5). Participation in on-line computer games was found to be significantly more likely among students with a sub-clinical or clinical level of addiction compared to those with no symptoms of addiction (non-clinical group); Pearson χ^2 (1, $N = 1743$) = 23.37, $p < .001$, Cramér's $V = .12$; Pearson χ^2 (1, $N = 821$) = 25.60, $p < .001$, Cramér's $V = .18$, respectively. Although the sub-clinical and addicted group comparison was significant, Pearson χ^2 (1, N = 1104) = 9.80, p < .01, Cramér's V = .094, this association appeared to be more likely to be due to chance as inspection of all Cramér's V values suggests that this association lacked power, therefore indicating that only a weak relationship existed between addiction (only slightly better than change) and participation in on-line games.

Table 16 shows differences in the frequency of computer game play per week by students with a non-clinical, sub-clinical and clinical level of addiction. Over 60% of students in the non-clinical group played less than once a week compared to more regular participation by students with problematic computer game behaviour, particular those meeting the criteria for addiction.

Table 16

Frequency at which Students[a] with a Non-clinical, Sub-clinical and Clinical Level of Addiction Played Computer Games per Week

Weekly frequency	Non-clinical (n = 731)	Sub-clinical (n = 1013)	Addicted (n = 91)
< 1	61.6	26.9	8.8
1 - 2 times	21.2	24.6	11.0
3 - 4 times	12.2	22.3	17.6
5 - 6 times	3.0	11.7	11.0
7 or more	1.9	14.4	51.6

Note. The sample includes students from university, secondary schools and colleges.
[a]n = 1834.

Approximately 73% of sub-clinical and 91% of addicted gamers played computer games regularly at least once a week compared to only 38% of those with a non-clinical level of addition. A two-way contingency table analysis was employed to examine whether this observed difference in frequency of participation represented a significant association between regular participation and level of addiction. A significant association was established, with Pearson χ^2 (2, N = 1835) = 252.41, p < .001, Cramér's V = .37 (see Appendix M, Table M6). Significant follow up pairwise comparisons suggest that students who experience either some symptoms of addiction (sub-clinical) or met a diagnosis of addiction are more likely to play computer games regularly as opposed to non-clinical gamers; χ^2 (1, *N* = 1744) = 211.14, *p* < .001, Cramér's *V* = .35 and χ^2 (1, *N* = 822) = 91.86, *p* < .001, Cramér's *V* = .33, respectively (see Appendix M, Table M7). Although the comparison between the addicted and sub-clinical groups was significant, χ^2 (1, *N* = 1104) = 14.51, *p* < .001, Cramér's *V* = .12, inspection of the Cramér's *V* value suggested that this relationship has low statistical power. Findings therefore suggest that there is a medium association between experiencing some symptoms of addiction, irrespective of whether a diagnosis of addiction is met, and regular computer game play.

Table 17 presents the number of hours spent playing computer games according to group membership. It appears that as the level of addiction increases so too does the number of hours spent playing computer games. The majority of non-clinical gamers played for less than 10 hours per week, tending to spend less than one hour engaging in computer games (61.7%) compared to sub-clinical gamers who were found to be most likely to play between two to 10 hours a week (approximately 55%). The addicted sample had the highest level of engagement with approximately half the sample playing over 11 to 15 hours a week (14.3% played in excess of 30 hours).

A two-way contingency table analysis was conducted to evaluate whether having at least some symptoms of addiction was related to higher engagement in computer games. Analysis revealed that the relationship was significant, with Pearson χ^2 (2, *N* = 1835) = 122.78, *p* < .001, Cramér's *V* = .26 (see Appendix M, Table M8). Significant follow up pairwise comparisons were established between the proportions of students with a high/medium level of engagement in each group; non-clinical (7%), sub-clinical (15.6%), addicted (48.4%).

Table 17

Number of Hours Students[a] with a Non-clinical, Sub-clinical and Clinical Level of Addiction Spent Playing Computer Games per Week

Hours per week	Non-clinical (n = 731)	Sub-clinical (n = 1013)	Addicted (n = 91)
< 1	61.7	29.7	18.6
2 - 5	20.6	33.2	15.4
6 - 10	10.7	21.5	17.6
Total	93.0	84.4	51.6
11 - 15	5.9	6.8	11.0
16 - 20	0.8	4.0	13.2
21 - 25	0.1	1.8	5.5
26 - 30	0	1.1	4.4
> 30	0.1	1.9	14.3

Note. Values represent percentage of students. High/medium engagement is defined as playing computer games for 11–15 hours or more per week.
[a]*n* =1833.

Findings from Peason's chi-square tests showed that significantly fewer high/medium engagers were found among the non-clinical sample than among those with a sub-clinical level of addiction, χ^2 (1, N = 1744) = 29.92, $p < .001$, Cramér's V = .13, and among those with addiction compared to those with a sub-clinical level of addiction, χ^2 (1, N = 1104) = 59.92, $p < .001$, Cramér's V = .23. There were also significantly fewer high/medium engagers in the non-clinical than the addicted groups, χ^2 (1, N = 822) = 135.53, $p < .001$, Cramér's V = .41. Examination of Cramér's V values indicates that a moderately strong relationship existed between a high/medium level of engagement and addiction (see Appendix M, Table M9). Results suggest that addicted individuals, followed by students with a sub-clinical level of addiction, were significantly more likely to play at least 11 – 15 hours per week compared to students who experience no problems with their computer game use.

The proportion of students who found that computer game play impacted on time they devoted to homework and relationships was found to increase with greater level of addiction symptomatology. Playing computer games was found to impact on a moderate proportion of all gamers homework time (i.e., 21.4% of non-clinical gamers), particularly amongst those with sub-clinical (49.2%) and clinical (71.4%) addiction. In comparison, preferring to play computer games rather than spending time with friends and/or family appears to be more a function of addiction than sub-clinical behaviour. A total of the 37.4% of addicted sample reported preferring gaming over time spent with friends or family compared to only 7% of sub-clinical and 1.8% of non-clinical computer gamers.

Risk Factors for Computer Game Addiction

A binary logistical regression was employed to assess whether playing on-line games and off-line games, starting to play these games before five years of age, regular participation, high/medium engagement, being male, and playing to escape negative emotions, contribute to computer game addiction. A test of the full-model including all the aforementioned predictor variables was significant, χ^2 (7, N = 1825) = 251.94, $p < .001$, and better than the constant-only model at successfully differentiating between non-addicted and addicted individuals. The variance accounted for by the full model was unimpressive with the Nagelkerke $R = .39$ and $R^2 = .35$. Only 18.7 percent of addicted individuals were correctly predicted by the full-model. As 99.1% of non-addicted individuals were correctly classified the overall prediction accuracy was 95.1%.

Later models excluded sequentially the variables which attributed the least variance to the model; step 2 age of onset variable excluded; step 3, the age of onset variable and playing off-line computer games were excluded. The step 2 and step 3 models were both more accurate than the constant-only model and significantly predicted computer game addiction, χ^2 (6, N = 1825) = 251.72, $p < .001$ and χ^2 (5, N = 1825) = 250.49, $p < .001$ respectively, although when compared to the full-model neither made a significant contribution nor correctly predicted any of the addicted sample. The full-model was therefore deemed to be more reliable at indicating which predictor variables were making a significant contribution to accurately predicting computer game addiction. According to the Wald chi-square criterion, computer game addiction was significantly predicted by three of the seven variables included in the model; playing to escape negative emotions, χ^2 (1, N = 1825) = 104.74, $p < .001$, high/medium level of engagement, χ^2 (1, N = 1825) = 17.30, $p < .001$, and being male, χ^2 (1, N = 1825) = 5.97, $p < .05$ (see Appendix M, Table M10). As expected playing to escape negative emotions made the greatest contribution to predicting addiction (R = .14) because it is a diagnostic symptom of addiction. In summary, the findings from the regression analysis suggest that males who have a higher level of engagement and play to induce a positive change in subjective experience are more likely to become addicted to computer games.

Summary of Computer Game Behaviour

Across all education samples investigated, approximately 95% of school students and 83% of university students had played computer games at least once in their lifetime. The majority of students surveyed played computer games for entertainment (particularly older students) and for fun and excitement (especially among primary students). Off-line games were more popular across education samples and groups with varying levels of addiction symptomatology (non-clinical, sub-clinical and addicted samples). In comparison to off-line games, participation in on-line games was more common among sub-clinical and particularly addicted (79.1%) gamers. A significant, although weak, association was found between on-line games and addiction, however participation in on-line games did not significantly contribute towards addiction.

Over half the sample of students had at least a sub-clinical level of addiction and 5% of students met the modified criteria for computer game addiction. A greater proportion of secondary students were found to be addicted to computer games (7% vs. 3.3% of college, 2.6% of university students). Results indicate that frequency and duration of participation increase on a continuum with addiction. Over 50% of the addicted sample had a high/medium level of engagement, with 14.3% playing in excess of 30 hours a week. The majority of sub-clinical and addicted individuals played computer games regularly, with 50% of the addicted sample participating at least seven times a week. Given that regular engagement was characteristic of both a sub-clinical and clinical level of addiction, Pearson's chi-square analysis revealed that the association between regular gaming and addiction was significant, with the strength of this association not influenced by whether a diagnosis of addiction was met. Consistent with this finding, logistical regression analysis established that regular participation was not a significant predictor of addiction, therefore suggesting it is not a unique feature of clinical addiction. Regression analysis however, established that high/medium engagement significantly predicted addiction, with inspection of the effect size of Pearson's chi-square analyses indicating that addicted individuals were more likely to have a high/medium engagement compared to sub-clinical gamers.

The Internet

Participation and Engagement in the Internet

Nearly all primary (97.6%), secondary (98.4%), college (96.4%) and university (98.4%) students investigated in the study had used the Internet at least once in their lifetime. As shown in Table 18, frequently endorsed reasons why students logged on were for fun and excitement, entertainment, and to use up spare time. The highest percentage of primary students used the Internet to use up spare time, while more secondary and college students went on-line for entertainment purposes. 'Other' reasons such as for study and research were common motivating factors reported by the university sample.

Table 18

Reasons that Primary, Secondary, College and University Students gave for using the Internet

Reason	Primary [a]	Secondary [b]	College [c]	University [d]
Spare time	61.5	42.6	52.9	38.5
Fun / excitement	56.6	62.7	40.2	22.9
Entertainment	51.5	69.5	57.3	49.6
Try new things	40.2	24.6	18.6	16.9
Boredom / loneliness	39.6	42.6	33.7	25.5
Test skills	30.2	27.0	9.6	7.6
Thrill of winning	16.4	15.4	6.8	2.0
Other reason		51.0	45.8	62.1
Recreation / relaxation		41.4	46.7	42.1
Meet people			25.4	13.0

Note. Values represent percentage of students.
[a]$n = 371$. [b]$n = 974$. [c]$n = 323$. [d]$n = 694$.

Table 19 presents the percentages of students engaging in each type of Internet activity. Playing games on the Internet was the most common Internet activity reported by primary students, while email was the most highly endorsed activity secondary, college and university students reported. Other common activities performed on the Internet included WWW searches, playing on-line games and activities related to school work. Gambling on-line did not appear to be a popular activity among the sample investigated.

Table 19

Percentage of Primary, Secondary, College and University Students Participating in Each Internet Activity

Activity	Primary [a]	Secondary [b]	College [c]	University [d]
Play on-line games	80.9	73.6	56.7	26.2
School work	69.8	82.6	85.1	95.2
WWW searches	66.0	84.6	91.0	91.4
Email	40.4	85.1	92.6	95.5
Other	34.5	50.1	29.4	17.9
Chat rooms	16.4	46.0	48.0	32.1
FTP downloading			38.1	38.2
Newsgroups/forums			25.7	16.1
Cybersex/adult resources			11.8	3.7
Gambling			4.3	1.7

[a]*n* = 371. [b]*n* = 974. [c]*n* = 323. [d]*n* = 694.

In relation to the frequency at which students participated in the Internet, it can be seen in Table 20 that the majority of students used the Internet more than once a week. University students had the highest frequency of engagement, followed by college students, and secondary students. The greatest proportion of university students used the Internet three times or more a week (86.3%) compared to college students (77.7%). Primary students had the lowest frequency of participation across the education samples surveyed. Similarly, inspection of Table 21 shows that the highest percentage of secondary, college and university students spent two to five hours a week using the Internet. College students were found to have the highest level of engagement per week compared to secondary students, and even more so than university students. Approximately 16% of college students use the Internet in excess of 16 hours a week (including 7.1% spending over 30 hours on-line) compared to 12% of secondary and 9% of university students. In contrast, the majority of Primary students (68.7%) spent less than one hour a day on the Internet (see Appendix K, Table K1).

Table 20

Frequency at which Primary, Secondary, College and University Students Use the Internet per Week

Weekly frequency	Primary[a]	Secondary[b]	College[c]	University[d]
< 1	36.4	8.3	2.8	2.2
1 - 2 times	29.1	21.5	19.2	11.2
3 - 4 times	24.0	35.4	26.3	33.3
5 - 6 times	5.7	17.9	22.6	24.2
7 or more	4.9	16.5	28.8	28.8

Note Values present percentage of students.
[a]*n* =371.[b]*n* = 974. [c]*n* = 323. [d]*n* = 694.

Table 21

Number of Hours per Week Students Spend Using the Internet

Hours per week	Secondary[a]	College[b]	University[c]
< 1	18.0	9.0	7.2
2 - 5	41.5	43.3	48.8
6 - 10	18.8	22.0	23.6
11 - 15	8.8	9.3	11.0
16 - 20	4.9	3.1	4.5
21 - 25	2.4	2.8	1.7
26 - 30	2.1	2.8	1.0
> 30	2.6	7.1	1.9

Note. Values present percentage of students (secondary, college and university only).
[a]*n* = 974. [b]*n* = 323. [c]*n* = 694.

A similar percentage of college and secondary students (5.6%) were found to be addicted to the Internet compared to a smaller proportion of university students (3.2%) (see Appendix K, Table K2 for a breakdown by gender). The most highly endorsed consequence of one's engagement was staying online longer than intended for secondary (53.7%), college (55.4%) and university (62%) students. Cognitive salience and anticipating future on-line activities was the second most highly endorsed element of addiction reported across each education group; 21% secondary Internet users, 24.8% college and 12.1% of university students. Across samples surveyed engagement in the Internet to escape problems or unpleasant feelings, tolerance and lack of control over reducing engagement were the most commonly experienced symptoms reported by 10% of secondary and college and 5% of university students (Appendix N, Table N1).

Some key components of problematic Internet use were also assessed among primary school students, with results outlined in Table 22. Given that the majority of primary students spent on average less than one hour a day on-line and only four percent spent over four hours, it was expected that only a small proportion of students would report that their level of engagement was causing them problems. Over 11% of primary students reported that they had made unsuccessful attempts to cut back their on-line behaviour (lack of control).

Table 22

Percentage of Primary Students (n = 371) Endorsing Aspects of Computer Addiction

Symptom of addiction	No	A little bit	Yes
Withdrawal	83.8	10.5	4.9
Tolerance	74.9	16.4	7.8
Strong desire	73.9	21.6	3.8
Lack of control	64.7	22.6	11.9

Continuum of Non-clinical Engagement to Addiction

The secondary, college and university student samples were collapsed to form one large sample ($n = 2156$). Only students who had participated in the Internet at least once in their lifetime ($n = 1991$) were classified according to whether they had a non-clinical (36.5% of sample; $n = 727$) or sub-clinical (58.9%, $n = 1173$) level of addiction or met the full criteria for Internet addiction (4.6%; $n = 91$) (refer to Appendix N, Table N1 for gender breakdown).

Table 23 presents the percentage of students engaging in interactive two-way Internet media (i.e., chat-rooms and on-line games) and for research/communication purposes (i.e., WWW searches and email). As can be seen in Table 23, the majority of all students had used the Internet for research and/or communication purposes, while on-line interactive media were more popular among those who experienced at least a sub-clinical level of addiction (see Appendix N, Table N3 for breakdown of percentage of participation in different types of interactive and research media).

Table 23

Level of participation in Interactive and Research/Communicative Media by Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to the Internet

Media	Non-clinical[a] ($n = 727$)	Sub-clinical[b] ($n = 1173$)	Addicted[c] ($n = 91$)
Research/communication	99.2	99.0	98.9
Interactive	58.9	72.8	94.5

Note. The values represent percentages of students (secondary, college, university only) engaging in each type of media at least once in their lifetime. Interactive two-way media is defined as activities such as chat-rooms and on-line games. Research/communication media is defined as using WWW searchers and communicating via email.

A two-way contingency table analysis was employed to examine the relationship between student participation in interactive Internet media and level of addiction. Analysis revealed that these two variables were significantly related, Pearson

χ^2 (2, N = 1991) = 70.04, p < .001, Cramér's V = .19 (see Appendix N, Table N4). Follow up pairwise comparisons between groups were significant; non-clinical vs. sub-clinical, χ^2 (1, N = 1900) = 30.70, p < .001, Cramér's V = .15; non-clinical vs. addicted, χ^2 (1, N = 818) = 43.98, p < .001, Cramér's V = .23; sub-clinical vs. addicted, χ^2 (1, N = 1264) = 20.86, p < .001, Cramér's V = .13 (see Appendix N, Table N5). Given that Cramér's V values indicate weaker associations between the non-clinical and sub-clinical, and sub-clinical and addicted groups, it can be concluded that addicted individuals are significantly more likely to engage in interactive media as opposed to non-clinical and sub-clinical users.

Table 24 presents the weekly rate of participation in the Internet across each group. Results show that the majority of all students use the Internet more than once a week, regardless of the level of addiction met. Regular participation in the Internet increases parallel with increments on the continuum of addiction, with the majority of non-clinical students going on-line between one and four times a week (63%), sub-clinical users three to four or more times (83.1%), while over 60% of the addicted sample logged on seven or more times a week. A two-way contingency table analysis examined the relationship between regular participation and level of addictive experience. A significant Pearson's chi-square test was found, χ^2 (2, N = 1991) = 22.08, p < .001, Cramér's V = .11 (see Appendix N, Table N6). Given the poor effect size of the association between these variables, follow up pairwise comparisons were non-significant (non-clinical and sub-clinical vs. addicted) or showed insufficient power (Cramér's V <.10 for non-clinical vs. sub-clinical) (see Appendix N, Table N7).

Table 25 shows the number of hours spent on the Internet by students with different levels of problematic engagement. As can be seen in Table 25, the number of hours spent on-line increases with greater addiction symptomatology; the addicted group spends the most amount of time on-line and the non-clinical group the least

(91.7% less than 10 hours per week). Although a greater proportion of the sub-clinical group have a higher level of participation than the non-clinical group, the majority (74.2%) log on for less than 11 hours a week (i.e., 25.7% vs. 8.1% in non-clinical).

Table 24

Frequency at which Students (n = 1836) in a Non-clinical, Sub-clinical or Clinical Level of Internet Addiction used the Internet per Week

Weekly frequency	Non-clinical (n = 727)	Sub-clinical (n = 1173)	Addicted (n = 91)
< 1	8.2	3.8	2.2
1 - 2 times	25.7	13.1	9.9
3 - 4 times	37.3	32.4	12.1
5 - 6 times	16.6	24.0	15.4
7 or more	12.2	26.7	60.4

Table 25

Number of Hours Spent on the Internet by Students (n = 1833) with a Non-clinical, Sub-clinical or Clinical Level of Internet Addiction

Hours per week	Non-clinical (n = 727)	Sub-clinical (n = 1173)	Addicted (n = 91)
Less than 1 hour	21.8	8.0	4.4
2 - 5 hours	55.2	41.1	6.7
6 - 10 hours	14.7	25.1	21.1
		High/medium engagement	
11 - 15 hours	5.0	11.6	22.2
16 - 20 hours	1.7	5.5	14.4
21 - 25 hours	0.6	3.1	4.4
26 - 30 hours	0.7	2.5	2.2
30 hours or more	0.3	3.2	24.4

Note. Values represent percentage of students. High/medium engagement is defined as participation in excess of 11 – 15 hours per week.

Level of engagement was a differentiating factor between sub-clinical and clinical addiction, with over 67% of the addicted group having a higher level of engagement (over 11 hours) including 24.4% who used the Internet in excess of 30 hours per week. This difference was examined further by employing a two-way contingency table analysis, which showed that higher engagement in the Internet was significantly related to addiction, Pearson χ^2 (2, N = 1991) = 203.48, $p < .001$, Cramér's V = .32 (see Appendix N, Table N8). Follow up pairwise comparisons established significant differences in the proportion of high/medium Internet users between the groups (see Appendix N, Table N9). The greatest association was established between the proportions of high/medium users in the non-clinical compared to the addicted group, χ^2 (1, N = 818) = 224.28, $p < .001$, Cramér's V = .52. The strength of the association between high/medium engagement and group was similar for the non-clinical vs. sub-clinical group comparison, χ^2 (1, N = 1900) = 90.65, $p < .001$, Cramér's V = .22, and sub-clinical and addicted comparison, χ^2 (1, N = 1264) = 70.32, $p < .001$, Cramér's V = .24. Inspection of Cramér's V values indicates that, in sequential order, addicted Internet users followed by sub-clinical Internet users are significantly more likely to have a high/medium level of engagement compared to non-clinical users. Results suggest that it is more likely that students who experience some symptoms of addiction, particularly for Internet 'addicts', to have a higher level of engagement in the Internet as opposed to those with no symptoms (non-clinical group).

In relation to the impact that Internet use has on students' study and interpersonal relationships, the study examined whether these aspects differed between groups. Results suggest that a large proportion of users go on-line instead of doing their homework, particularly those who experience at least some symptoms of addiction. In total, 32.8% of non-clinical, 67.8% of sub-clinical and 90.1% of the addicted sample used the Internet during time allocated for study. Preference for using the Internet as opposed to spending time with friends or family was more frequently reported by individuals with Internet addiction (46.2%) than those with a sub-clinical or non-clinical level of addiction (6.5% and 1.9% respectively).

Risk Factors for Internet Addiction

A binary logistic regression analysis was conducted to examine whether using the Internet for interactive two-way purposes (for example chat-rooms), going on-line prior to five years of age, regular participation, high/medium engagement, playing to escape negative emotions, and being male, significantly contribute towards Internet addiction. The full-model including all six predictor variables was found to be significant, with χ^2 (6, N = 1981) = 263.65, $p < .001$, and superior to the constant-only model at successfully differentiating between non-addicted and addicted individuals. The variance accounted for by the full-model was poor (R^2 = .36 and Nagelkerke R = .40). Although the overall model correctly predicted 95.8 percent of the sample, only 28.9 percent of individuals meeting the criteria for Internet addiction were correctly predicted by the model as being addicted.

Backward stepwise models (step 2, 3 and 4) which sequentially excluded variables contributing the least amount of variance were better than the constant-only model and were found to predict Internet addiction significantly. Step 2 excluded frequency of participation, χ^2 (5, N = 1981) = 263.65, $p < .001$; step 3 excluded an additional variable age of onset, χ^2 (4, N = 1981) = 263.36, $p < .001$; step 4 removed sex and the two variables excluded from step 3, χ^2 (3, N = 1981) = 261.72, $p < .001$. The contributions made by step 2, 3 and 4 did not significantly differ from the full-model at accurately predicting addiction. The full-model was therefore viewed as the most reliable from which to examine the contribution of variables at accurately predicting Internet addiction. In order from the most to the least contributor, going on-line to escape negative emotions, χ^2 (1, N = 1981) = 124.0, $p < .001$, high/medium engagement,

χ^2 (1, N = 1981) = 32.11, $p < .001$, and participating in interactive two-way media, χ^2 (1, N = 1981) = 5.80, $p < .05$, significantly contributed to accurately predicting Internet addiction (see Appendix N, Table N10). Consistent with results reported on video-arcade game and computer game addiction, engaging in on-line activity to escape negative emotions accounted for the greatest proportion of variance in Internet addiction (R = .17). These results suggest that secondary, college and university students who engage in on-line interactive media at least 11- 15 hours per week and who log on to escape negative emotions and to obtain a positive change in mood are more likely to become addicted to the Internet.

Summary of the Findings on Internet Behaviour

Over 96% of school students and 98% of university students used the Internet, with the majority going on-line for fun and excitement, entertainment, and to use up spare time. The frequency with which college and secondary students used the Internet was similar to university students, however these younger samples of students had a higher level of engagement (particularly college students). Sixty percent of the sample had at least a sub-clinical level of addiction. A higher proportion of secondary (5.2%) and college students (5.6%) were found to be addicted to the Internet compared to university students (3.2%). Differences in the prevalence of addiction between college and university samples may partly be attributed to the college sample having the highest level of on-line engagement (hours per week), in light of findings that higher engagement is significantly associated with addiction and predicts Internet addiction. Sub-clinical and addicted samples had a higher frequency of regular use compared to the non-clinical group. Logistical regression analysis revealed that a stronger association was established between high/medium engagement and clinical addiction than sub-clinical addiction, which is consistent with the higher proportion of sub-clinical users having a low level of engagement, only slightly higher than students in the non-clinical sample. Further analysis revealed a weak association between regular use and addiction, however regular participation did not contribute to addiction significantly.

Discussion

Consistent with previous research, lifetime engagement, frequency and duration of participation and prevalence of addiction, was greater for computer games and the Internet compared to students' involvement in gambling and video-arcade games (Shaffer, 1996). Results from the present study show that a small percentage of students exhibited a clinical level of addiction to gambling, video-arcade games, computer games, and the Internet (2.3%, 4.2%, 5%, and 4.6%, respectively). Consistent with the prevalence of high engagement in the addicted sample, high/medium engagement was found to predict addiction significantly, and significantly greater proportions of students with a sub-clinical and clinical level of addiction (greatest proportion) had a high/medium level of engagement, compared to students who experienced no symptoms of addiction. The study also established that addiction to video-arcade games, computer games and the Internet was significantly related to, and predicted by (predictor for video-arcade games only), regular weekly participation. Preferring to engage in activities over spending time with friends and family was found to act as a function of addiction only, while participation that impacted on homework time was found to be characteristic of sub-clinical and clinical addiction.

Summary of the prevalence of engagement and addiction to each activity

Gambling

The present study established that over half of the sample of Tasmanian university students surveyed had gambled at least once in their lifetime (54.9%). This is lower than the lifetime prevalence of college and university student gambling reported in previous studies conducted in Australia (Delfabbro & Thrupp, 2003; Moore & Ohtsuka, 1997), the United States (Engwall et al., 2004; Lesieur et al., 1991), Canada (Derevensky & Gupta, 2000) and New Zealand (Clarke & Rossen, 2000). The sample consisted largely of individuals who gambled irregularly (less than once a week), with only a small proportion (10.6%) gambling weekly. This frequency of participation was lower compared to past research citing that between 15% (Delfabbro & Thrupp, 2003; Derevensky & Gupta, 2000) and 23% (Lesieur et al., 1991) of students gamble regularly. Consistent with the frequency of participation, the majority (90%) of university students reported that they gambled for less than one hour a week.

Results show support for the popularity of continuous forms of gambling, as the greatest proportion of gamblers had gambled on slot machines and at a Casino (Gupta & Derevensky, 1998a; Lesieur et al., 1991; Moore & Ohtsuka, 1997). A proportion of gamblers in the present study endorsed items indicative of a cognitive illusion of control; gambling as a means to win money (28.2% of university gamblers) and that one's skill level influences gambling outcomes (10% of university gamblers). Researchers examining this illusion of control and misperception that gambling is not based on chance, suggest that such gamblers are more likely to become addicted or experience gambling-related problems and engage in more continuous forms of gambling, such as slot machines and other Casino activities.

In line with previous research conducted in Australia, the majority (81.7%) of the sample did not experience any gambling-related problems (Delfabbro & Thrupp, 2003; Moore & Ohtsuka, 1997). The prevalence of sub-clinical addiction (16%) and pathological gambling (2.3%) was lower in comparison to previous research (Clarke & Rossen, 2000; Derevensky & Gupta, 2000; Moore & Ohtsuka, 1997). Students who did experience symptoms of addiction were more likely to report chasing past losses, similar to findings by Moore and Ohtsuka. In summary, it appears that despite claims by other researchers in the field (e.g., Shaffer & Hall, 1996), the level of sub-clinical and clinical gambling has not increased with greater gambling accessibility, but rather it may have reduced over time. The lower level of gambling participation and prevalence of sub-clinical and clinical addiction may however be due to methodological factors, as this study separately investigated video-arcade game play and gambling, while previous research tended to group together slot machine gambling and arcade games.

Video-Arcade Games

Approximately 60% of participants had played video-arcade games at least once in their lifetime, with a higher proportion of younger students compared to those in college and university, playing regularly at least once a week and for longer periods of time. Similar to recent studies (e.g., Johansson & Gatestam, 2004; Tejeiro Salguero & Bersabe Moran, 2002) only a small proportion of students played video-arcade games regularly compared to earlier findings (see Fisher, 1994). In line with the prevalence of sub-clinical video-arcade game addiction inferred in Fisher's study, 22.4% of the present sample reported experiencing some symptoms of addiction, and a total of 4.2% met a diagnosis of addiction (greater among secondary students).

These results suggest that frequency and duration (hours per week) exist on a continuum with addiction, with significantly more students from the non-clinical group, followed by the sub-clinical group, having an infrequent and lower level of engagement compared to the addicted sample. This is consistent with regression analysis establishing that both regular participation per week and a high/medium level of engagement, significantly contributed towards addiction (although minimally).

Computer Games

Consistent with previous research on student computer game behaviour (e.g., Johansson & Gatestam, 2004; Tejeiro Salguero & Bersabe Moran, 2002), the majority of primary, secondary, college and university students surveyed had played computer games weekly for over an hour in total (engagement was higher among college students followed by secondary students). The frequency and duration of student computer game play per week was lower than that of adolescents in previous studies (e.g., Griffiths & Hunt, 1998; Phillips et al., 1995). The popularity of on-line games however was greater in this study compared to earlier research (e.g., Tejeiro Salguero & Bersabe Moran, 2002). In accordance with past studies, on-line computer games were found to be significantly related to addiction, although on-line gaming did not predict addiction.

In relation to the continuum of addiction symptomatology, over half the sample of computer game players (55.2%) experienced some symptoms of addiction whilst 5% were clinically addicted (highest among secondary students). The prevalence of sub-clinical and addicted students in this sample was higher than the proportion reported in Johansson and Gatestam's (2004) study of adolescent gamers (9.8%). The addicted sample played more frequently and for more hours per week compared to the sub-clinical group, with the greatest level of disparity compared to the non-clinical sample. However, differences in frequency of participation between groups were not aligned with the continuum of addiction hypothesis, but rather sub-clinical and clinical samples did not differ significantly according to their level of regular participation in computer games.

The Internet

The high lifetime prevalence of Internet use among all students (96% school-aged and 98% of university) was consistent with previous research conducted using pencil-paper questionnaires (Morahan-Martin & Schumacher, 2000; Wang, 2001). The majority of students, particularly college students, used the Internet weekly and for over two to five hours per week. The pattern of popularity of different Internet media is similar to earlier studies (e.g., Scherer, 1997; Wang, 2001), with the highest proportion of students using email followed by WWW searches, playing on-line games, and chat-rooms. A higher proportion of students had a sub-clinical level of Internet addiction (58.9%) compared to earlier studies conducted in Korea (Whang et al., 2003) and Australia (Wang, 2001), however this was lower than the proportion of sub-clinical Internet users identified in a study of college students from the United States (Morahan-Martin & Schumacher, 2000). Despite the higher prevalence of a sub-clinical level of Internet addiction found in the present study, a lower percentage of students met a diagnosis of addiction (4.6%) compared to other studies (6%) (e.g., Chih-Hung et al., 2005; Chou & Hsiao, 2000).

Results pertaining to the level of engagement of sub-clinical and clinical samples are consistent with the continuum of addiction symptomatology, whereby the proportion of high/medium engagers (at least 11 – 15 hours per week) sequentially increased from the non-clinical group, to the sub-clinical group, to the clinical group. A high to medium level of engagement in activities was found to be significantly associated with and predicted Internet addiction, whilst going on-line at least once a week was unrelated to Internet addiction.

Comparison of engagement and addiction to activities investigated

Consistent with past research, the results of Study 1 suggest that the popularity of computer games and use of the Internet was greater than lifetime participation in gambling (assessed among university students only) and video-arcade games. In line with the difference in lifetime participation, the majority of students who gambled or played video-arcade games did so infrequently, and for less than one hour per week, and experienced no symptoms of addiction. Compared with gambling and video-arcade game participation, most students regularly played computer games and used the Internet for a greater number of hours per week, and a higher percentage, over 50%, experienced at least some symptoms of addiction of met the criteria for addiction. This further highlights the importance of separately examining participation in, and addiction to these activities, despite the fact that they are structurally similar and all have the ability to induce changes in physiological arousal and subjective experience.

Across each activity investigated, the majority of students reported that fun and excitement and entertainment were the reasons for their engagement. These findings regarding the motivating factors behind student engagement are consistent with past research conducted on gambling (e.g., Gupta & Derevensky, 1998a), computer games (e.g., Phillips et al., 1995) and the Internet (e.g., Morahan-Martin & Schumacher, 2000). Thrill of winning was endorsed by a higher proportion of gamblers compared to those engaging in other activities, suggesting that this is a predominant motivating factor in gambling. In line with claims that computer games and Internet media, such as interactive on-line games, are designed to encourage continuous play, over 50% of students who played computer games and used the Internet reported that they spent more time than intended engaging in these activities.

The present study supports previous research (e.g., Griffiths & Wood, 2004) reporting that students with problematic involvement in the activities are more likely to engage in them as a means of escaping from negative feelings, and hence reality. It was established in Study 1 that engagement motivated by wanting to escape from unpleasant emotions significantly predicted addiction to video-arcade games, computer games, and the Internet. As escapism is a symptom of addiction it was expected that these variables would be significantly related, yet this item was included in the regression analysis to determine whether escapism differentiated between an addicted and sub-clinical level of addiction (i.e., unique predictor of addiction). Contrary to past research, earlier age of onset, sex (except for computer game addiction), regular participation (except video-arcade game addiction) and engagement in on-line computer games did not significantly predict addiction to the activities investigated.

Differences in engagement and addiction across student samples

It can be suggested from the results obtained in Study 1, that there may be a progression over time in the type of activity students engage in and become addicted to. When examining differences in students' patterns of behaviour and addiction from different education samples, it can be seen that secondary students have a greater level of engagement and addiction to video-arcade games and computer games, both on- and off-line. Engagement in computer and arcade games decreases during later school years, with a subsequent increase in engagement in Internet use during college and university. This increase develops as students have greater access to the Internet and more flexible time schedules (Kandell, 1998; Lin & Tsai, 2002; Morahan-Martin & Schumacher, 2000). The increased prevalence of computer game addiction during secondary school appears to progress into college years as a more Internet based addiction. Higher prevalence of Internet addiction in college students appears to be related to engagement in more interactive media, including chat-rooms as well as on-line gaming. This indicates that college students are more addicted to interactive media than on-line gaming per se, as if the latter were true a greater percentage of students would have met the criteria for computer game addiction rather than Internet addiction. The opposite was found, with 5.6% of college students addicted to the Internet compared to 3.3% to computer games. Although more university students have used the Internet compared to college students, they spend less time on-line per week and their engagement has a more research and education focus. This reduction in engagement from college to university may be indicative of older students having greater control over their behaviour, or that for some students Internet addiction is of a transient nature and something that they 'mature out of'. However, it may also be true that the university sample has a different demographic profile to those school students surveyed, and young adults who do not go on to university may have a different level of engagement and prevalence of addiction compared to the sample of university students surveyed.

Continuum of engagement and addiction

Results from this study generally support the continuum of addiction hypothesis, as clinical groups show greater engagement than sub-clinical, followed by non-clinical samples. The study further highlights the necessity of using a multilevel classification system when investigating behavioural addiction, given that sub-clinical and non-clinical samples vary greatly according to lifetime participation, frequency and duration of engagement, and the impact participation has on their homework and interest in spending time with friends and family. It appears that high/medium engagement is not only a significant predictor of addiction, but it may also exist on a continuum with addiction as it differentiates non-clinical, sub-clinical and clinical addiction sequentially across these groups. Similarly, preference for spending time engaging in activities rather than spending time with friends and family appears to differentiate non-clinical, sub-clinical and addicted samples. Further examination of this continuum hypothesis of addiction and whether high/medium engagement precedes addiction will be the focus of the following empirical chapters.

CHAPTER 8

Continuum of Engagement and Addiction: Configuration of Groups

The majority of past research on addiction has been based on a dichotomous classification system, with participants differentiated according to whether they did or did not meet a diagnosis of addiction. More recent studies have employed a multilevel classification system to examine various levels of engagement-related problems. Multilevel classification systems are based on a continuum hypothesis of addiction, which categorize participants according to the severity of engagement-related problems they experience (e.g. Shaffer & Hall, 1996).

Shaffer and Hall's (1996) comprehensive classification system differentiates five levels of gambling behaviour. It specifically separated those who had never gambled (Level 0), gambled but not experienced any problems or symptoms of pathological gambling (Level 1), gambled and experienced some symptoms of gambling-related problems (Level 2), experienced gambling-related problems which met the DSM-IV criteria for pathological gambling (Level 3), and pathological gamblers willing to receive treatment (Level 4) (Shaffer & Hall, 1996). This five-level classification system enables fluidity between groups, emphasising the need to distinguish gamblers in-transition towards pathological gambling from those at the lower end of the continuum who had either never gambled or did not experience any problems due to their engagement. However, Shaffer and Hall's (1996) model did not distinguish differing levels of engagement in activities, dependent on the amount of time spent gambling.

Charlton (2002) reported that participants with a high level of engagement in activities may experience some of the key features of addiction. In his factor analytical study of computer-related behaviour, Charlton emphasised the need to differentiate high engagement from addiction, as high engagement alone does not constitute addiction. Neuroscientific research has not examined the underlying relationship between high engagement and varying levels of addiction to potentially addictive activities. Personality and psychopathology differences between participants with varying levels of engagement and addiction to gambling, video-arcade games, computer games and the Internet has also not been assessed. These limitations will be addressed in the present series of studies across all four structurally related activities; gambling, video-arcade games, computer games and the Internet.

Configuration of Group Sets

In order to address the limitations of past research and to test these continuum theories of engagement and addiction, participants in Studies 2, 3 and 4 were divided into three group sets, each set corresponding to one of the three continuum hypotheses. Unlike for gambling, no valid criteria are currently available to assess addiction to computer/video-arcade games and the Internet. The configuration of experimental groups is consistent with Jacobs (1986) general theory of addiction and Shaffer et al.'s (2004) hypothesis that different addictions are not independent entities, but rather share the same underlying addiction syndrome. Participants were not separated according to the type of behaviour they were addicted to; gambling, video-arcade games, computer games or the Internet. Rather, participants were merged to construct one collective addicted group based on the premise that all individuals had a behavioural addiction(s) and the activities investigated share similar structural characteristics, and that a similar level of dysfunction would be experienced by those addicted to any one or more of these activities.

The configuration of groups (Group Sets) in Studies 2, 3 and 4 was modelled on past research examining the prevalence of engagement and addiction to computer games and video-arcade games (Brown & Roberston, 1993; Chiu et al., 2004; Fisher, 1994;

Griffiths & Hunt, 1998; Johansson & Gatestam, 2004; Phillips et al., 1995; Tejeiro Salguero & Bersabe Moran, 2002; Wood, Gupta et al., 2004), the Internet (Chih-Hung et al., 2005; Chou & Hsiao, 2000; Niemz et al., 2005; Young, 1998) and gambling (Gupta & Derevensky, 1998a; Moore & Ohtsuka, 1997; Shaffer & Hall, 1996), within youth and university populations.

On the basis of past research and theoretical models, participants in Studies 2, 3 and 4 were divided into groups for each of three Group Sets. Each Group Set tested one of the continuum hypotheses; examination of the proposed continuum of engagement to addiction (Group Set 1) (Charlton, 2002), combined continuum of engagement and addictive symptoms (Group Set 2), continuum of addiction symptomatology from no clinical symptoms to addiction (Group Set 3) (Shaffer & Hall, 1996). It was beyond the scope of this study to examine each progressive stage on the continuum of engagement and/or addiction, indicative, for example, of differences between participants with one through to nine symptoms of addiction.

Group Set 1

All participants had engaged in a minimum of one of the four activities investigated at least once in their lifetime. Participants were firstly categorised based on the presence or absence of addiction, that is, whether or not the participant met the criteria for addiction to any one of the four activities investigated. The level at which participants engaged in at least one of the four activities was used to differentiate the remaining sample who did not meet a diagnosis of addiction. Participants were classified as having either a 'high', 'medium' or 'low' level of engagement in one or more activities.

Group membership in the Addicted group (ADD) required a cut-off score or above on one (or more) of the four addiction checklists included in the University Questionnaire (completed in Empirical Study 1). Cut-off scores for addiction to computer games and the Internet (Young, 1998) were set at a score of five endorsed items (range zero to eight), and cut-off scores of four endorsed items (range zero to nine) were required for a classification of addiction to video-arcade games (Fisher, 1994) and gambling (Lesieur & Rosenthal, 1991). Membership of the ADD group was not dependent on the participant's level of engagement in the given activity, thus the number of hours participants spent engaging in these activities varied.

Engagement was classified in terms of hours spent gaming, rather than frequency of participation, given the marked difference between two potential individuals who, for example, may play seven times a week for either ten minutes or seven hours each session. Participants were required to engage in at least one of the four activities for a minimum of 16 to 20 hours per week to meet the criteria for the High Engagement (HE) group. Within this group, the level of engagement in the remaining three activities could vary between "never participated in their lifetime" to engaging "over 30 hours per week". Participants in the Medium Engagement (ME) group engaged in at least one of the four activities for 11 to 15 hours (maximum) per week, and between "never participated in their lifetime" to engaging for less than 15 hours a week in the remaining three activities. The HE and ME groups were collapsed for analysis (HME). Classification to the Low Engagement (LE) group was based on participants' level of engagement in all four activities ranging between never participated and participating less than five hours per week. All participants in the LE group had participated in at least one of the four activities at least once in their lifetime. Participants in the HME and LE groups may have endorsed some symptoms of addiction but they did not meet the required cut-off score for addiction (see Figure 1).

Group Set 2

Figure 1 illustrates how participants in Group Set 1 were separated into groups in Group Set 2 to test the combined continuum of engagement and addiction hypothesis. In

Group Set 2 the HME and LE groups from Group Set 1 were separated into two separate groups according to whether participants experienced any addictive symptoms due to their engagement in the given activity(ies). Group Set 2 therefore comprised five groups; Addicted (ADD), High/Medium Engagement with some symptoms of addiction (HMAS), High/Medium Engagement with no symptoms of addiction (HMNAS), Low Engagement group with some symptoms of addiction (LAS), and Low Engagement group with no addictive symptoms endorsed (LNAS).

Group Set 3

Groups in Group Set 3 comprised the same participants included in Group Sets 1 and 2. The three groups in Group Set 3 were based on Shaffer and Hall's (1996) classification system of gambling experience, which was expanded by the present study to also include engagement in video-arcade games, computer games and the Internet. In doing so, the groups in Group Set 3 were formed based on the presence or absence of symptoms of addiction, regardless of the participants' level of engagement in the activity(ies). Participants who did not endorse any symptoms of addiction to any of the four activities investigated, were deemed to have a non-clinical level of addiction (NAS group); those with some symptoms of addiction (below the cut-off score for addiction) to one or more activities had a sub-clinical level (AS group); and participants at the clinical level met the criteria for addiction to one or more activities (ADD group). Level 4 of Shaffer and Hall's (1996) classification system was not investigated as it was not pertinent to the present study to examine participants willing to receive treatment for their addiction. Unfortunately, Level 0 of Shaffer and Hall's (1996) model was not examined as it was expected that university students would have participated in at least one of the activities (i.e., gambling, video-arcade games, computer games or the Internet) at least once in their lifetime, especially given that University enrolment requires on-line communication.

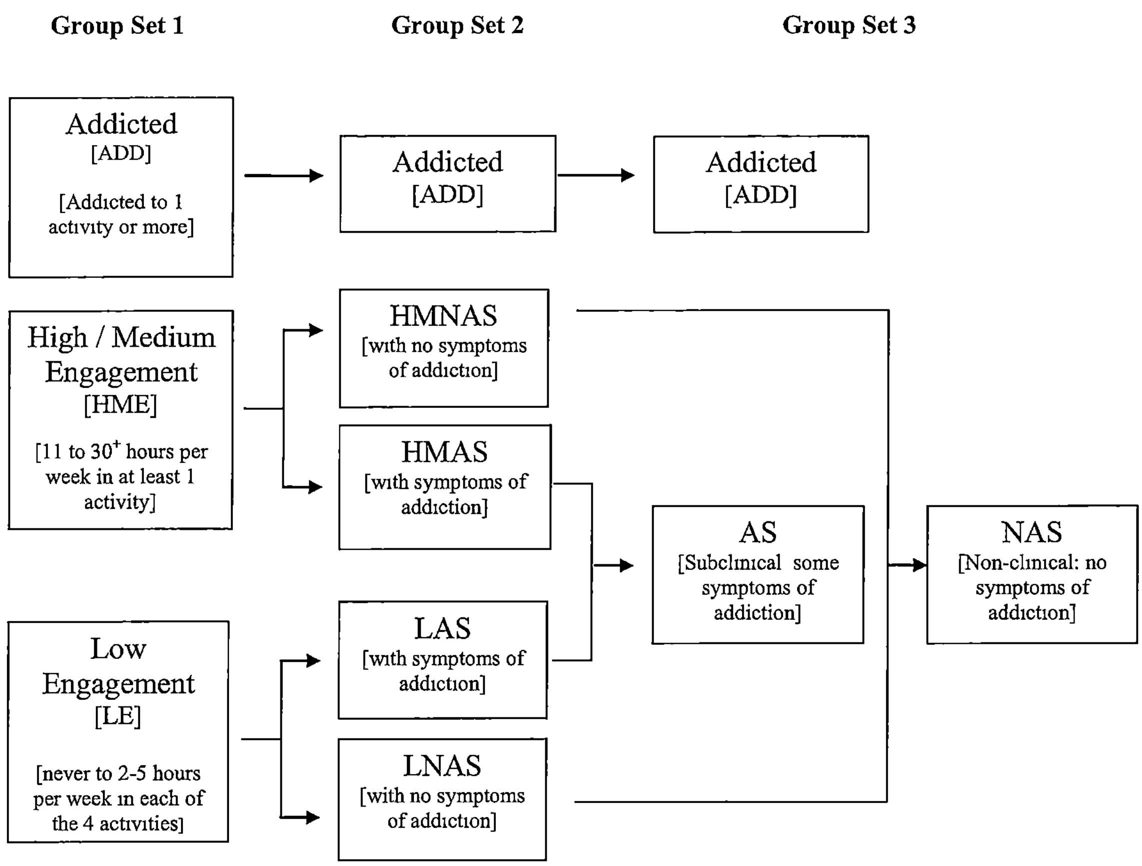

Figure 1. Group Configurations of Group Set 1, Group Set 2, and Group Set 3 used in Studies 2, 3 and 4. Abbreviations of groups in Group Set 1 relate to the Addicted group (ADD), High/Medium Engagement (HME) and Low Engagement (LE) groups; groups in Group Set 2 include the Addicted (ADD), High/Medium Engagement group with no symptoms of addiction (HMNAS), High/Medium Engagement group with symptoms of addiction (HMAS), Low Engagement group with symptoms of addiction (LAS) and Low Engagement group with no symptoms of addiction (LNAS); Group Set 3 includes the Addicted (ADD), Sub-clinical (AS) and Non-clinical (NAS) group.

CHAPTER 9

Study 2

Psychophysiological Examination of Engagement and Addiction to Gambling, Video-arcade games, Computer Games and the Internet among University Students as Indexed by the P300 Component

Controversy surrounds suggestions that similar to the addictive properties of drugs, activities that can induce desired changes in physical arousal and subjective experience also have the propensity to become the object of an addictive pattern of behaviour (Griffiths, 2003; Shaffer, 1996, 1999a; Shaffer & Albanese, 2005). It is unknown whether all substance and behavioural addictions are a manifestation of the same underlying addiction syndrome (Shaffer et al., 2004). There is however mounting evidence that this may be true, given the high prevalence of co-morbid addictions and disinhibition disorders (Krueger et al., 2002), and the common neurobiology and neurophysiology of substance addiction and pathological gambling (Goldstein & Volkow, 2002; Potenza, Leung et al., 2003; Regard et al., 2003; Robinson & Berridge, 2003). Furthermore, researchers have shown that there is a genetic basis for both substance addictions (Begleiter et al., 1995; Bierut et al., 1998; Goodwin, 1986), externalizing disinhibitory behaviours (Krueger et al., 2002) and pathological gambling (Eisen et al., 1998; Ibáñez et al., 2003; Ibáñez et al., 2002; Slutske et al., 2000).

Leaders in behavioural addiction state that supporting scientific evidence is required to substantiate the validity of addiction to activities that have the ability to influence physiological arousal and produce robust changes in subjective experience, such as video-arcade games, computer games and the Internet (e.g., Shaffer et al., 2000). To date, the cognitive neuroscience field has largely failed to investigate whether psychophysiological deficits underlying substance addiction also index behavioural addiction. The lack of neuroscientific research in this area is surprising given that "Ultimately the brain is the final common pathway of subjective experience; the psychosocial features of experiences are painted on the backdrop of neurobiology" (Shaffer & Kidman, 2003, p. 5).

The amplitude of the genetically mediated P300 component of the ERP indexes disinhibition of the CNS (Begleiter & Porjesz, 1999) and has been found to be reduced in participants with substance addictions (e.g., Anokhin et al., 2000; Porjesz & Begleiter, 1995). Likewise, pathological gamblers have been found to have decreased inhibitory regulation of the frontal cortex (Cavedini et al., 2002) and reductions in the activation of the mesolimbic reward pathway (Reuter et al., 2005). Researchers however are yet to fully examine whether P300 deficits also underlie sub-clinical and clinical levels of pathological gambling, despite P300 indexing cognitive functioning generated by the neuronal substrates implicated in this behavioural disorder. Fundamental to future research in behavioural addiction, researchers propose that reduced P3b amplitude acts as a psychophysiological phenotypic marker for one aspect of genetic vulnerability to substance and alcohol dependency, unrelated to personal alcohol use (Begleiter & Porjesz, 1995; Begleiter et al., 1984; Pfefferbaum et al., 1991; Porjesz & Begleiter, 1990; Porjesz et al., 1998). P3b also indexes risk of developing other externalizing behaviours in the disinhibitory spectrum characterised by poor impulse control (Iacono et al., 2003). In addition to P3b amplitude, the fronto-centrally distributed P3a peak has been found to be reduced among older high-risk offspring of alcoholics (see Hada et al., 2001; Holguín et al., 1999).

As indicated in Chapters 7 and 8, the level of one's engagement in activities and engagement-related problems can also be conceptualized as existing on a continuum of non-pathological involvement to addiction. Slutske et al.'s (2000) twin study established supporting evidence for the proposed continuum of gambling-related problems, with sub-clinical gamblers sharing some of the risk factors identified among pathological gamblers. Carlson et al. (1999) were the first to employ P3b amplitude as a psychophysiological index of the continuum of disinhibitory psychopathology in a sample of 93 males aged 16 to18 years. The researchers hypothesised that incremental reductions in P3b (smallest, average, largest P3b amplitude) would be associated with greater externalizing psychopathology. Reductions in P3b elicited in a difficult visual discrimination two-stimulus oddball task supported the proposed continuum of risk. A significantly higher proportion of participants who met a diagnosis for substance disorder, or who experienced some symptoms of substance dependency, were found to have smaller P3b amplitude and average P3b amplitude at Pz. Participants with small and average P3b amplitudes did not significantly differ according to number of substance dependency diagnoses, level of substance-related problems or externalizing psychopathology.

The P3a and P3b components of the ERP will therefore be examined in the present psychophysiological study to determine whether the P3b trait marker for substance addiction and externalizing psychopathology indexes progressive stages on a continuum of engagement, combined continuum of level of engagement and addiction symptomatology, and continuum of engagement-related problems (symptoms of addiction) to potentially addictive activities; gambling, video-arcade games, computer games, and the Internet. Specifically, it is hypothesized that fronto-central P3a and centro-parietal P3b amplitude will be sequentially reduced in participants with progressively greater engagement in these activities and addictive symptoms, compared to participants with low levels of engagement and no symptoms of addiction. It is expected that the Addicted group will elicit the smallest P3a and P3b amplitude. It is also hypothesized that latency and behavioural performance will not significantly differ between experimental groups as past researchers have not implicated P3a and P3b latency, RT or behavioural performance as predisposing markers of alcoholism (Begleiter et al., 1984; Berman et al., 1993; Carlson et al., 1999; Hill & Steinhauer, 1993; O'Connor et al., 1986; Pfefferbaum et al., 1991; Porjesz & Begleiter, 1990; 1995).

Method

Participants

Study 2 was conducted on 80 participants from the University of Tasmania, Hobart campus during 2004 and 2005. The sample consisted of 32 male (*M* = 19.09 years, *SD* = 2.16) and 48 female (*M* = 19.08 years, *SD* = 2.53) students. Participation in the experiment was voluntary. First year psychology students received two hours research course credit for their time and non-psychology students were reimbursed. All students were right-hand dominant, with normal or corrected-to-normal vision, and were non-smokers, not binge drinkers or illicit drug users, and not on prescription medication. No participant had been diagnosed with psychological dysfunction over the past 12 months, nor had any history of neurological illness or severe neurological trauma. In relation to the country of origin of participants, the majority were Australian (87.5%). Of the 71 psychology students, the majority were enrolled in an Arts related degree (63.48%), and 25.33% were enrolled in a Science related degree. Ninety-one percent were completing their first year of university (91.55%).

On the basis of their responses to the questionnaire completed in Study 1 (Chapter 7), participants were divided into groups in each of the three Group Sets according to group criteria outlined in Chapter 8. Group Set 1 comprised three groups: Addicted

(ADD), High/Medium Engagement (HME), Low Engagement (LE); Group Set 2 had five groups: Addicted, High/Medium Engagement with no symptoms of addiction (HMNAS), High/Medium Engagement group with some symptoms of addiction (HMAS), and Low Engagement with no symptoms of addiction (LNAS), and Low Engagement group with some addictive symptoms (LAS); and three groups in Group Set 3: Addicted, non-clinical group with no symptoms of addiction (NAS), and sub-clinical group with some symptoms of addiction (AS).

Group Set 1

The Addicted group consisted of seven male and five female students with a mean age of 19.00 years (*SD* = 2.63). Nine participants were found to be addicted to one activity; two to computer games and seven to the Internet, and three participants (two male, one female) were addicted to two activities; two participants were addicted to both the Internet and computer games and one participant to the Internet and video-arcade games (see Appendix O). Additionally, two participants had a high and two participants a medium level of engagement in activities for which they did not meet the criteria for addiction. Overall the Addicted group consisted mainly of medium engagers.

The HME group consisted of 32 participants (*M* = 19.06 years, *SD* = 2.27); 18 High Engagers (13 male, five female) and 14 Medium Engagers (seven male and seven female). Of the High Engagers, 13 had a high level of engagement in one activity (11 in the Internet and two participants in computer games) and five participants had a high level of engagement in two activities (computer games and the Internet). Five participants with high levels of engagement in an activity were also found to have a medium level of engagement in other activities. Of the 14 participants categorised as Medium Engagers, nine had a medium level of engagement in the Internet and five participants had a medium level of engagement in two activities (computer games and the Internet). The Low Engagement group comprised 36 participants (five male and 31 female) with a mean age of 19.14 years (*SD* = 2.45). Within this group 17 participants had a low level of engagement in one to two activities and 19 participants had a low level of engagement across all four activities.

Group Set 2

All participants in Group Set 1 were included in Group Set 2, with the ADD group (*n* = 12) remaining the same and the HME and LE groups differentiated according to whether participants did or did not endorse any symptoms of addiction due to their engagement in an activity(s). The HMNAS group consisted of five participants (two male, three female) with a mean age of 18.20 years (*SD* = 1.10). Within this group one participant had a high level of engagement in the Internet, three participants had a medium level of engagement in the Internet and one participant had medium engagement in both the Internet and computer games. Twenty seven participants (18 male, nine female) were segregated into the HMAS group (*M* = 19.22 years, *SD* = 2.40). Of these participants, 17 had a high level of engagement (12 participants in one activity and five in two activities) and 10 had a medium level of engagement (six participants in one activity and four in two activities).

The LNAS group consisted of 12 participants (one male, 11 female) with a mean age of 18.25 years (*SD* = .05). Four participants had a low level of engagement in one to two activities and eight participants across all four activities. Four male and 20 female participants (*M* = 19.58 years, *SD* = 2.90) were in the LAS group; 13 had low levels of engagement in one to two activities and 11 across all four activities.

Group Set 3

The ADD group (*n* = 12) remained unchanged. The HMNAS (*n* = 5) and LNAS (*n* = 12) groups from Group Set 2 were collapsed to form the NAS group in Group Set 3 (*M* = 18.24 years, *SD* = .66). The 17 participants (3 males) in the NAS group did not endorse any symptoms of addiction. Participants in the AS group (*n* = 51, 22 males) did experience some symptoms of addiction and comprised participants from the HMAS and LAS group in Group Set 2. The mean age of the AS group was 19.39 years (*SD* = 2.63).

Materials

Medical Questionnaire

Participants were screened for possible factors reported in the literature as influencing P300 (Picton et al., 2000; Polich & Kok, 1995). Exclusion criteria pertained to regular tobacco smoking (over five cigarettes per day), binge drinking for at least one year, illicit drug use, prescription medication (excluding the contraceptive pill and taking preventative asthma medication occasionally), history of head trauma and concussion, neurological and mental illness, and familial substance dependency. Participants aged 35 years and over were excluded to control for age effects, as previous research has found P3b amplitude decreases with increasing age (Friedman, Kazmerski, & Cycowicz, 1998; Friedman & Simpson, 1994). In addition to the medical questionnaire, the Edinburgh handedness questionnaire was given to ensure participants were predominately right handed (see Appendix P).

ERP Recordings

Electroencephalographic (EEG) activity was collected from 16 channels (sites 7, 3, Z, 4, 8 at frontal, central and parietal regions) of the 64 channel Quickcap with in-built Ag/AgCl electrodes, according to the international 10-20 system of electrode placement. EEG activity was recorded using Neuroscan AQUIRE 4.3.1 data sampling software and amplified by Neuroscan SynAmps 1. Neuroscan SynAmps amplified the signal by a factor of 1000 and sampled EEG activity continuously at a frequency of 500Hz within a band of 0.05 to 100Hz. Electrooculographic (EOG) and EEG activity were referenced to linked Ag/AgCl electrodes at each mastoid, and the ground electrode site was AFz.

The three-stimulus oddball task was presented on an IBM compatible 486 computer with a 13-inch monitor using Neuroscan STIM 1 software. Reaction time (RT) and accuracy to each stimulus presentation were recorded using Neuroscan STIM software.

Stimuli

A visual three-stimulus oddball paradigm with difficult target to standard discrimination and highly discrepant distractor non-target stimuli, and low target and non-target stimulus probability was employed as it elicits the greatest fronto-centrally distributed P3a and central-parietal P3b components (Comerchero & Polich, 1999; Goldstein et al., 2002; Halgren et al., 1995; Holguín et al., 1999; Katayama & Polich, 1998; Polich & Comerchero, 2003). As the sample will involve participants with varying exposure to gambling and gaming media, the task did not involve the salient rewards (Zink, Pagnoni, Martin-Skurski, Chappelow, & Berns, 2004) or processing of losses (Gehring & Willoughby, 2002) that past studies on pathological gamblers have employed (for example Potenza et al., 2003a; Reuter et al., 2005) as this may have disproportionately influenced ERP recordings of high engagers and pathological users.

Adapted from Comerchero and Polich's (1999) study, the visual paradigm consisted of three solid blue shapes; a 10.18cm^2 circle (common stimulus), larger 12.57cm^2 circle (target stimulus), and 20cm^2 square (distractor stimulus). The distractor stimulus was a well differentiated (but not "novel") non-target stimulus. The stimulus duration was 75ms and stimuli were presented in random series with an inter-stimulus interval of 2s. A total of 400 trials were given, with the probability of the common stimulus set at 0.8, target at 0.1 and non-target distractor at 0.1.

Procedure

Ethics approval was obtained from the Northern Tasmania Social Sciences Human Research Ethics Committee. Prospective participants were identified from the questionnaires completed in Study 1 and given the medical screening questionnaire (see Appendix P) (and also checked for a history of severe skin sensitivity). Students meeting screening requirements were invited to participate in Study 2 and instructed to abstain from consuming alcohol, drinking caffeinated substances or smoking for four hours prior to the testing session.

Prior to testing, participants were issued an information sheet (see Appendix P) and the researcher gave an explanation of the equipment to be used, preparation procedure and provided an opportunity to answer questions. All participants then completed consent forms (see Appendix P).

Participants were then prepared for EEG recording. The electrode skullcap was sized and positioned on the participant's head. The electrodes at mastoid sites and electrodes positioned at the horizontal EOG sites at the outer canthi of both eyes and at the vertical EOG sites above and below the left eye were filled with electrode gel. The 16 channels (including AFz) were then filled with electrode gel and all sites were checked to ensure that impedance values were 10KΩ or less, where possible.

Testing took place in a sound attenuated room, with participants seated one metre away from the IBM computer. The visual oddball task was displayed in the centre of the 13-inch monitor at a constant medium level of brightness. Participants were instructed to respond as accurately and quickly as possible to the target stimulus by pressing a button on the response pad with their right index finger. Participants were also instructed not to respond to the common or distractor stimuli. A practice period was given before recording commenced. EEG activity, response accuracy, and reaction time to the target stimulus (hits) and common stimulus (false alarms) were continuously recorded for the duration of the task. Reaction time was recorded with a precision of 1ms.

Post ERP Processing

For each participant, continuous EEG data was merged with the corresponding behavioural data, edited for bad channels and corrected for (EOG) activity greater than +/- 70μV. Data was then band pass filtered at 0.15Hz to 30Hz with 48dB/oct cut-off to remove drift and high frequencies, with bidirectional filtering to ensure zero phase-shift from stimulus presentation. Averages were computed for a 1000ms epoch commencing 100ms prior to stimulus onset, and baseline corrected. Epochs with data in excess of +/- 100μV were excluded from the averages. Averages with less than eight EEG samples of the target stimulus were not included in the analyses.

Design and Data Analysis

A three-way mixed design was employed. Independent variables were the between participants factor Group, and the electrode sites (Sagittal and Coronal) were the repeated measures factors. Separate analyses were performed for each Group Set; Group Set 1 [three groups], Group Set 2 [five groups] and Group Set 3 [three groups], and on the dependent variables of the P300 component (peak amplitude and latency) elicited by the non-target distractor stimulus (P3a), target stimulus (P3b), and common stimulus. Behavioural performance dependent variables included reaction time to target stimuli (hits) and common stimuli (false alarms) and percentage of responses to the target (hits) and common stimulus (false alarms).

Behavioural Data

Means and standard deviations were calculated for reaction times to correct responses (hits) and false alarms, and percentage of responses to the target stimulus and false alarms to the common stimulus. Univariate Analyses of Variance (ANOVAs) were conducted on the behavioural performance data, examining group differences in reaction time and percentage of responses for each Group Set analysis.

Electrophysiological Data

Grand means were calculated for non-target distractor stimulus, target and common stimuli. Visual inspection of grand means determined the scalp region and time interval with the most observable ERP components. The non-target distractor stimulus elicited an earlier P3a component which was defined as the maximum peak across frontal and central regions in the time window 250 to 500 ms post stimulus onset (Polich & Comerchero, 2003). The most prominent positive peak elicited by the target stimulus representing the later P3b component was measured as the maximum peak at central and parietal sites in the 300 to 600 ms interval post stimulus onset (Comerchero & Polich, 1999; Goldstein et al., 2002; Katayama & Polich, 1998; Polich & Kok, 1995). Latencies (ms) were calculated as the time between stimulus onset and the peak of the ERP component (P3a peak and P3b peak). The amplitude and latency of the common stimulus was identified within the same intervals for comparison with the P3a and P3b components. Peak latencies and peak amplitudes (μV) were measured with an automatic peak detection program set to detect the maximum positive peak within the predefined time window. The researcher was blind to the group membership of participants to prevent potential bias when adjusting peaks identified at the extremities of the latency range.

To test for significant amplitude and latency differences in fronto-central P3a and centro-parietal P3b, three-way mixed measures ANOVAs were performed for each of the Group Sets, with Group as the between participants factor and Sagittal region and Coronal site as the within participants factors. The significance level was set at $p < .05$, unless otherwise stated. Post-hoc breakdown ANOVAs and pairwise comparisons with a Bonferroni adjusted alpha level were performed following significant interactions and main effects where necessary.

Results

Data Screening and Preliminary Analysis

Analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 14.0 for Windows. Data screening was performed on all raw data, including behavioural data: reaction time and percentage of hits and false alarms; and P3a and P3b amplitude and latency data. Missing values ($n = 16$) were detected within the data to the non-target distractors stimulus and replaced by the mean of the given channel calculated from all participants in the total sample with valid recordings.

Preliminary analyses were conducted to ensure that the three-stimulus oddball task elicited a P3a component in response to the distractor stimulus which was shorter in latency and more anteriorly distributed than the later centro-parietal P3b to the target stimulus. As expected, significantly larger P3a and P3b amplitudes were elicited by the non-target distractor and target stimulus, respectively, in comparison to the common stimulus. The common stimulus was therefore excluded from further analysis.

Exploratory data analysis was performed to identify significant outliers to the non-target and target stimuli that were near or in excess of two standard deviations from the group's mean amplitude. Excluding outliers did not change the significance of target P3b results and therefore these participants were not removed from the final sample (Tabachnick & Fidell, 1996). In relation to the non-target P3a component the data of one participant were in excess of three standard deviations from the group mean amplitude at several electrode sites. As these amplitude recordings influenced the significance of the overall findings they were excluded from analyses of this component.

Sex differences were examined despite the low statistical power of the analyses. Preliminary Group x Sex analyses with repeated measures variables Sagittal region and Coronal site were performed for groups in Group Set 1, Group Set 2 and Group Set 3 for each dependent variable (amplitude and latency of P3a and P3b) to determine whether group findings were significantly mediated by sex differences. For P3a amplitude and latency, no significant interactions were established for Group x Sex repeated measures ANOVAs (see Appendix Q, Table Q1). In relation to the P3b component, for each Group Set analysis, male participants had significantly larger P3b amplitudes. However, no significant Group x Sex interactions were established with repeated measures factors Sagittal region or Coronal site for any of the three Group Set analyses for either P3b amplitude or P3b latency, with the exception a significant Group x Sex x Sagittal region interaction for Group Set 2 P3b latency data, $F(4, 70) = 2.57$, $p < .05$, however subsequent breakdown ANOVAs did not reach significance(see Appendix Q, Table Q1). Thus, Sex was not a considered to be a significant between-participants factor for either the P3a or P3b component.

Behavioural Data

The means and standard deviations of reaction time to hits and to false alarms, and percentage of responses to targets and common stimuli were calculated. As shown in Table 26, the HME group in Group Set 1 had more hits than the ADD and LE groups. This finding was similar for Group Set 2 data for both High/Medium Engagement groups (HMNAS and HMAS). Little difference existed between the percent of hits made by participants in the NAS and AS groups who responded more to targets than the ADD group. Participants in Group Set 2 who experienced no symptoms of addiction (HMNAS and LNAS groups) and the non-clinical group in Group Set 3 (NAS) appear to have made more false alarm responses.

Table 26

Reaction Time (ms) to Hits and False Alarms (standard deviations in parentheses) and Percentage (%) of Hits and False Alarms made by participants in each Group Set

	Hits		False Alarms	
Group Set	Reaction Time	%	Reaction Time	%
Set 1[a]				
ADD[b]	0.53 (0.064)	81.50	0.47 (0.14)	2.98
HME[c]	0.52 (0.064)	86.51	0.51 (0.12)	6.13
LE[d]	0.52 (0.075)	82.32	0.51 (0.14)	6.0
Set 2[a]				
ADD[b]	0.53 (0.064)	81.50	0.47 (0.14)	2.98
HMNAS[e]	0.48 (0.040)	87.32	0.47 (0.11)	7.71
HMAS[f]	0.53 (0.065)	86.36	0.52 (0.13)	5.84
LNAS[g]	0.49 (0.092)	81.30	0.46 (0.14)	12.25
LAS[h]	0.53 (0.065)	82.83	0.56 (0.13)	2.87
Set 3[a]				
ADD[b]	0.53 (0.064)	81.50	0.47 (0.14)	2.98
NAS[i]	0.49 (0.079)	83.07	0.46 (0.13)	10.92
AS[j]	0.53 (0.064)	84.70	0.53 (0.13)	4.44

Note. 'Hits' refers to responses to the target stimulus. Group Set 1: Addicted (ADD); High/Medium Engagement (HME); Low Engagement (LE). Group Set 2: Addicted (ADD); High/Medium Engagement with no symptoms of addiction (HMNAS); High/Medium Engagement with symptoms (HMAS); Low Engagement with no symptoms of addiction (LNAS), Low Engagement with symptoms (LAS). Group Set 3: Addicted (ADD); non-clinical group with no symptoms of addictive (NAS); sub-clinical group with some symptoms (AS).
[a]n = 80. [b]n = 12. [c]n = 32. [d]n = 36. [e]n = 5. [f]n = 27. [g]n = 12. [h]n = 24. [i]n = 17. [j]n = 51.

ANOVAs conducted on the reaction time to hits found no significant main effects for Group in the analyses conducted on the Group Set 1, Group Set 2 or Group Set 3 data, $F(2, 77) = .12$, *ns*, $F(4, 75) = 1.09$, *ns*, and $F(2, 77) = 2.16$, *ns* respectively, or for reaction time data to false alarms $F(4, 75) = 0.57$, *ns*, $F(4, 73) = 1.14$, *ns*, and $F(2, 77) = 2.28$, *ns*, respectively (see Appendix Q, Table Q2). Despite differences observed in Table 26 between the percentage of hits made by each group, no significant main effects were found for the analyses conducted on Group Set 1, $F(2, 77) = 1.06$, *ns*, Group Set 2, $F(4, 75) = 0.55$, *ns*, or Group Set 3 $F(2, 77) = 0.31$, *ns*. For the percentage of false alarms, no significant main effect was established for Group for Group Set 1, $F(2, 77) = 0.38$, *ns*, or Group Set 2, $F(4, 75) = 1.67$, *ns*, however a trend approaching significance was established in the Group Set 3 analysis, $F(2, 77) = 2.61$, $p = .080$ (see Appendix Q, Table Q2).

Overall, groups within each of the three Group Sets were found to be behaviourally equivalent, regardless of level of engagement or level of addiction symptomatology experienced. Therefore, differences observed between group ERP responses are salient to differences in the level of attentional resources redirected (and time taken) to process non-target distractor stimuli (P3a component), and cognitive resources employed (and time taken) to discriminate the target from the non-target common stimulus (P3b component).

P3a Component: Grand Means Waveforms, Amplitude and Latency

Grand Mean Waveforms to the Non-target Stimulus

Figure 2, 3 and 4 show the grand mean waveforms elicited by the infrequent distractor stimulus for Group Set 1, Group Set 2 and Group Set 3 respectively. The P3a component has a sharp positive peak at all sites and is largest at frontal and central midline sites for each group within all of the three Group Sets. Accordingly only frontal and central sites will be discussed in relation to this earlier P3a component.

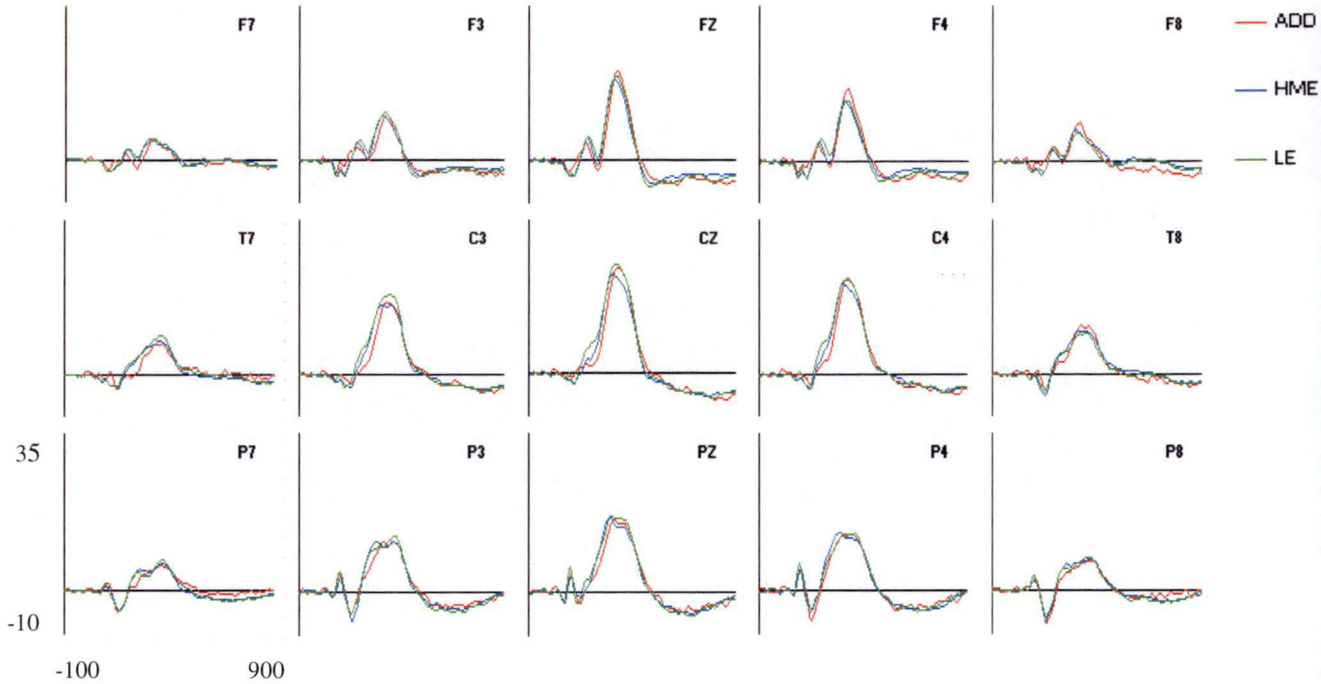

Figure 2. Grand mean averages of responses to the non-target distractor stimulus for the Addicted (ADD), High/Medium Engagement (HME), and Low Engagement (LE) groups in Group Set 1.

As can be seen in Figure 2, little difference exists between the frontal P3a across groups in Group Set 1. At central sites, the ADD and LE groups appear to be of similar amplitude and larger than the P3a peak amplitude of the HME group. As can be seen in Figure 3 the HMNAS and LNAS groups have the largest P3a amplitude at central sites. It appears from inspection of Figure 3 that two predominate clusters exist between groups in Group Set 2, particularly at frontal and central midline sites. Each cluster equates to the presence or absence of addictive symptoms, with larger P3a amplitude observed in both LNAS and HMNAS groups, than in the LAS and HMAS groups and ADD group. These differences are also observable at central left (C3) and right (C4) hemispheric sites.

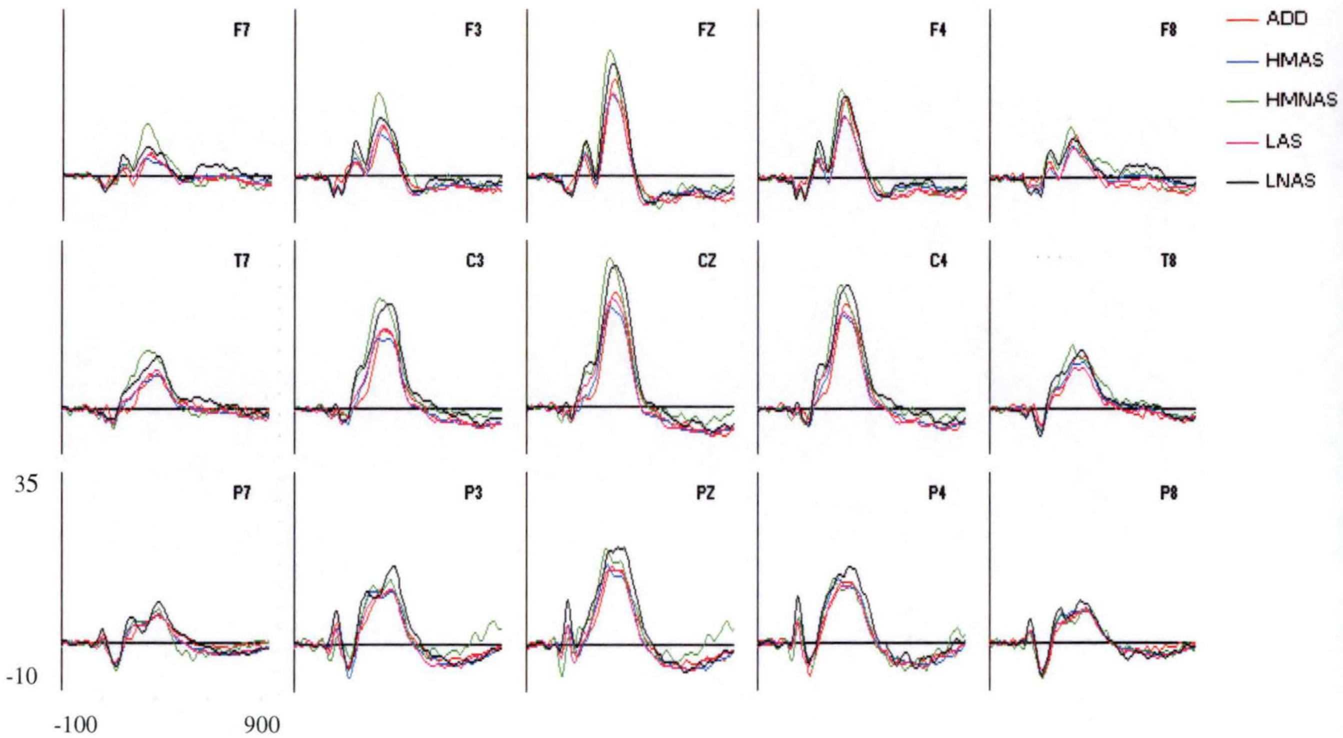

Figure 3. Grand mean averages of responses to the non-target distractor stimulus for groups in Group Set 2: Addicted (ADD), High/Medium Engagement who did not endorse any addictive symptoms (HMNAS), High/Medium Engagement who did endorse addictive symptoms (HMAS), Low Engagement who did not endorse any addictive symptoms (LNAS), and Low Engagement who did endorse addictive symptoms (LAS).

Consistent with Group Set 2, the grand mean waveforms presented in Figure 4 show that P3a amplitude is larger in the NAS group than in the AS and ADD groups in Group Set 3, particularly at frontal midline sites and central midline and left and right hemispheric sites. Examination of the grand mean waveforms of the three Group Sets suggests that presence of addictive symptoms, regardless of whether a sub-clinical or clinical number of symptoms are endorsed, influences P3a amplitude while level of engagement has little effect on earlier involuntary processing.

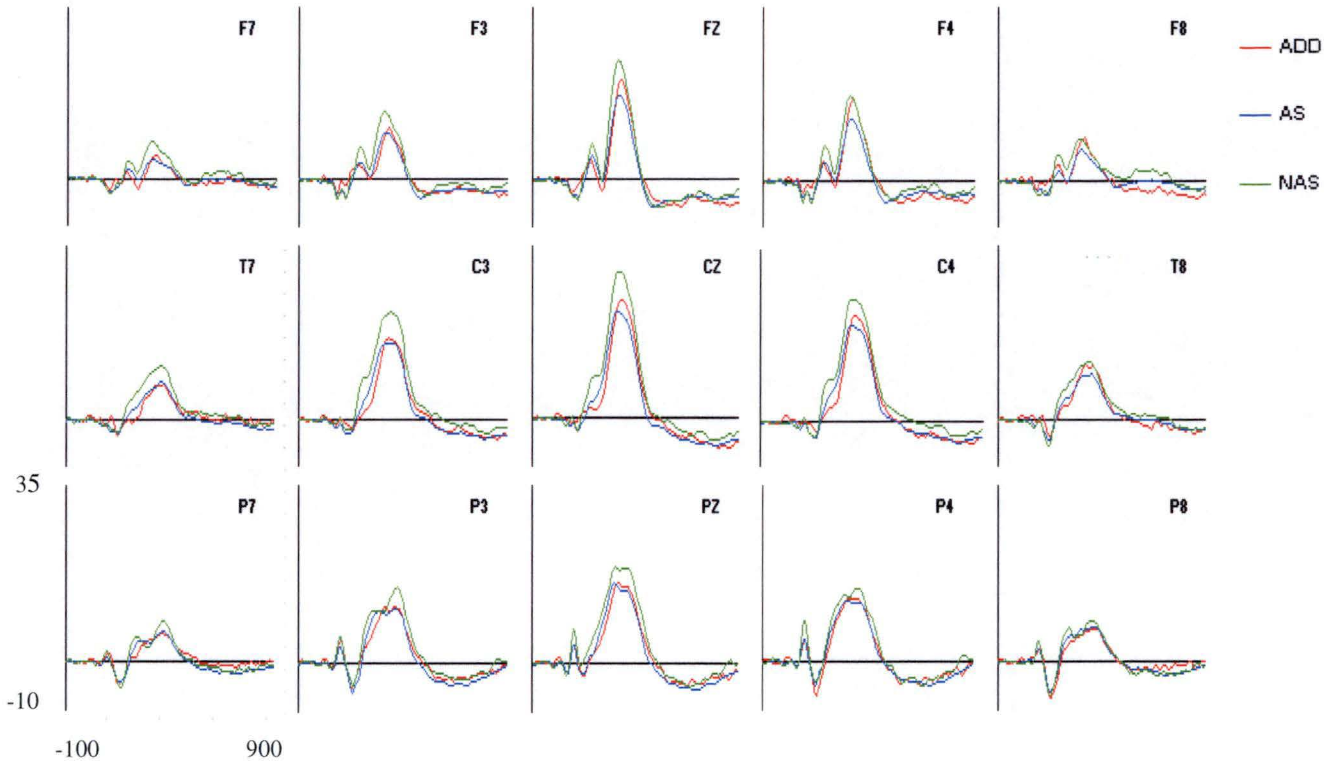

Figure 4. Grand mean averages of responses to the non-target distractor stimuli for groups in Group Set 3; Addicted (ADD), Sub-clinical group with some symptoms of addiction (AS) and Non-clinical group with no symptoms of addiction (NAS).

P3a Amplitude

Group Set 1 analyses. A 3 [Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA was performed on P3a amplitude data elicited by the non-target distractor stimulus (see Appendix Q, Table Q3). The main effect for Group did not reach significance, $F(2, 76) = 0.002$, *ns.* Similarly, interactions involving Group and Sagittal region, Coronal site, and the higher three-way interaction did not reach significance, suggesting that engaging in one or more activities at a higher level does not significantly influence fronto-central activation.

Group Set 2 analyses. Analysis of P3a data for Group Set 2 employed a 5[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q3).

Despite differences observed in the grand mean waveforms, the main effect of Group was not significant $F(4, 74) = 2.00$, *ns* and also no interactions were significant. Although not significantly different, the HMNAS ($M = 19.88$ μV) and LNAS ($M = 18.38$ μV) groups with no symptoms of addiction had more positive P3a peak amplitude than the groups with symptoms of addiction; ADD ($M = 15.95$ μV), HMAS ($M = 15.12$ μV) and LAS ($M = 14.70$ μV).

Group Set 3 analyses. The P3a component elicited by the non-target distractor stimulus was analysed using a 3[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q3). The main effect of Group was significant, $F(2, 76) = 3.86, p <.05$, with Bonferroni adjusted pairwise comparisons indicating that the mean P3a amplitude of the AS group ($M = 14.96$ μV) was significantly lower than the NAS group who did not experience any symptoms of addiction ($M = 18.95$ μV).

Neither the two-way interaction between Group and Sagittal region, nor three-way interaction was significant. However, the significant main effect for Group was qualified by a significant Group by Coronal site interaction, $F(3.53, 133.93) = 2.53$, $p < .05$. Further analysis of this interaction using breakdown ANOVAs with Bonferroni adjusted corrections revealed a significant difference in P3a amplitude in the far left hemisphere, $F(2, 76) = 5.87, p < .01$, left hemisphere, $F(2, 76) = 3.83, p < .05$ and midline sites $F(2, 76) = 4.24, p < .05$ (see Appendix Q, Table Q3). As can be seen across these respective coronal sites presented in Figure 5, little difference exists between groups with symptoms of addiction (ADD and AS), particularly at left hemispheric sites, comparative to the more positive peak amplitudes recorded for the NAS group.

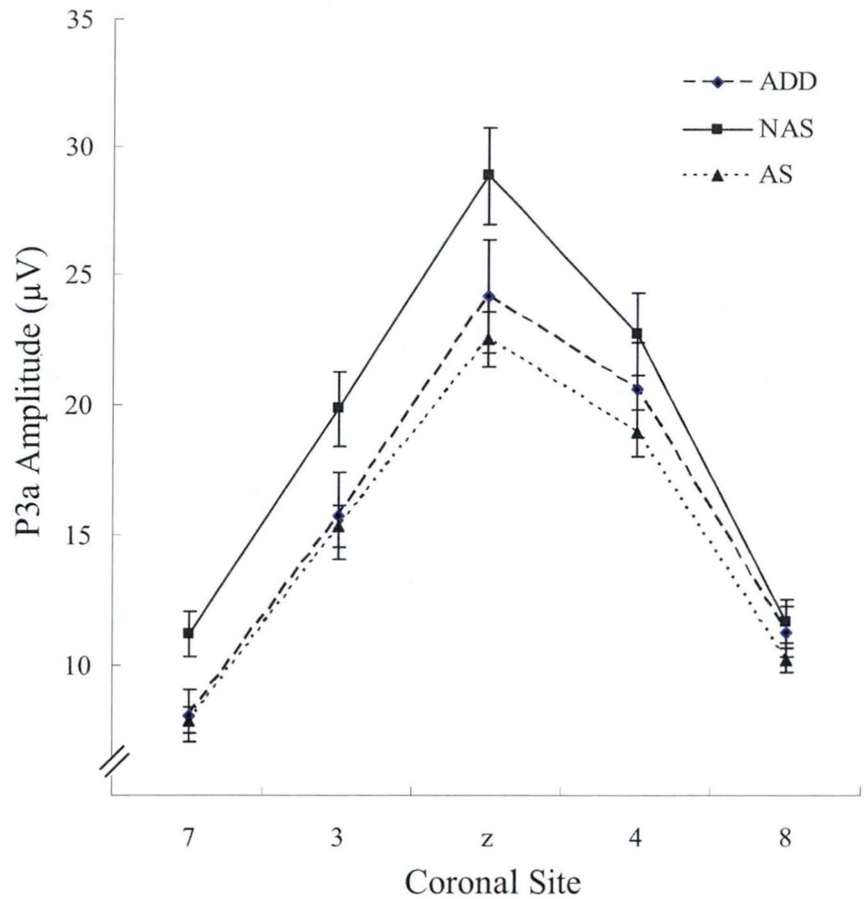

Figure 5. Mean P300 amplitude (P3a) elicited by the non-target distractor stimulus across far left (7), left (3), midline (Z), right (4) and far right (8) coronal sites of groups in Group Set 3; Addicted (ADD), Non-clinical group with no symptoms of addiction (NAS), and Sub-clinical group who experience some symptoms of addiction (AS). Points represent the mean P3a amplitude (μV); vertical lines depict standard errors of the means.

As shown in Figure 5, the effect of experiencing symptoms of addiction was highlighted by pairwise comparisons indicating a trend for larger P3a amplitude to be elicited in the NAS group than in the ADD group at far left hemispheric sites ($p = .058$). Figure 5 illustrates that the ADD group also showed widespread reduction in P3a amplitude particularly at left and midline sites, which did not reach significance possibly due to this group's small sample size. Significantly larger peaks were recorded for the NAS group compared to reduced P3a voltage of the AS group at midline sites ($p < .05$), and across the far left ($p < .001$) and left hemisphere ($p < .05$) (see Appendix Q, Table Q4). These results substantiate non significant differences observed between groups in Group Set 2.

P3a Latency

Group Set 1, Group Set 2 and Group Set 3 analyses. The latency of the P3a component elicited by the non-target distractor stimulus was analyses for Group Set 1 using a 3[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA; Group Set 2 P3a data was analysed by a 5[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA; and Group Set 3 was investigated using a 3[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q3). These analyses revealed no significant main effect for Group for any of the Group Sets: Group Set 1, $F(2, 76) = 1.11$, *ns*; Group Set 2, $F(4, 74) = 1.14$, *ns*; or Group Set 3, $F(2, 76) = 0.52$, *ns*: nor interactions.

Summary of P3a Amplitude and Latency Results

Results suggest that varying levels of engagement do not significantly influence the amount of resources employed in the automatic processing of irrelevant distractor stimuli. Similarly, the combined continuum of engagement and addiction symptomatology was not significantly indexed by P3a amplitude although the influence of addictive symptoms, as opposed to engagement, did separate groups into two clusters although these differences were not significant. The most profound finding related to differences in the level of addiction symptomatology experienced, whereby significantly greater processing of the non-target distractor stimulus occurred in participants who had no symptoms of addiction (NAS) in comparison to those with symptoms of addiction (AS) and those who met a diagnosis of addiction (ADD). The results suggest that participants who experience either a sub-clinical or clinical level of behavioural addiction manifest a widespread reduction in P3a amplitude, especially in the left hemisphere, and at midline sites (AS only). The data shows that neither higher engagement nor experiencing symptoms of addiction due to one's engagement contribute to delayed processing of non-target distractor stimuli (P3a latency).

P3b Component: Grand Mean Waveforms, Amplitude and Latency Results

Grand Mean Waveforms to the Target Stimulus

The grand mean waveforms of responses elicited by the target stimulus are illustrated in Figure 6 (Group Set 1), Figure 7 (Group Set 2) and Figure 8 (Group Set 3).

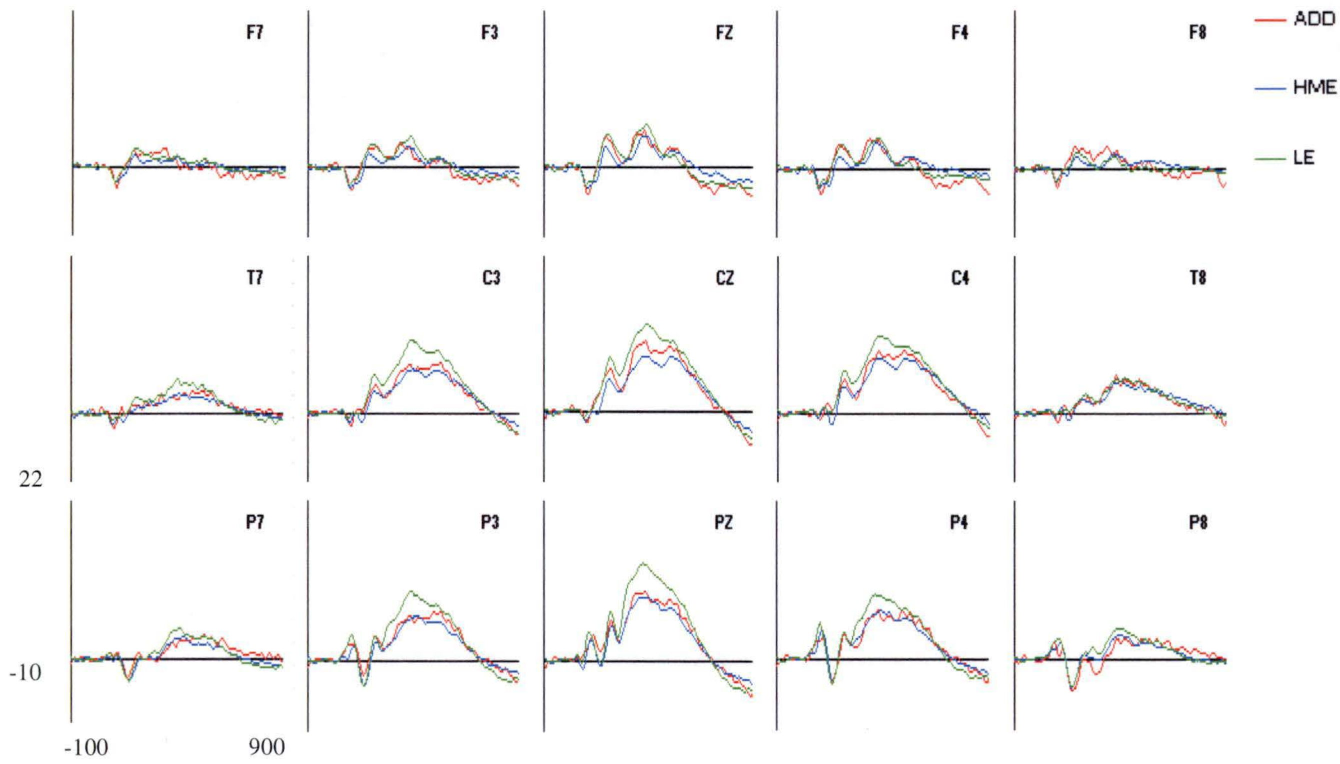

Figure 6. Grand mean averages of target stimuli for the Addicted (ADD), High/Medium Engagement (HME) and Low Engagement (LE) groups in Group Set 1.

As shown in Figure 6, P3b amplitude is similar in the ADD and HME groups, and comparatively larger in the LE group. At central midline sites, reduced P3b amplitude is observed in the HME group compared to the ADD group.

As Figure 7 illustrates, P3b amplitude is smaller for the HMAS and ADD groups than for the HMNAS group for Group Set 2, suggesting that experiencing some symptoms of addiction or meeting a diagnosis of addiction influences P3b amplitude.

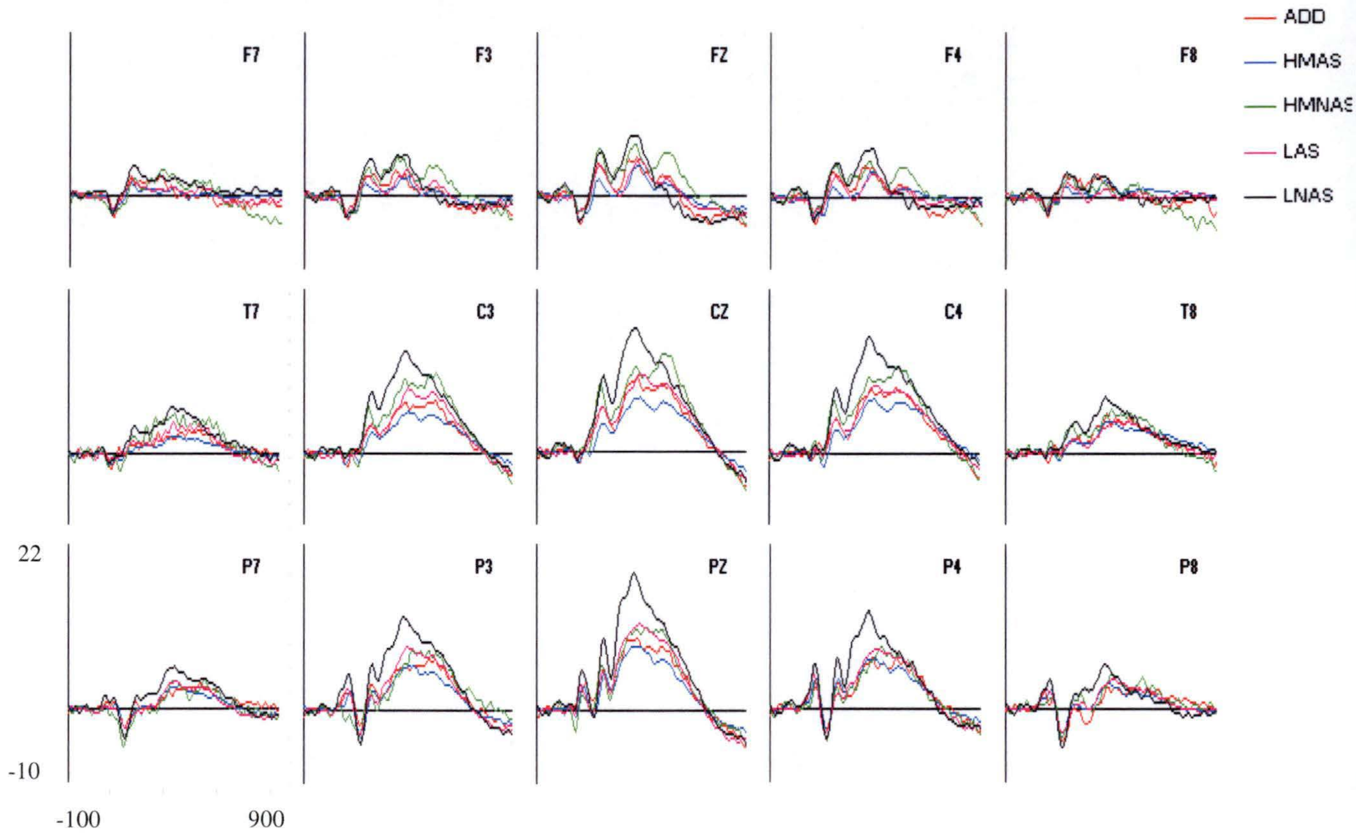

Figure 7. Grand mean averages of target stimuli for groups in Group Set 2; Addicted (ADD), High/Medium Engagement who did not endorse any addictive symptoms (HMNAS), High/Medium Engagement who did endorse addictive symptoms (HMAS), Low Engagement who did not endorse any addictive symptoms (LNAS), and Low Engagement who did endorse addictive symptoms (LAS).

The role of increased engagement on P3b can be seen by comparing the higher peak amplitude of the LNAS group to the smaller P3b amplitude recorded for the HMNAS group, and also by comparing the larger amplitude of the LAS to that of the HMAS group. Overall, P3b amplitude is observably earlier and larger in the LNAS group than, from least to greatest voltage difference, in the HMNAS, LAS, ADD, and HMNAS groups. Therefore, inspection of the grand means of Group Set 2 suggests that participants with lower levels of engagement and no symptoms of addiction have larger P3b amplitude at central and parietal locations in the midline, left (3) and right (4) hemispheric sites.

The continuum of addictive symptoms as indexed by P3b amplitude is also observable in Group Set 3 grand mean waveforms presented in Figure 8.

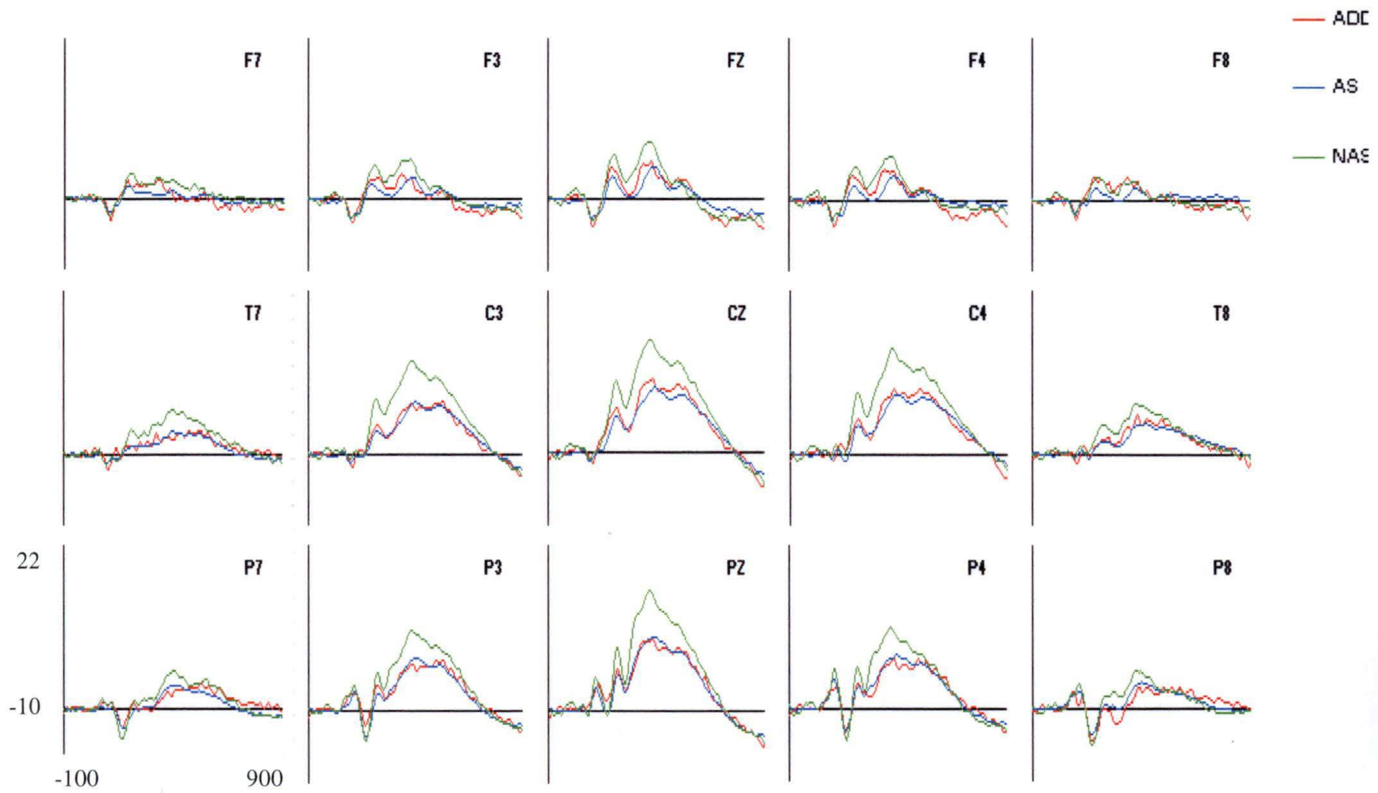

Figure 8. Grand mean averages of response to the target stimuli for groups in Group Set 3; Addicted (ADD), Sub-clinical group with some symptoms of addiction (AS) and Non-clinical group with no symptoms of addiction (NAS).

P3b Amplitude

Group Set 1 analyses. A 3[Group] x 2(Sagittal) x 3(Coronal) mixed three-way ANOVA was performed on P3b amplitude data, elicited by the target stimulus (see Appendix Q, Table Q5). A significant main effect was found for Group, $F(2, 77) = 6.07$, $p < .01$. Follow-up pairwise comparisons revealed that the target stimulus elicited significantly smaller P3b amplitude in the HME than in the LE group ($p < .01$) (see Appendix Q, Table Q6)

Although the grand means indicate that greater positive peak amplitudes were recorded for the LE group than the HME and ADD groups across parietal compared to central locations, no significant higher order interaction involving Group and Sagittal site or three-way interaction was established. However, a trend towards significance was established for the Group x Coronal site interaction, $F(3.83, 147.57) = 2.09$, $p = .088$, with breakdown ANOVAs revealing that this interaction was significant across midline sites $F(2, 77) = 6.24, p < .01$, and left $F(2, 77) = 6.96, p < .01$, and right hemispheric sites $F(2, 77) = 4.01, p < .05$ (see Appendix Q, Table Q5)

As illustrated in Figure 9, pairwise comparisons established that the significant Group by Coronal site interaction was indicative of the LE group having significantly larger P3b amplitudes across midline sites ($p < .01$) and the left ($p < .01$) and right hemisphere ($p < .05$) in comparison to the HME group. The P3b amplitude of the ADD group was also reduced across sites compared to the LE group, with a trend established between these groups in the left hemisphere ($p = .078$). Such differences may not have reached significance due to the ADD group's small sample size ($n = 12$) and high within participants variability (see Appendix Q, Table Q6)

As shown in Figure 9 similar widespread P3b amplitude reductions, extending across hemispheric regions, were found for both the HME and ADD groups with pairwise comparisons revealing that the small amplitude differences between these respective groups were not significant.

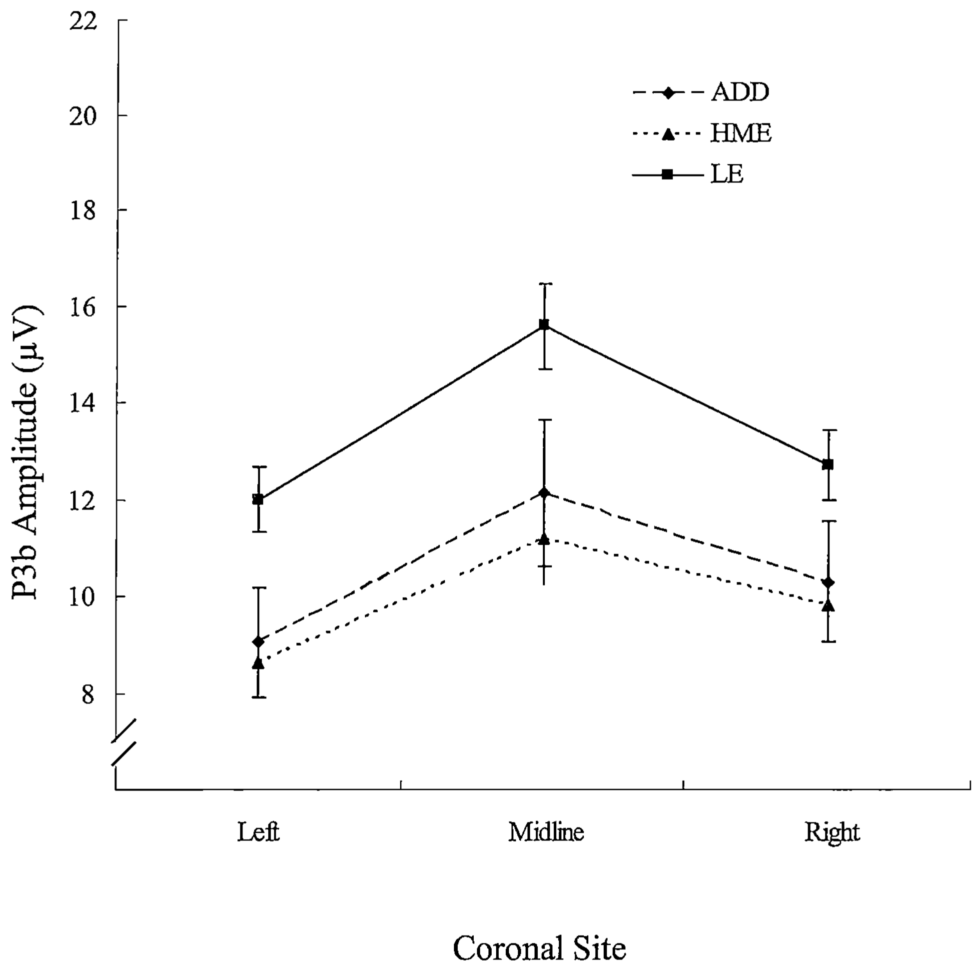

Figure 9. Mean P300 amplitude (P3b) elicited by the target stimulus across left (3), midline (Z) and right coronal sites of groups in Group Set 1; Addicted (ADD), High/Medium Engagement (HME) and Low Engagement (LE) groups. Points represent the mean P3b amplitude (μV); vertical lines depict standard errors of the means.

Group Set 2 analyses. A 5[Group] x 2(Sagittal) x 3(Coronal) mixed three-way ANOVA was performed on the P3b amplitude data for Group Set 2 (see Appendix Q, Table Q5). A significant main effect for Group was established, $F(4, 75) = 6.36$, $p < .001$. Pairwise comparisons indicated that P3b amplitude in the LNAS group ($M = 16.43$ μV) was significantly higher than in the ADD group ($M = 10.49$ μV) at

$p < .01$, HMAS group ($M = 9.45$ μV) at $p < .001$, and LAS group ($M = 11.92$ μV) at $p < .05$ (see Appendix Q, Table Q7). This significant main effect was qualified by a significant higher- order interaction with Coronal site, $F(4, 75) = 2.54, p < .01$.

Breakdown ANOVAs showed that the significant interaction between group and Coronal site was present across left hemispheric sites, $F(4, 75) = 6.58$, $p < .001$, midline sites, $F(4, 75) = 6.66, p < .001$, and right hemispheric sites, $F(4, 75) = 4.66$, $p < .01$ (see Appendix Q, Table Q5). Differences across coronal sites are shown in Figure 10, with similar patterns in P3b amplitude found between groups at each site. The interaction with Sagittal site and the three-way interaction did not reach statistical significance for groups in Group Set 2, with little difference observed between the pattern of groups' grand means between central and parietal sites (see grand means waveforms Figure 7).

Figure 10 illustrates the interactive effect of addiction and increased engagement on cognitive resource allocation employed to process the target stimulus. Pairwise comparisons revealed that significantly larger P3b amplitude was elicited by the target stimulus in the left hemisphere, midline and right hemisphere of the LNAS compared to the ADD ($p < .01, p < .01, p < .05$, respectively), and HMAS (ps $< .001$) groups. No significant differences were found between the HMAS and ADD groups.

The effect of experiencing symptoms of addiction, regardless of engagement, on P3b amplitude was isolated by comparing the two low engagement groups, with pairwise comparisons indicating significantly higher P3b amplitude elicited both centrally and in the right hemisphere (ps $< .05$) in those with no symptoms of addiction (LNAS) in comparison to those with such an experience (LAS). Furthermore, as can be seen in Figure 10 greater P3b amplitude was found in the HMAS group than the HMNAS group across sites, however this difference did not reach significance (see Appendix Q, Table Q7). Additionally, little difference was observed between the

HMNAS group and LAS group's P3b amplitudes at right and midline sites, despite the former group having a higher level of engagement in activity(s).

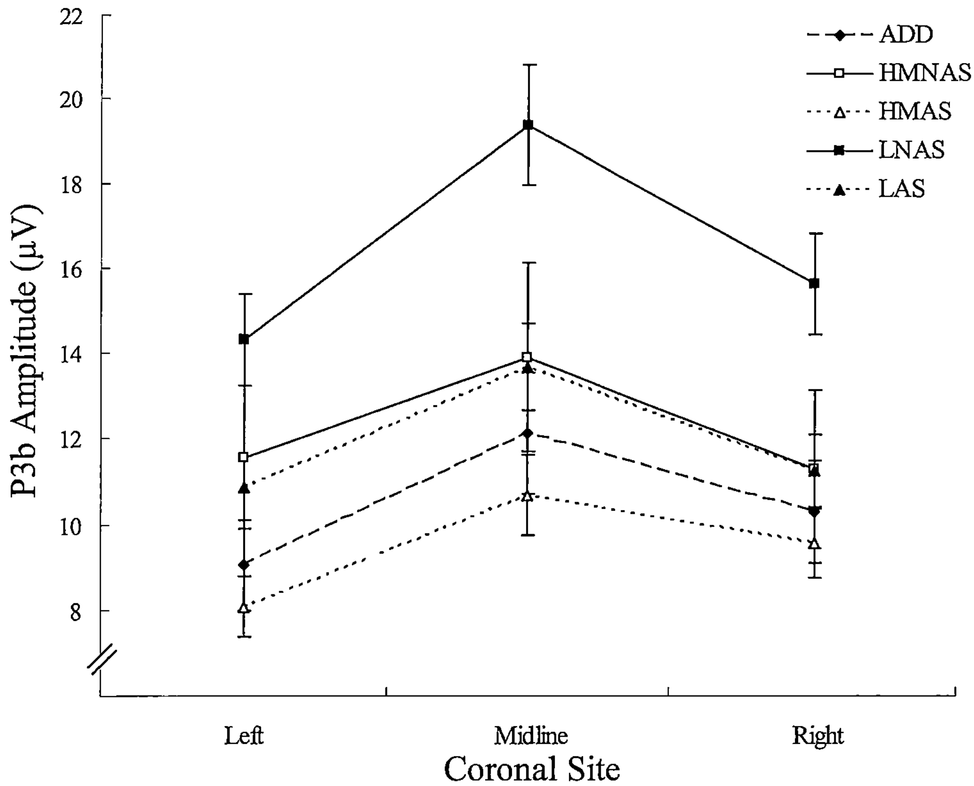

Figure 10. Mean P3b amplitude (μV) elicited by the target stimulus across left (3), midline (Z) and right (4) coronal sites of groups in Group Set 2; Addicted (ADD), High/Medium Engagement with no addictive symptoms (HMNAS), High/Medium Engagement with addictive symptoms (HMAS), Low Engagement with no addictive symptoms (LNAS), and Low Engagement with addictive symptoms (LAS). Points represent the mean P3b amplitude (μV); vertical lines depict standard errors of the means.

Group Set 3 analyses. The peak amplitude of the P3b component elicited by the target stimulus was analysed for Group Set 3 using a 3[Group] x 2(Sagittal) x 3(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q5). The main effect of Group was significant, $F(2, 77) = 7.89, p < .01$, with pairwise comparisons revealing the

P3b amplitude of the NAS group was significantly more positive ($M = 15.20$ μV) than both groups with symptoms of addiction; ADD ($M = 10.49$ μV) at $p < .05$, and AS ($M = 10.69$ μV) at $p < .01$ (see Appendix Q, Table Q8).

No significant interaction was established for Group x Sagittal site or for the three-way interaction. However, the significant main effect of Group was qualified by a trend towards significance for the Group x Coronal interaction, $F(3.87, 148.81) = 2.28$, $p = .066$. Follow-up breakdown ANOVAs revealed that this interaction was significant across the left hemisphere, $F(2, 77) = 7.91$, $p < .01$, midline sites, $F(2, 77) = 8.08$, $p < .01$, and right hemisphere, $F(2, 77) = 6.01$, $p < .01$ (see Appendix Q, Table Q5). As can be seen in Figure 11, Bonferroni adjusted pairwise comparisons established significantly larger P3b amplitude of the NAS group compared to the ADD and AS groups across left (*p*s < .01), midline ($p < .05$ and $p < .01$, respectively) and right ($p < .05$ and $p < .01$, respectively) hemispheric sites (see Appendix Q, Table Q8).

Figure 11 shows a reduction in cognitive resources employed by participants in the AS and ADD groups extending across each coronal area, consistent with results reported for the combined continuum of engagement and addiction examined by Group Set 2. Results for Group Set 3 support a more dichotomous distinction as opposed to continuum of addiction symptomatology, whereby participants with no symptoms of addiction (non-clinical level) are able to use more cognitive resources when performing a perceptually difficult discrimination task than participants who experience some level of addictive experience, regardless of whether the number of symptoms endorsed meets a diagnosis of behavioural addiction (i.e., sub-clinical or clinical level of addiction).

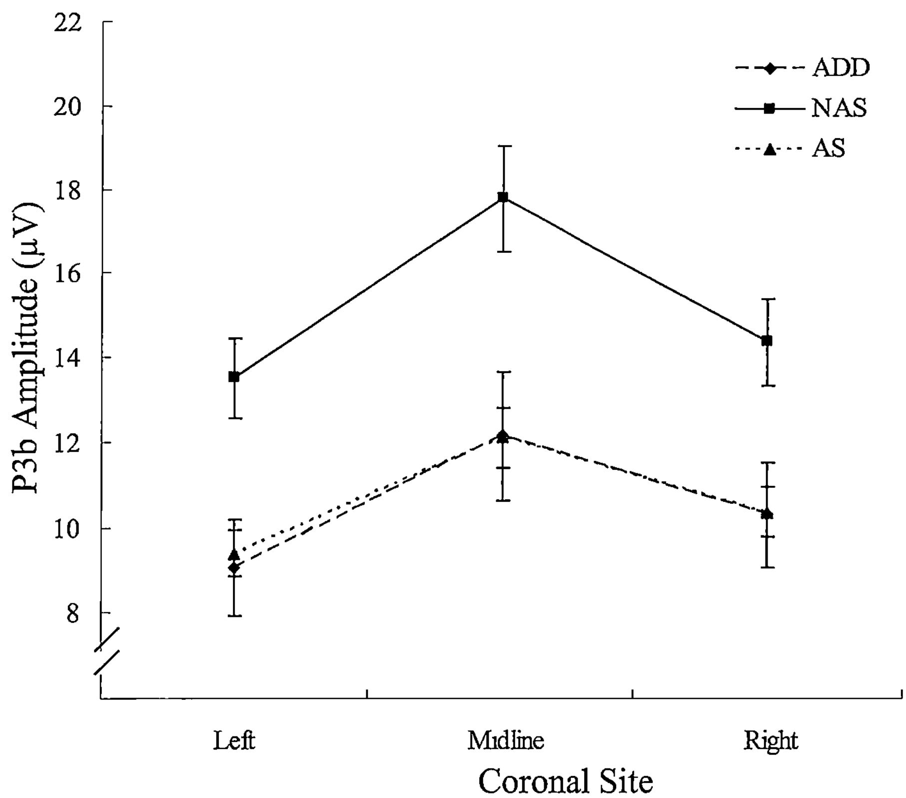

Figure 11. Mean P3b amplitude (μV) across left, midline and right hemisphere coronal sites of groups in Group Set 3; Addicted (ADD), Non-clinical group with no symptoms of addiction (NAS), and Sub-clinical group who experience some symptoms of addiction (AS). Points represent the mean P3b amplitude (μV); vertical lines depict standard errors of the means.

P3b Latency

Group Set 1 analyses. P3b latency data was analysed with a 3[Group] x 2(Sagittal) x 3(Coronal) mixed ANOVA (see Appendix Q, Table Q5). The main effect for the between participants factor Group did not reach significance, $F(2, 77) = 1.93$, *ns*. As can be seen in the grand mean waveforms (seen in Figure 6), the similarity between P3b peaks latencies for each group across sites accounted for the non-significant higher-order interactions for Group Set 1.

Group Set 2 analyses. P3b latency data of Group Set 2 was analysed using a 5[Group] x 2(Sagittal) x 3(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q5). Figure 12 shows the mean P3b latency for each group within Group Set 2. The main effect for Group was significant $F(4, 75) = 3.60, p < .01$. There were no significant two- or three-way interactions involving Group, Coronal site or Sagittal region, indicating that latency differences between groups did not differ significantly across specific brain regions.

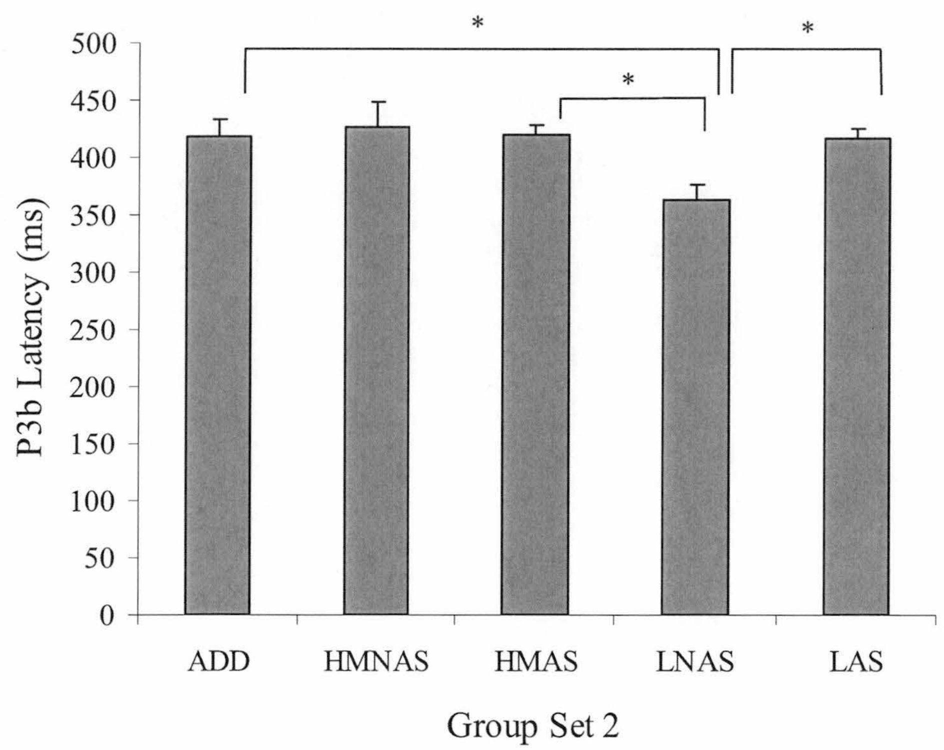

Figure 12. Mean P3b latency (ms) in response to the target stimulus of groups in Group Set 2; Addicted (ADD), High/Medium Engagement with no addictive symptoms (HMNAS), High/Medium Engagement with addictive symptoms (HMAS), Low Engagement with no addictive symptoms (LNAS), and Low Engagement with addictive symptoms (LAS). Vertical lines represent standard errors of the means.

$^*p < .05$.

As can be seen in Figure 12, peak latency occurred earlier in the LNAS group compared to other groups. Pairwise comparisons further examining the main effect for Group, revealed significantly earlier P3b latency in the LNAS than in the ADD, HMAS and LAS groups (*ps* $< .05$) (see Appendix Q, Table Q9). The significant difference between the two low engagement groups (LNAS and LAS) suggests the significant role of addictive experience on stimulus evaluation time. However, the HMNAS group had the longest latency, although no significant difference was found with the LNAS possibly due to the former group's small sample size ($n = 5$), and additionally no significant difference was noted between the two high engagement groups (HMNAS and HMAS).

Group Set 3 Analyses. P3b latency was examined by a 3[Group] x 2(Sagittal) x 3(Coronal) mixed three-way ANOVA (see Appendix Q, Table Q5). Figure 13 depicts the significant main effect of Group, $F(2, 77) = 3.66, p < .05$, with Bonferroni adjusted pairwise comparisons revealing that the P3b component of the NAS group occurred significantly earlier ($M = 382.21$ ms) than the AS group ($M = 417.70$ ms).

As shown in Figure 13, the ADD group ($M = 419.08$ ms) had a similar, slightly later, peak latency to the AS group. However, pairwise comparisons did not indicate that the ADD differed significantly to the peak onset of the NAS group, possibly due to the former groups small sample size (see Appendix Q, Table Q10). The main effect of Group was not quantified by significant two- or three-way interactions involving Sagittal region or Coronal site. These results are consistent with Group Set 2 results, as differences from a non-clinical to a sub-clinical level of addiction is indexed by a sequential decrease in stimulus evaluation speed and slowed processing.

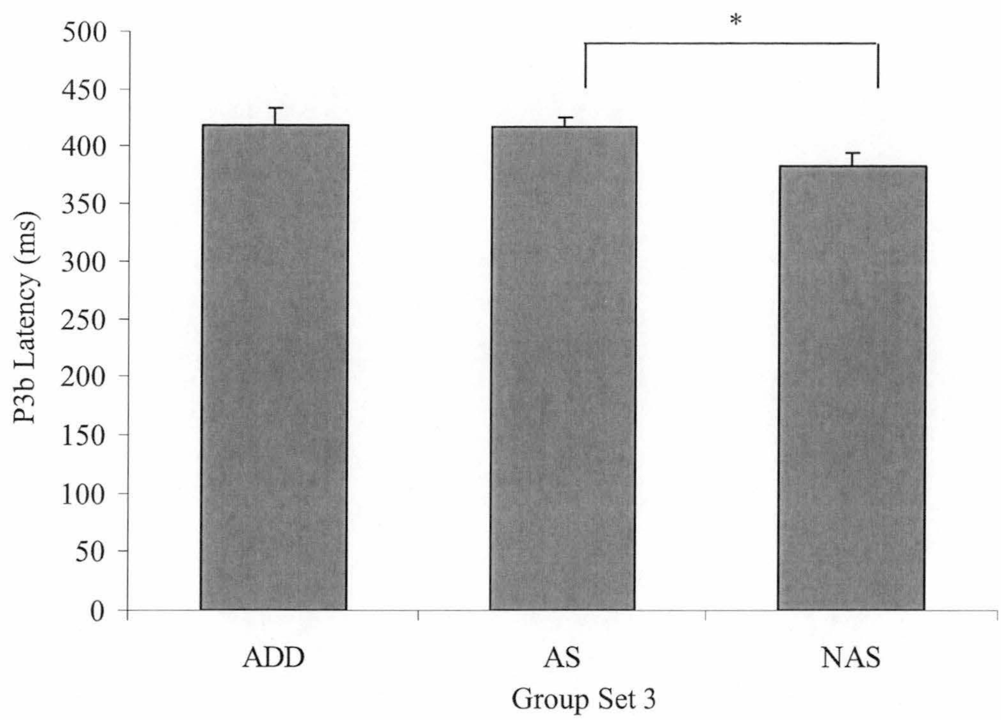

Figure 13. Mean P3b latency (ms) of groups in Group Set 3; Addicted (ADD), Non-clinical group with no symptoms of addiction (NAS), and Sub-clinical group who experience some symptoms of addiction (AS). Vertical lines depict standard errors of the means.

*$p < .05$.

Summary of P3b Amplitude and Latency Results

Results show that there is psychophysiological support for increased engagement and addiction symptomatology to the activities investigated, but that such distinctions are limited to differentiating between non-clinical and sub-clinical levels of dysfunction, and low and high/medium engagement. No significant difference was found between participants with high/medium engagement and addiction, or sub-clinical and clinical levels of dysfunction. Decreases in processing speed (P3b latency) were found for participants with higher engagement and addiction symptomatology, although these differences were not localized to a specific scalp location.

Discussion

Results from Study 2 provide supporting evidence that P3a and P3b amplitude index both a sub-clinical and clinical level of behavioural addiction to the collection of activities investigated; gambling, video-arcade games, computer games, and the Internet. Reductions in P3a and P3b amplitude did not support any of the three continuum hypotheses. Instead, a dichotomous distinction was evident between individuals with no symptoms and a low level of engagement, compared to participants with greater engagement and/or an experience of some problems due to their participation.

In line with hypotheses, significant reductions in P3a amplitude were established among participants with a sub-clinical level of addiction compared to those with no symptoms of addiction. Reductions in the attentional processing of participants in the sub-clinical group were localized in the left hemisphere only. However, the non-significant although observable, difference noted between the non-clinical and addicted samples, together with the addicted group failing to exhibit the smallest P3a component, did not support the continuum of addiction hypothesis. These differences may not have reached significance due to the small sample size and high within group variability of this addicted group. The hypothesis that P3a amplitude would index varying levels of engagement in the aforementioned activities was not established. P3b amplitude was found to significantly differentiate groups, with participants who had lower levels of engagement and/or no addictive symptoms, having significantly more cognitive resources available to process target stimuli than participants with either a sub-clinical and/or high/medium level of engagement or a clinical diagnosis of addiction. These reductions in P3b amplitude were established across scalp topography. Consistent with hypotheses, RT, behavioural performance and P3a latency did not significantly differ among participants with varying levels of engagement and/or symptoms of addiction.

Conversely, P3b latency was significantly delayed among participants with a sub-clinical and clinical level of addiction, compared to non-clinical participants.

In support of findings on substance addiction (e.g., Holguín et al., 1999; Prabhu et al., 2001) and a genetic vulnerability to alcoholism (e.g., Hada et al., 2001; Holguín et al., 1999; van der Stelt et al., 1998), reduced peak P3a was found among participants with a sub-clinical and clinical addiction at midline and left hemispheric sites, compared to those with no symptoms of addiction. Results established for P3a amplitude suggest that both sub-clinical and clinical samples have similar reductions in inhibitory processing of irrelevant task information (Chorlian et al., 1995) associated with temporal and frontal lobe functioning (Goldstein & Volkow, 2002; Holguín et al., 1999). These results are consistent with past researchers reporting that pathological gamblers had frontal disinhibition and deregulation of the ventromedial prefrontal and orbiofrontal cortices (Cavedini et al., 2002; Potenza et al., 2003a; Potenza et al., 2003b).

Reductions in P3b amplitude established in Study 2 are consistent with neurophysiological deficits reported in the mesolimbic reward pathway (Frantz & Kobb, 2005; Hyman, 2005) and reduced inhibitory processing found among previous samples of participants with a diagnosis of substance dependency, or who experienced some symptoms of substance dependency and externalizing psychopathology (Carlson et al., 1999). Results from the present study are in line with assumptions made by past researchers that P3b amplitude deficits (Begleiter et al., 1984; Pfefferbaum et al., 1991; Polich et al., 1994; Porjesz & Begleiter, 1997) and reductions in the amplitude of event-related oscillations underlying the P3b component (e.g., Kamarajan et al., 2006; Rangaswamy, Porjesz, Ardekani et al., 2004), index a genetic vulnerability to substance addiction. Given that Study 2 examined behavioural addiction only, it appears that the P300 component, particularly P3b amplitude, may also index addiction to behavioural activities in participants who do not engage in binge drinking or use other drugs.

The functional significance of reductions in P3a and P3b amplitude established in Study 2, is that sub-clinical and addicted participants and those with higher engagement (P3b only) appear to have reduced high-order cognitive processing, particularly for planned-controlled behaviour (van der Stelt et al., 1998). Such global disinhibition of the CNS and deficits in one's ability to compare incoming stimuli to memory templates of infrequent events (Holguín et al., 1999), may therefore be a feature of experiencing symptoms of addiction to behavioural activities. An alternative premise would suggest that deficits in P300 (P3a and P3b) are present prior to the onset of problematic engagement in these activities, which would be consistent with past suggestions by Iacono et al. (2003) regarding externalizing disorders of disinhibition. These preliminary suggestions, while speculative in nature, imply that the reduced P3b trait marker for substance addiction may also index addiction to behavioural activities, present among both sub-clinical and clinical populations investigated in this study. Before such a conclusion can be made, investigation of the P3a and P3b components of the offspring of parents with behavioural addiction is required.

As expected, P3a latency did not differ significantly between groups in Group Set 1, 2 or 3, resembling previous findings on pathological gambling, substance dependency and genetic vulnerability to alcoholism (Hada et al., 2001; Holguín et al., 1999; Potenza et al., 2003a; van der Stelt et al., 1998). However, contrary to hypotheses, P3b peak latency was significantly earlier among participants in the LNAS compared to the other groups in Group Set 2, with the presence of a significant difference between the LNAS and LAS groups, showing the role that experiencing some symptoms of addiction has on the time taken to evaluate incoming stimuli. Similarly, results reported for Group Set 3 suggest that participants who experienced either a sub-clinical level of addiction or diagnosis of addiction, regardless of their level of engagement in activity(ies) per week, required greater time to recognise and categorise events and exhibited poorer cognitive functioning (Duncan-Johnson & Donchin, 1982) than those with no symptoms of addiction. Differences in P3b latency may be attributed to personal alcohol use (Berman et al., 1993), although the alcohol history of participants was screened in the present study with binge drinkers excluded and moreover, no differences in P3a latency were established.

In relation to behavioural performance, participants with higher engagement performed the task better than those with lower engagement, possibly due to the former groups' familiarity with responding to computer generated activities. The Addicted group had the lowest percentage of correct responses to target stimuli (hits), which may be attributed to behavioural impulsivity among these participants. Consistent with hypotheses and past research (e.g., Potenza et al., 2003; e.g., van der Stelt et al., 1998), the percentage of responses and RT to hits and false alarms did not reach statistical significance. Reductions in the P3a and P3b amplitude and P3b latency of participants are therefore unrelated to simple stimulus-response processing and response execution.

The following Chapter will report Study 3. Study 3 was designed to investigate whether participants with higher engagement and/or symptoms of addiction differ to those at the lower end of the engagement and/or addiction continuum in relation to pre-attentive automatic detection and processing of deviance (MMN amplitude).

CHAPTER 10

Study 3

Pre-attentive Auditory Processing (MMN) of University Students According to their Level of Engagement and Addiction to Gambling, Video-arcade Games, Computer Games and the Internet

Pre-attentive mismatch negativity (MMN) of the auditory ERP has been employed in addition to the P300 component, as a measure of genetic vulnerability to alcoholism and cortical disinhibition associated with the functioning of the frontal and fronto-temporal cortices. As opposed to the P3a component which indexes controlled-attentional processing, MMN enables further examination of the detection of deviance and involuntary attentional processing (Holguín et al., 1998). Previous studies have found that increased MMN amplitude is positively correlated with CNS disinhibition, impulsivity and extraversion (Franken et al., 2005; Sasaki et al., 2000; Zhang et al., 2001). It remains unclear whether MMN acts only as a state marker for alcoholism, indexing the toxic effects of alcohol on the brain and CNS hyper-excitability associated with ethanol withdrawal (Pekkonen et al., 1998), or whether it is also associated with a genetic vulnerability to alcoholism (Holguín et al., 1998; van der Stelt et al., 1998; Zhang et al., 2001).

Although reductions in MMN amplitude are associated with damage to the dorsolateral prefrontal, frontal and temporal structures (Alain et al., 1998; Alho et al., 1994), structures known to be involved in both pathological gambling and substance addiction (Cavedini et al., 2002; Goldstein & Volkow, 2002; Potenza & Winters, 2003; Reuter et al., 2005), the MMN has not been examined in individuals addicted to gambling or other potentially addictive activities, such as video-arcade games, computer games, and the Internet. Pathological gambling has also been linked to other factors associated with increased MMN amplitude and CNS disinhibition; higher levels of impulsivity, psychopathology, extraversion, sensation seeking and risk-taking (see Blaszczynski et al., 1985; Engwall et al., 2004; Petry, 2001; Vitaro et al., 1999). Researchers have recently begun to examine the relationship between other potentially addictive activities and personality and psychopathological variables, with tentative conclusions drawn between greater pathology and addiction and excessive use (Lavin et al., 1999; Lin & Tsai, 2002; Shapira et al., 2000; Yang et al., 2005).

As increased MMN amplitude is positively related to greater deviation in personality dimensions (for example extraversion and impulsivity), clinical psychopathology and cortical functioning associated with substance addiction and disinhibitory disorders, it is proposed that MMN amplitude will be subsequently increased in participants with greater levels of engagement in, and symptoms of addiction to, behavioural activities. The primary aim of this psychophysiological study is therefore to determine whether greater MMN amplitude indexes progressive stages on the continuum of engagement, combined continuum of engagement and addiction symptomatology, and continuum of engagement-related problems (symptoms of addiction) to gambling, video-arcade games, computer games, and the Internet. It is hypothesized that fronto-centrally distributed MMN amplitude will be higher among participants with greater engagement and/or symptoms of addiction, compared to participants with low levels of engagement and/or no symptoms of addiction.

If MMN amplitude is a trait marker for alcoholism and general addictive pathology and CNS disinhibition, it is expected that the MMN amplitude of participants with sub-clinical symptoms of addiction, would not significantly differ from the MMN amplitude elicited by addicted participants (largest amplitude), as markers for risk should be present among both sub-clinical and pathological samples (see Slutske et al., 2000). If no MMN amplitude differences are found between the sub-clinical and clinical addicted groups when compared to the non-clinical group, or between the high/medium engagement and addicted group when compared to the low engagement group, it would be assumed that individuals with higher engagement and/or a greater level of addiction symptomatology are not impulsive and do not show significant frontal disinhibition. As MMN latency is unrelated to personality traits (Franken et al., 2005; van der Stelt et al., 1998), it is proposed that no differences in MMN latency will exist between groups.

Method

Participants

The overall sample (N = 79) comprised 33 male (M = 19.09 years, SD = 2.13) and 46 female (M = 19.04 years, SD = 2.55) students, after participants with incomplete data and excessive artefacts were excluded. The majority (n = 78) had participated in Study 2. Psychology students received research course credit for their participation and non-psychology students (n = 9) were reimbursed. Those volunteering to participate were screened according to criteria employed in Study 2 (see Chapter 9) and divided into groups for each of the three Group Sets, following group configuration criteria (see Chapter 8) that was based on their responses to the University Questionnaire completed in Study 1 (Chapter 7).

Group Set 1

The Addicted (ADD) group (M = 19.00 years, SD = 2.53) consisted of 13 participants with the inclusion of one male student addicted to gambling who was not included in the ADD group in Study 2. Of the 31 participants in the High/Medium Engagement (HME) group (M = 19.10 years, SD = 2.30), 18 were high engagers and 13 medium engagers. This group was equivalent to that in Study 2, with the exclusion of one female participant with a medium level of engagement in both computer games and the Internet. The Low Engagement (LE) group (M = 19.14 years, SD = 2.49) consisted of 35 of the 36 participants in Study 2, barring one female participant with a low level of engagement in two activities.

Group Set 2

The ADD group (n = 13) in Group Set 2 remained unchanged from Group Set 1. Both the High/Medium Engagement group with no symptoms of addiction (HMNAS) (n = 5) and Low Engagement group with no symptoms of addiction (LNAS) (n = 12) were the same as in Study 2. The High/Medium Engagement group with symptoms of addiction (HMAS) comprised 26 participants (M = 19.27 years, SD = 2.44), one less female participant with medium engagement than in Study 2. The Low Engagement group with some symptoms of addiction (LAS) (n = 23) had a mean age of 19.48 years (SD = 2.92) and included the same participants as in Study 2, with the exclusion of one female with a low level of engagement in two activities.

Group Set 3

The ADD group (n = 13) remained unchanged. The HMNAS and LNAS groups from Group Set 2 were collapsed to form the non-clinical sample (M = 18.24 years, SD = 0.66) comprising 17 participants (3 males) who collectively did not experience any symptoms of addiction (NAS group). Similarly, the HMAS and LAS groups from Group Set 2 formed the sub-clinical sample of participants who did experience some symptoms of addiction (sub-clinical level; AS group). The 22 males and 27 females included in the AS group had a mean age of 19.37 years (SD = 2.65).

Materials

Materials and ERP Recordings

Materials and EEG recording apparatus did not differ from that outlined in Chapter 9 for Study 2. Participants were screened according to the medical questionnaire (including screening for hearing impairment) and handedness questionnaire used in Study 2. Age affects were controlled as MMN amplitude has been found to be reduced in older adults (Gaeta, Friedman, Ritter, & Cheng, 1998).

The MMN task was presented via binaural speakers using NeuroScan STIM Version 1 software on an IBM compatible 486 computer. EEG activity elicited by the auditory task was recorded continuously on a computer in the adjoining room using NeuroScan AQUIRE 4.3.1 data sampling software, and amplified by NeuroScan SynAmps 1.

Stimuli

The MMN (auditory oddball) task was modified from Morgan and Grillon's (1999) paradigm. The task considered of 1600 trials, divided into four consecutive blocks of deviant (rare) and standard tones occurring at a probability of 0.1 and 0.9, respectively. Each block consisted of 400 stimuli, 40 deviant stimuli (pitch of 1064 Hz) and 360 standard stimuli (pitch of 1000 Hz). Stimuli were separated by a 600 ms SOA, and had a presentation duration of 100 ms at 60dB (with 10 ms rise and 10 ms fall time). Stimuli were delivered in random series with the caveats that no two deviant stimuli were presented in succession and at least two standard tones separated deviant tones.

Procedure

The recruitment of participants, screening, and preparation guidelines for collecting EEG activity followed the same procedure outlined in Study 2. The testing procedure involved participants being seated in a sound attenuated room and presented with stimuli via binaural speakers in four blocks of 400 trials. Participants were instructed to read a standardised passage of text for the duration of the task, to focus their attention on this material, and to ignore auditory stimuli. Thus, participants were not required to perform a response task upon presentation of the deviant tone.

To enhance focussed attention, students were informed that they would be asked questions on the reading material at the end of the experiment. EEG and EOG activity were continuously recorded on a computer using NeuroScan AQUIRE 4.3.1 data sampling software. On conclusion of testing, students were asked general questions relating to the chapter of text they had read.

Post ERP Processing

ERP data processing followed the same procedure discussed in Study 2. Epochs with data in excess of +/- 100 μV were excluded from the averages. Averages with more than 128 accepted EEG samples to deviant stimuli were included in analyses.

Design and Data Analysis

The hypothesis that incremental increases in MMN amplitude will index higher engagement in behavioural activities will be examined by Group Set 1 analyses; combined continuum of engagement and addiction symptomatology by Group Set 2; and Group Set 3 analyses will examine the hypothesis that the continuum of addiction symptomatology will be indexed by incremental increases in MMN amplitude. Study 3 represents a mixed design involving the between participants factor, group for each Group Set, and repeated measures variables, Sagittal region and Coronal site. Specifically, the first hypothesis was examined using a 3[Group] x 2(Sagittal; frontal, central) x 5(Coronal; far left, left, midline, right, far right) mixed design for the Group Set 1 data. Separate analyses were performed to test the remaining hypotheses; Group Set 2 [five groups] was employed to examine the second hypothesis and Group Set 3 [three groups] the third. As the majority of MMN studies examining substance addiction, heritability of alcoholism, and impulsivity have focused on differences in peak amplitude (e.g., Franken et al., 2005; Holguín et al., 1998; Kathmann, Wagner, Rendtorff, & Engel, 1995) and therefore the dependent variables investigated in Study 3 were limited to MMN peak amplitude (μV) and latency (ms).

Electrophysiological Data

The MMN was calculated by subtracting the ERP waveform elicited by the standard tone from the ERP waveform elicited by the deviant tone (Alho et al., 1994; Beauchemin & De Beaumont, 2005; Gaeta et al., 1998; Morgan & Grillon, 1999; Näätänen, Pakarinen, Rinne, & Takegata, 2004; Paavilainen et al., 1993). Visual inspection of the grand mean difference waveforms, representing the grand means of the MMN, determined the region and time-window with the most prominent negative peak. The MMN was determined as the maximum peak at the frontal and central sites (Fein et al., 2004; Gaeta et al., 1998; Holguín et al., 1998; Morgan & Grillon, 1999; Schrager et al., 1996; Zhang et al., 2001) in the 100 to 300 ms post stimulus onset interval (Morgan & Grillon, 1999). The latency (ms) of the MMN was scored as the time between stimulus onset and peak amplitude. Amplitude (µV) and latency (ms) were measured with an automatic peak detection program set to detect the maximum peak within the predefined time window.

The MMN amplitude and latency data were analysed for main effects and interactions using three-way mixed ANOVAs. Significance was determined at $p < .05$. Greenhouse-Geisser corrections were applied to counter violations of sphericity (Morgan & Grillon, 1999). Significant two- and three-way interactions were followed up using breakdown ANOVAs and Bonferroni adjusted pairwise comparisons.

Results

Data Screening and Preliminary Analysis

Exploratory data analysis identified three outliers with amplitudes near two standard deviations from the mean electrode amplitude for the given group. As excluding outliers did not change the significance of the overall results, the three participants were included in the final sample for analysis.

Preliminary Group x Sex analysis was performed for each Group Set to determine the inclusion of Sex as a variable in the repeated measures design. No significant Group x Sex interactions were established for either MMN amplitude or latency (see Appendix R, Table R1). Sex was therefore considered not to be a significant between-participants factor in the mixed design. As the mean age of participants in each group did not vary considerably, ranging between 18.24 and 19.48 years, it was deemed that results were unlikely to be mediated by differences in age.

Grand Mean Waveforms

In accordance with Picton et al. (2000), the grand mean waveforms to the standard (Figure 14, 15 and 16) and deviant (Figure 17, 18 and19) stimuli elicited are reported for each Group Set.

Grand Mean Waveforms to the Standard Tone

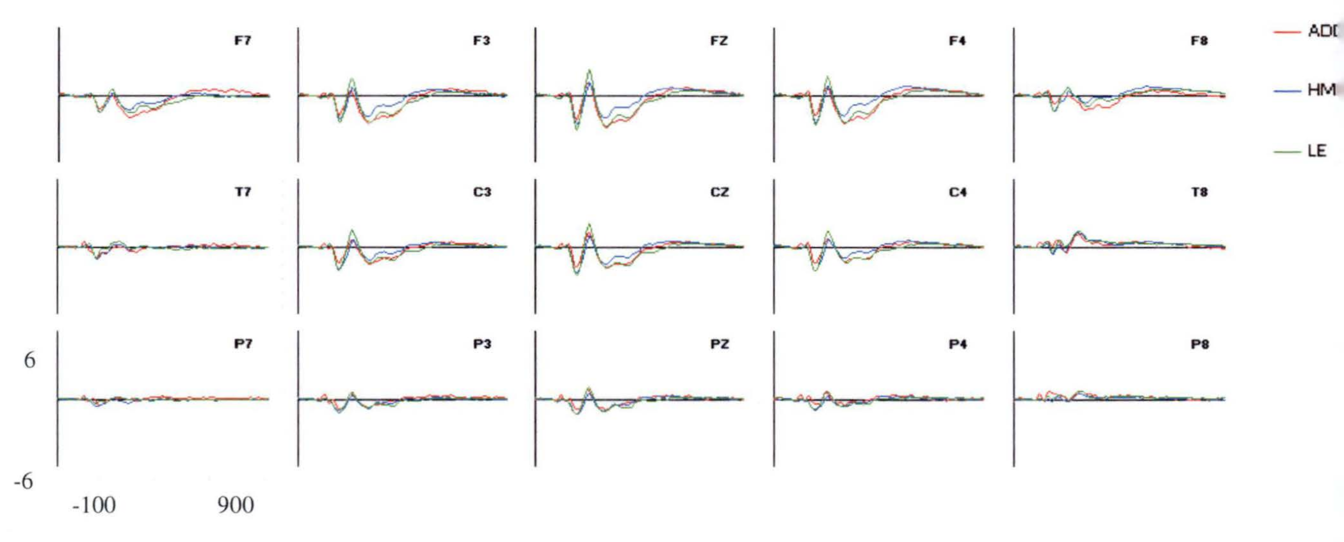

Figure 14. Grand mean waveforms to the standard tone for groups in Group Set 1.

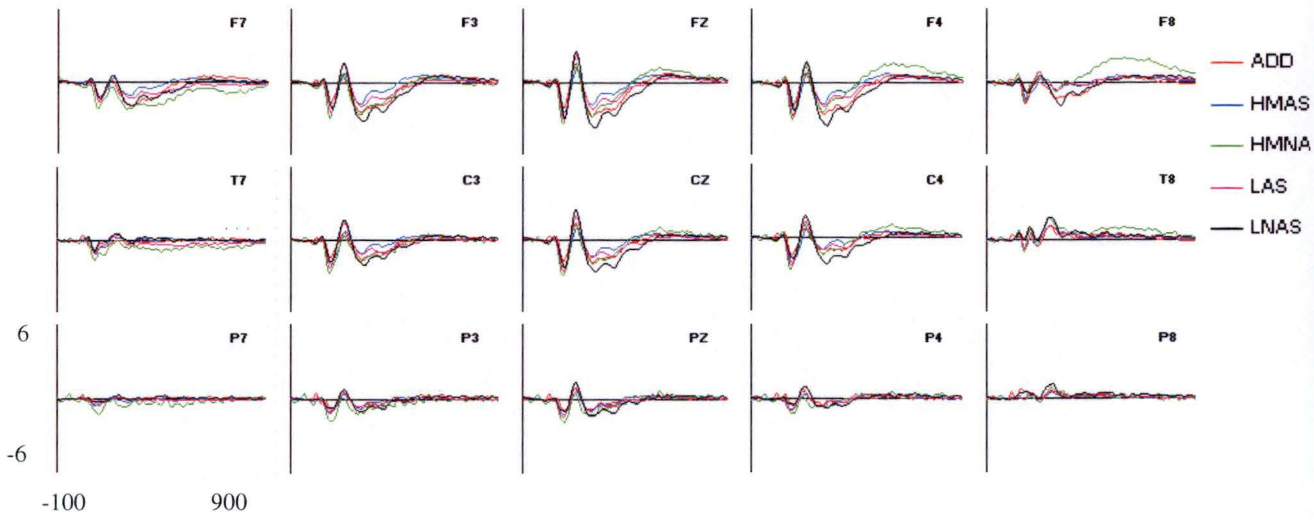

Figure 15. Grand mean waveforms to the standard tone for groups in Group Set 2.

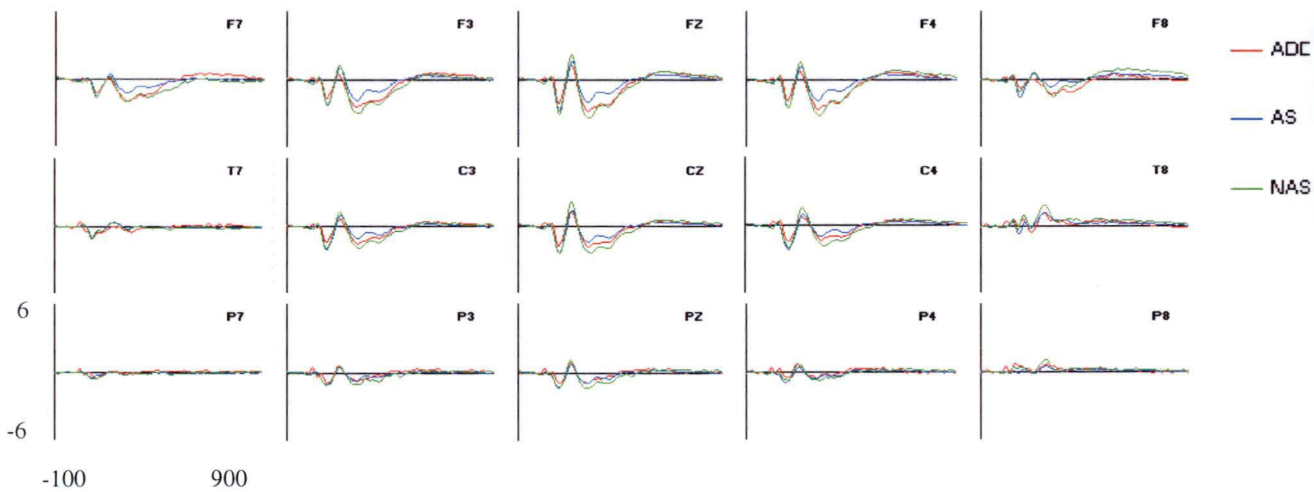

Figure 16. Grand mean waveforms to the standard tone for groups in Group Set 3.

Grand Mean Waveforms to the Deviant Tone

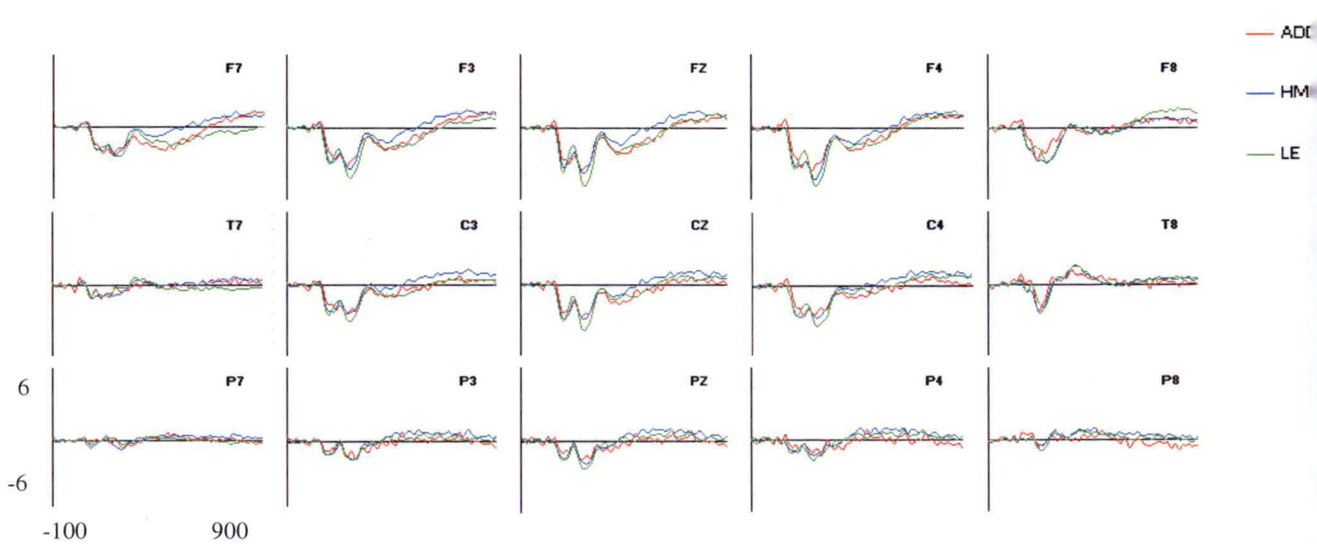

Figure 17. Grand mean waveforms in response to the deviant tone for groups in Group Set 1.

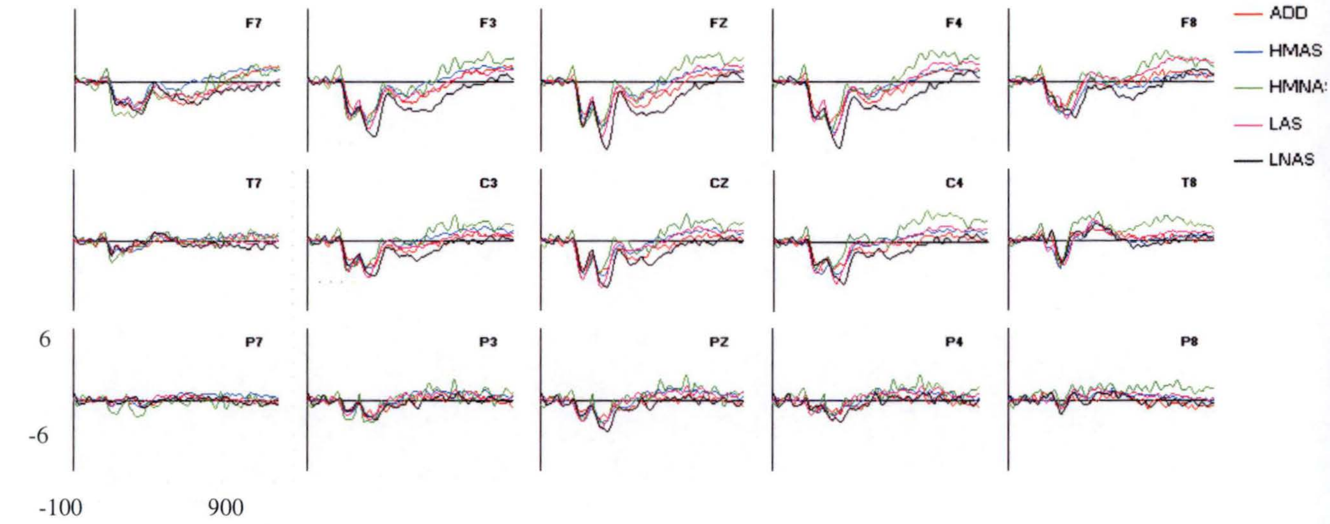

Figure 18. Grand mean waveforms in response to the deviant tone for groups in Group Set 2.

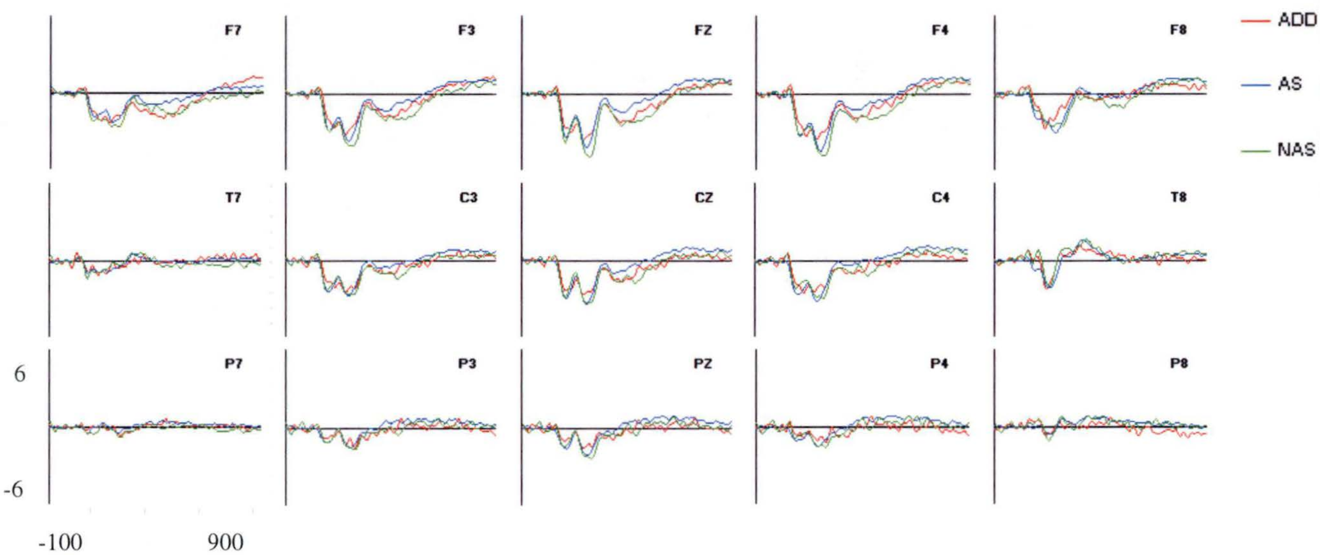

Figure 19. Grand mean waveforms to the deviant tone for groups in Group Set 3.

MMN: Grand Means, Amplitude and Latency

Grand Mean Difference Waveforms

Figure 20, 21 and 22 show the grand mean waveforms of Group Set 1, Group Set 2 and Group Set 3 MMN data, respectively. As can be seen in these figures, pronounced negativity is observable at approximately 180 ms across all coronal sites in both frontal and central regions, however is indistinguishable at parietal sites. As previously mentioned, analyses for all Group Sets were therefore confined to frontal and central regions only.

Consistent with past research (Alho et al., 1998; Holguín et al., 1998; Kathmann et al., 1995; Zhang et al., 2001), MMN appears greatest across frontal sites for all groups in each Group Set. Upon inspection of Figure 20 (Group Set 1), the MMN amplitude of the LE group is larger across left, midline and right hemispheric sites in both frontal and central regions. The MMN waveforms established for the ADD and HME groups appear to be of similar amplitude and smaller than in the LE group, particularly at midline and left hemispheric sites. The MMN amplitude was also earlier in the ADD group in comparison to the HME and LE groups.

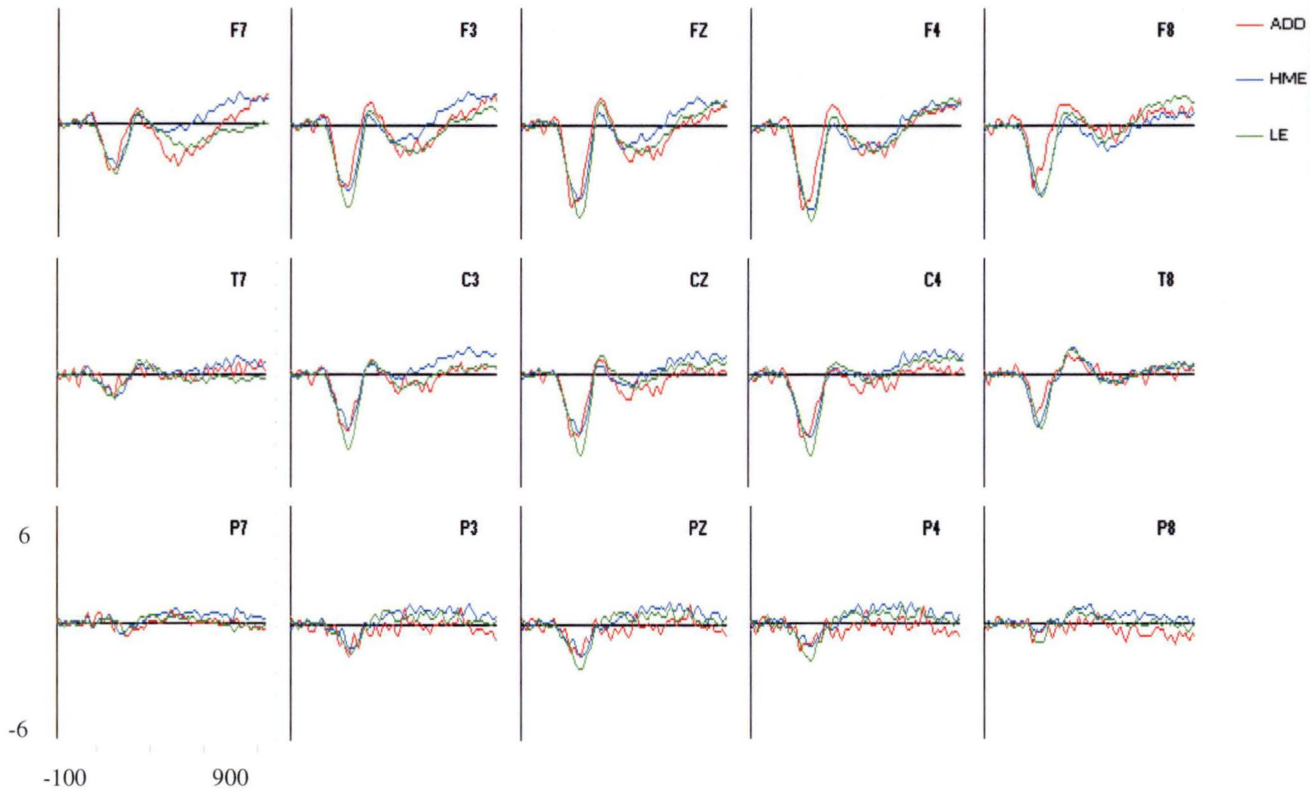

Figure 20. Grand mean difference waveforms (MMN) for the Addicted (ADD), High/Medium Engagement (HME) and Low Engagement (LE) groups in Group Set 1.

Similarly, larger MMN amplitudes are observed for both low engagement groups with and without symptoms of addiction (LAS and LNAS) in Group Set 2. As shown in Figure 21, MMN amplitude for LNAS and LAS groups are larger at frontal and central sites compared that of the ADD, HMNAS and HMAS groups. The differences observed in Figure 21 appears to be related to differences in level of engagement rather than experiencing symptoms of addiction, with differences more pronounced at midline and left hemispheric sites.

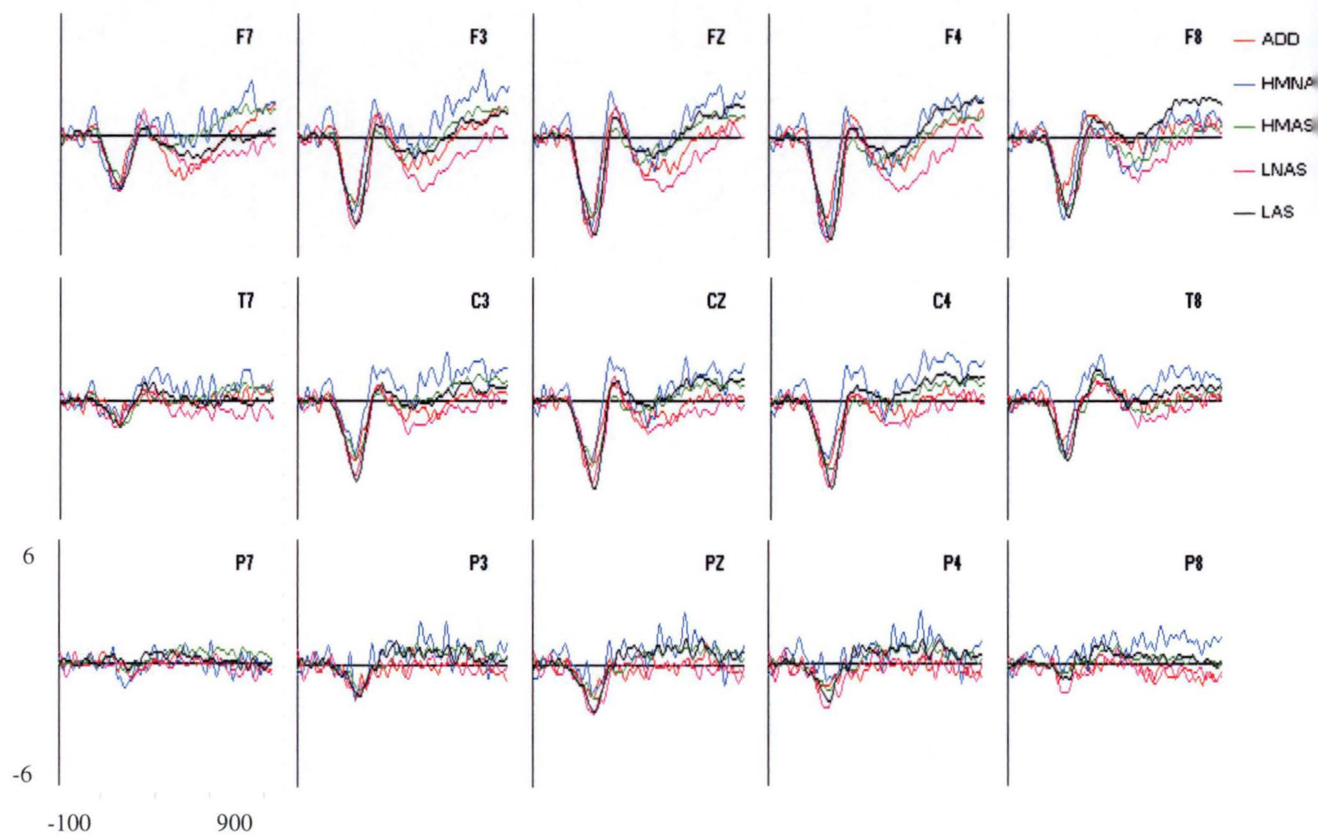

Figure 21. Grand mean difference waveforms (MMN) for groups in Group Set 2; Addicted (ADD), High/Medium Engagement with no symptoms of addiction (HMNAS), High/Medium Engagement with addiction symptoms (HMAS), Low Engagement with no symptoms of addiction (LNAS) and Low Engagement with symptoms of addiction (LAS).

In contrast to Group Set 1 and Group Set 2 grand means, the grand mean difference waveforms presented in Figure 22 for Group Set 3 show little difference between groups. The non-clinical (NAS) and sub-clinical (AS) groups appear to have similar amplitudes across frontal and central sites, with both groups having greater negativity compared to the ADD group.

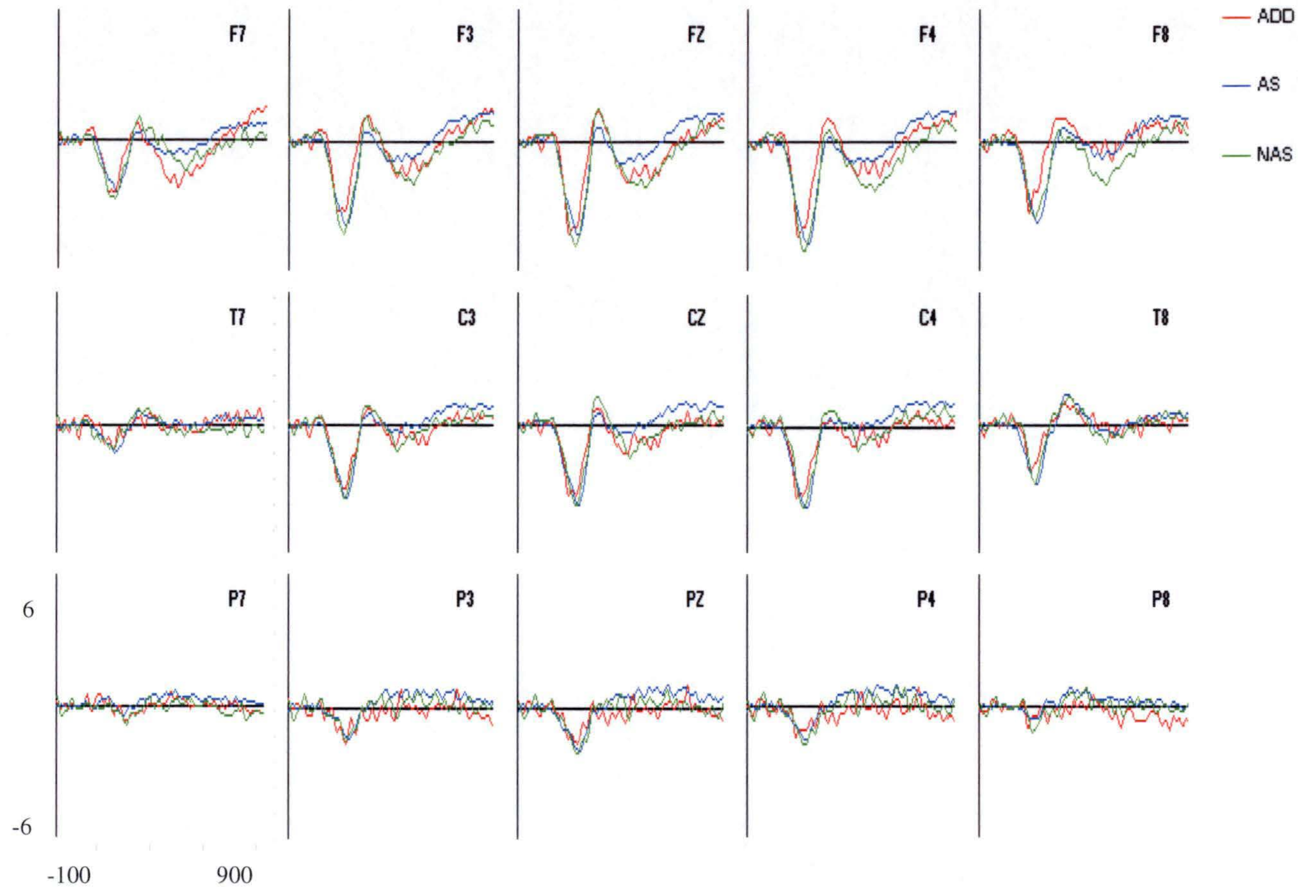

Figure 22. Grand mean difference waveforms (MMN) for groups in Group Set 3; Addicted (ADD), Non-clinical group with no addictive symptoms (NAS), and Sub-clinical group with some addictive symptoms (AS).

MMN Amplitude

Group Set 1 analyses. MMN was analysed using a 3[Group] x 2(Sagittal) x 5(Coronal) three-way repeated measures ANOVA (see Appendix R, Table R2). No significant main effect was found for Group, $F(2, 76) = 0.12$, *ns*. Although the LE group had a more negative peak compared to the HME and ADD groups at frontal sites as opposed to central sites, the interaction between group and Sagittal region did not reach significance. Despite the grand mean waveforms (see Figure 20) of the LE groups showing greater negativity compared to the other two groups at midline and left hemispheric sites, there was no significant interaction involving Group and Coronal site nor three-way interaction.

Group Set 2 analyses. Analysis using a 5[Group] x 2(Sagittal) x 5(Coronal) three-way ANOVA was performed MMN amplitude data (see Appendix R, Table R2). Analysis did not identify a significant main effect for Group, $F(4, 74) = 0.89$, *ns*, even though the grand mean waveforms presented in Figure 21 show the LAS and LNAS groups had more negative peaks across all frontal and central sites in comparison to the ADD group and both High/Medium Engagement groups. Furthermore, no significant two- or three-way interactions were established for Group and Sagittal region, Coronal site. Results therefore did not reveal any significant differences despite those observed in the grand means.

Group Set 3 analyses. A 3[Group] x 2(Sagittal) x 5(Coronal) three-way ANOVA was performed to examine MMN amplitude (see Appendix R, Table R2). No significant differences were established between groups, $F(2, 76) = 0.10$, *ns*. Further substantiating results reported for Group Set 2, the interactions between Group and Sagittal region and Coronal site did not reach significance.

MMN Latency

Group Set 1, Group Set 2 and Group Set 3 analyses. MMN latency was analyses for Group Set 1 using a 3[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA; Group Set 2 was analysed by a 5[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA; and Group Set 3 was investigated using a 3[Group] x 2(Sagittal) x 5(Coronal) mixed three-way ANOVA (see Appendix R, Table R2). These analyses revealed no significant main effect for Group for any Group Set: Group Set 1, $F(2, 76) = 0.13$, *ns;* Group Set 2, $F(4, 74) = 0.33$, *ns*; or Group Set 3, $F(2, 76) = 0.10$, *ns*: nor higher order two- or three-way interactions.

Summary of MMN Amplitude and Latency Results

Results indicate that MMN amplitude does not act as a significant index for the continuum of engagement, as it did not differentiate participants with low engagement, high/medium engagement and addiction. Similarly, Group Set 2 results indicate that neither a combination of higher engagement and experiencing some symptoms of addiction, or a clinical level of addiction, has a significant effect on neuronal-mismatch processing. This was further supported by results found for Group Set 3, which established that the presence of a sub-clinical level of addiction or diagnosis of addiction did not reflect significant greater excitation of neuronal generators underlying sensory memory.

Results indicate that the onset of MMN (i.e., latency) did not differentiate participants according to their level of engagement in activities, combined level of engagement and level addiction symptomatology, or number of symptoms of addiction experienced ranging from a non-clinical to clinical level.

Discussion

It was hypothesised that MMN amplitude would be significantly more negative among participants with high levels of engagement and/or addiction symptomatology compared to those with lower engagement and/or no symptoms of addiction. The MMN was not found to index the continuum of engagement to addiction hypothesis, combined continuum of addiction symptomatology hypothesis, nor continuum of addiction hypothesis. As expected, no significant MMN latency differences were established between participants with varying levels of engagement or addiction.

While the MMN peak amplitude of participants with low engagement (in Group Set 1) and low engagement with and without symptoms of addiction (Group Set 2) appeared to be greater in the grand means than that of participants with higher engagement and/or addiction symptomatology or clinical addiction, differences did not reach statistical significance. These results are in the opposite direction than that proposed by the continua hypotheses, and therefore suggest that participants at the higher end of each continuum have reduced pre-attentive auditory processing. As such differences did not reach significance it appears that overall the automatic involuntary processing of deviant stimuli does not differ significantly between participants, regardless of level of engagement or level of behavioural addiction. Results also do not show a dichotomous distinction between groups. Therefore it can be tentatively concluded that differences in bottom-up processing of incoming stimuli, associated with impulsivity and temporal functioning (Franken et al., 2005), were not present among sub-clinical or clinical samples investigated in the present study.

As impulsivity and CNS disinhibition and neuronal hyper-excitability is significantly indexed by increased MMN amplitude (Franken et al., 2005), the results suggest that the addicted participants in this study were not impulsive. Although not currently classified as clinical disorder, the absence of impulsivity among the addicted sample questions whether addiction to these activities belong in the spectrum of externalizing pathology along with ADHD and conduct disorder (Gorenstein & Newman, 1980; Iacono et al., 2003). Although pathological gambling is considered to be an externalizing disorder of disinhibition (Blaszczynski et al., 1997; Ibánez et al., 2001; Slutske et al., 2000), only one participant with pathological gambling was included in the Addicted group in the present study. As the Addicted group consisted predominately of participants addicted to technological activities, addiction to these activities may represent a different subset of non-externalizing behavioural disorders.

The absence of MMN amplitude differences between groups is consistent with the majority of studies conducted on samples of high risk offspring of alcoholics (for example Holguín et al., 1998; van der Stelt et al., 1998). These results add to the uncertainty regarding the validity of the MMN amplitude as a trait marker for addiction, and suggest that MMN may only act as an index of the toxic effect of substance use on the brain. However, the absence in MMN amplitude differences between groups may be due to the lower level of pathology in the present sub-clinical and clinical groups compared to that of past samples of university students (Niemz et al., 2005), or it may be that these addictive behaviours are not associated with impulsivity.

In summary, MMN amplitude was not found to index a sub-clinical or clinical level of behavioural addiction, nor did it index a high/medium level of engagement in the activities investigated. As MMN has been previously found to index impulsivity associated with other personality traits such as extraversion and neuroticism, Study 4 will examine the personality and psychopathology characteristics of groups involved in Studies 2 and 3, to determine if participants with a sub-clinical and clinical level of behavioural adiction have an elevated level of psychopathology and personality traits associated with impulsivity.

CHAPTER 11

Study 4

Personality and Psychopathology Factors Underlying Addiction

Addiction has been associated with various personality traits (Arai, Hosokawa, Fukao, Izumi, & Hisamichi, 1997; Blaszczynski et al., 1985) and symptoms of psychopathology (Cunningham-Williams, Cottler, Compton, & Spitznagel, 1998). Researchers suggest a complex relationship exists between personality and psychopathology variables and underlying measures of psychophysiology, such as the P300 and MMN components of the ERP (Daruna, Karrer, & Rosen, 1985; Ditraglia & Polich, 1991; Franken et al., 2005; Polich et al., 1994; Stelmack & Houlihan, 1995). The following sections will give an outline of the literature on individual differences associated with addiction.

Personality Factors Related to Addiction

Elevated personality dimensions of extraversion, neuroticism, and psychoticism differentiate addicted and non-addicted populations. For example, research investigating the relationship between personality and addiction, has established higher levels of neuroticism among Australian males with heroin addiction and males with pathological gambling, with increased rates of psychoticism across genders for those addicted to the aforementioned activities (Blaszczynski et al., 1985). Likewise, extraversion and psychoticism have also been found to be elevated in males and females with nicotine dependency (Arai et al., 1997). In contrast, the extraversion dimension has been found not to differ significantly among university students with exercise addiction compared to controls (Mathers & Walker, 1999), nor are high frequency adolescent video-gamers significantly elevated on extroversion-introversion or neuroticism dimensions (Kestenbaum & Weinstein, 1985). This suggests that personality dimensions may differ between samples addicted to structurally different activities, for example gambling compared to exercise, and also between addicted individuals and those with excessive use only.

Eysenck (1997) proposes the existence of a "causal chain linking personality and biological factors together in the production of addictive behaviours" (p. S79). Accordingly, increases in physiological arousal associated with engagement in behaviours such as gambling (Brown, 1986; Brown, Rodda, & Phillips, 2004), arcade fruit machine gambling (Moodie & Finnigan, 2005) and computer games (Griffiths & Dancaster, 1995) are suggested to have reinforcing effects and contribute to the development of addiction in participants with either reduced baseline arousal or greater physiological response to external stimulation (Eysenck, 1967; Stelmack, 1990). For instance, individuals with Type A personality were found to be twice as likely to be addicted to computer games, with computer game play eliciting the greatest increase in cortical arousal in participants with Type A compared to Type B personality (Griffiths & Dancaster, 1995). A study of 27 adult problem and 40 non-problem gamblers also found that problem gamblers reported experiencing increased arousal after gambling on electronic gambling machines, and greater negative affective valence if they lost (Brown et al., 2004).

The extraversion dimension of personality has been associated with cortical hyper-excitability, impulsivity and sensation seeking (Zuckerman, 1979). Impulsivity has been associated with a spectrum of disorders of CNS disinhibition, such as alcoholism (Justus, Finn, & Steinmetz, 2001; Pfefferbaum et al., 1991). Of the research investigating behavioural addiction and impulsivity, the majority has focused on pathological gambling with significantly elevated levels of impulsivity established among problem gamblers receiving treatment, and also those not engaged in treatment (Blaszczynski et al., 1997; Petry, 2001; Steel & Blaszczynski, 1998). Petry (2001) proposed that participants with pathological gambling and substance abuse had a greater preference for more immediate reward than delayed reward. However, results did not indicate whether decrements in impulse control were a consequence of such addiction or acted as a predisposition for their development. Additionally, problem gamblers exhibited deficits in their ability to reallocate attention resources to new stimuli and adjust their responses to changes in reinforcement (Vitaro et al., 1999).

In addition to extraversion and neuroticism personality traits (Blaszczynski et al., 1997), impulsivity has been significantly related to risk-taking and sensation seeking (Langewisch & Frisch, 1998). Sensation seeking encapsulates a range of different behaviours, including drug use, gambling, computer games and video games (Zuckerman, 1979). Powel, Hardoon, Derevensky et al. (1999) established that the level of sensation seeking and risk-taking among Canadian university students, incrementally progressed along the continuum of gambling involvement, with problem/pathological gamblers endorsing significantly greater risk taking and sensation seeking behaviours than sub-clinical gamblers, and non-clinical gamblers. Due to the similarities between on-line gaming and video-arcade games and computer games, Internet use has been identified as another possible novelty seeking activity (Lavin et al., 1999). However, inconsistent findings have been reported for the link between sensation seeking and Internet use, with some but not all studies showing that students with Internet addiction are impulsive (Lavin et al., 1999; Lin & Tsai, 2002).

Psychopathological Factors Related to Addiction

Higher rates of comorbid psychiatric presentations, particularly depression, occur within addicted populations of adult Internet users (Shapira et al., 2000) and pathological gamblers (Blaszczynski & McConaghy, 1988; Cunningham-Williams et al., 1998). Shapira et al. (2000) were the first to assess formally the presence of psychiatric disorders among a sample of adults with problematic Internet use who, on average, were spending 2.8 hours per week on essential use of the Internet and 27.9 hours on non-essential use. Of the 20 participants with problematic Internet use, all met the criteria for at least one Axis I diagnosis, with anxiety, mood disorders and Bipolar II the most prevalent (Shapira et al., 2000). Similarly, the psychopathological profile of adult pathological gamblers receiving inpatient treatment (Blaszczynski & McConaghy, 1988), and college students with excessive Internet use (Yang et al., 2005) compared to controls, were significantly elevated on scales on the SCL-90-R questionnaire.

As researchers propose that the personality and psychopathology composition of people with behavioural addictions differs from that of non-pathological samples, the prevalence of personality and clinical dysfunction was investigated in the present study. It is hypothesised that addicted individuals will have significantly elevated personality traits and psychopathology, compared to those with lower levels of engagement and/or addiction symptomatology. If scores on personality and psychopathology measures incrementally increase when comparing subjects with low engagement and/or no addiction symptomatology, high/medium engagement and/or some symptoms of addiction, and to those with clinical addiction, results would be consistent with a continuum of hypothesis. If this was the case, it would be expected that subjects with a high/medium engagement group and/or some addiction symptomatology would have a greater level of pathology than low engagers and those with no symptoms of addiction, but less pathology than the addicted sample. However, if these factors do not differentiate sub-clinical and non-clinical groups, or subjects with low engagement from those with high engagement, these measures would provide only a dichotomous measure of addiction (i.e., differentiating between non-addicted and addicted.

Method

Participants

Eighty students (32 male, 48 female) recruited from the University of Tasmania participated in this Study. Demographic information for each group in Group Set 1, Group Set 2 and Group Set 3 was reported in Chapter 9 (Study 2). Due to the high overlap between participants involved in Study 2 and Study 3 (overlap of $n = 78$), the results reported on group personality and psychopathology variables are based on all participants tested across the two studies ($n = 81$). Two participants with missing data on the personality index and one participant with missing psychopathology data were excluded.

Materials

Eysenck Personality Questionnaire-Revised (Short Scale)

The 48-item self-report Short Scale EPQ-R (Eysenck & Eysenck, 1997) assesses three dimensions of adult personality, Psychoticism (P scale), Neuroticism (N scale) and Extraversion (E scale), and the tendency to 'fake good' (Lie scale). The Psychoticism scale is a valid measure of psychopathology. The Lie scale is included as a validity check for socially desirable responding. Items request a yes/no response. Each scale consists of 12 items and has age-related normative means and standard deviations for each gender. The short-scale EPQ-R has sound reliability coefficients across each scale; P Scale (.62, .61), E Scale (.88, .84), N Scale (.84, .80) and L Scale (.77, .73) for male and females, respectively (Eysenck & Eysenck, 1997).

Symptom Checklist-90-R

The SCL-90-R (Derogatis, 1993) is a 90-item self-report instrument assessing nine primary psychological symptoms and three global indices of distress. The nine primary symptoms are; Somatization (SOM) Obsessive-Compulsive (O-C), Interpersonal Sensitivity (I-S), Depression (DEP), Anxiety (ANX), Hostility (HOS), Phobic Anxiety

(PHOB), Paranoid Ideation ((PAR), and Psychoticism (PSY). The three global indices measuring level of psychological distress include the Global Severity Index (GSI) indicating current depth of the disorder (number of symptoms reported and intensity of distress); Positive Symptom Distress Index (PSDI) measuring response style; and Positive Symptom Total (PST) reflecting the number of symptoms reported. Each item is assessed on a five-point Likert scale ranging from "not at all" to "extremely" distressed by the given symptom over the past seven days including the day of testing. This measure is widely used as a screening tool, and alpha coefficients range from .77 to .90 across indices (Derogatis, 1993).

Procedure

The Short Scale EPQ-R and SCL-90-R were administered to participants following standardised instructions. The researcher was available to interpret difficult items if required and informed participants that data would remain confidential, with all questionnaires coded and stored in a locked filing cabinet separate from identifiable information. All data was stored on a password protected computer.

Design and Data Analysis

Separate analyses were performed to test each of the proposed continuum hypotheses; Group Set 1 (three groups), Group Set 2 (five groups), and Group Set 3 (three groups). Dependent variables were the total mean scores obtained on the four scales of the EPQ-R, and the mean T scores on the SCL-90-R for the nine primary symptom scales and three global indices scales.

Means and standard deviations were calculated for the four scales on the EPQ-R Short Scale (P, E, N and L scales) for groups in each of the three Group Sets and separately for males and females in each group. Mean scores were compared to the means of the normative sample, according to sex and age (16-20 years and 21-30 years). Eight female and five male participants were compared to the normative mean of the latter age bracket, with their data included in the overall male and female scores reported. In accordance with past research, the total mean scores for each group were collapsed across males and females.

Raw scores were calculated for each participant on the 12 SCL-90-R scales (nine primary symptom scales and three global indices scales). Raw scores were converted to standardised T scores according to normative data from non-patient adults, separately for males and females. Standardised T scores enable scores to be compared to percentile ranks, whereby T scores above 70 equated to the 98th percentile (above two standard deviations from the normative mean). Means and standard deviations were calculated for the T scores, regardless of gender, of each group on eight of the SCL-90-R symptom scales (unable to calculate T scores for the Addiction scale). Group differences on SCL-90-R scales and on P, E, N and L scales were investigated for each of the three Group Sets using one-way ANOVAs with follow up Tukey HSD post hoc tests.

Results

Personality (EPQ-R)

Table 26 presents the total mean scores for each group and male and female participants within each group on the Psychoticism, Extraversion, Neuroticism, and Lie scales. Scale scores were found not to differ from the normative population mean range of males and females, with the exception of responses of female participants in the HME, HMAS, HMNAS, and AS groups on the Lie scale. On this scale females in the aforementioned groups had scores that were one standard deviation above the female normative mean but as the Lie scale scores were not above the 95 percentile the data was deemed valid. The total mean score of each group in the three Group Sets were all within the normal range. Given the format of normative data, male and female scale scores are reported separately in Table 26 although they are not the focus of analysis.

Table 26

Mean Score of Males, Females and Total Group on EPQ-R Scales for each Group Set

Scale	Group Set 1			Group Set 2					Group Set 3		
	ADD	HME	LE	ADD	HMAS	HMNAS	LAS	LNAS	ADD	AS	NAS
Psychoticism											
Total	3.46	2.10	2.43	3.46	2.19	1.50	2.17	3.0	3.46	2.18	2.60
Males	4.33	2.54	3.0	4.33	2.58	2.0	2.80	3.25	4.33	2.65	3.0
Females	1.50	1.78	2.23	1.50	1.87	1.33	2.0	2.86	1.50	1.94	2.40
Extraversion											
Total	8.38	7.42	8.94	8.38	7.37	7.75	8.75	9.36	8.38	8.02	8.93
Males	9.44	8.0	7.67	9.44	7.83	10.0	8.40	6.75	9.44	8.0	7.40
Females	6.0	7.0	9.38	6.0	7.0	7.0	8.84	10.90	6.0	8.03	9.70
Neuroticism											
Total	5.62	4.10	5.69	5.62	3.63	7.25	5.75	5.55	5.62	4.63	6.0
Males	4.67	3.23	5.44	4.67	2.92	7.0	6.0	4.75	4.67	3.82	5.20
Females	7.75	4.72	5.77	7.75	4.20	7.33	5.68	6.0	7.75	5.03	6.40
Lie											
Total	2.46	4.58	4.29	2.46	4.48	5.25	4.50	3.82	2.46	4.49	4.20
Males	2.56	3.69	3.89	2.56	3.83	2.0	3.80	4.0	2.56	3.82	3.60
Females	2.25	5.22	4.42	2.25	5.0	6.33	4.68	3.71	2.25	4.82	4.50

Note. Abbreviations for Group Set 1 refer to Addicted (ADD), high/medium engagement (HME), and low engagement (LE). Group Set 2: high/medium engagement with symptoms of addiction (HMAS), high/medium engagement with no symptoms (HMNAS), low engagement with symptoms (LAS), low engagement with no symptoms (LNAS). Group Set 3: sub-clinical group (AS), non-clinical group (NAS).

Group Set 1 analyses. One-way ANOVAs were conducted for Group Set 1 on the EPQ-R short scales scores (see Appendix S, Table S1). The main effect of Group on Lie scale score was significant, $F(2, 76) = 3.10, p < .05$. Tukey HSD post hocs indicated that the HME group and LE group had significantly greater tendencies to fake good compared to the ADD group ($ps < .05$). The main effects for Extraversion and

Neuroticism scale scores did not reach significance. However, a trend was established for Group on Psychoticism scores, $F(2, 76) = 3.10, p = .051$, with post hoc tests revealing that the ADD group had a significantly greater level of Psychoticism than the HME group ($p < .05$) (see Appendix S, Table S2).

Group Set 2 analyses. One-way ANOVAs conducted for Group Set 2 (see Appendix S, Table S1) showed the main effect of Group for Extraversion and Neuroticism did not reach significance, however there was a trend towards significance for the main effect of Group for Psychoticism, $F(4, 74) = 2.18, p = .079$ and Lie scale, $F(4, 74) = 2.26, p = .071$. Although the ADD group had the highest Psychotocism score and the HMNAS group the lowest, no significant post hocs were established between groups. Post hoc analysis revealed that for the Lie scale, as observed in Table 26, there was a trend towards a significant difference between the ADD group and the HMAS and LAS groups. The ADD group was less likely to over report positive responses (fake good) than the HMAS ($p = .086$) and LAS ($p = .092$) groups (see Appendix S, Table S2).

Group Set 3 analyses. The main effect of Group on scores on the Psychotocism, $F(2, 76) = 3.15, p < .05$ and Lie, $F(2, 76) = 2.26, p < .05$ scales were significant (see Appendix S, Table S1). Follow up post hocs revealed the ADD group had a significantly higher level of Psychoticism, and thus psychopathology, and were significantly less likely to give socially desirable responses (Lie score) than the sub-clinical AS group ($p < .05$) (see Appendix S, Table S2). No significant main effects for Group were established for the mean scores on the Extraversion or Neuroticism scales.

Summary of Personality Results

None of the three continuum hypotheses were supported by personality differences established between groups in any of the Group Sets. Rather, only a dichotomous distinction was found between the greater level of psychotocism experienced by the Addicted group compared to other groups that did not meet a diagnosis of addiction. The level of psychotocism reported by the Addicted group however was not of clinical significance, as it did not differ significantly from the normative mean. Traits of extraversion and neuroticism did not significantly differ between groups. In relation to the tendency to "fake good", the Addicted group were significantly less likely to give socially desirable responses than participants with either a high or low level engagement or sub-clinical level of addiction. The tendency for participants in these groups to "fake good" was not in a range that would question the validity of the results.

Psychopathology (SCL-90-R)

Mean scores were calculated for all groups in each of the three Group Sets according to responses to the SCL-90-R primary and global indices scales. As shown in Table 27 (primary scales) and Table 28 (global indices scales), across all scales the T scores calculated for the ADD group were higher than the other groups in each of the three Group Sets. Furthermore, scores on the Obsessive Compulsive and Interpersonal Sensitivity scales were close to a T score of 70 (98^{th} percentile) for the ADD group, suggesting that this group experienced a significant level of psychological dysfunction in these two respective areas. All scores were in the normal range for Group Set 1 HME and LE groups, Group Set 2 groups; HMAS, HMNAS, LAS, and LNAS, and the non-clinical NAS and sub-clinical AS groups in Group Set 3.

Table 27

Mean Scores on the Primary Scales of the SCL-90-R for each Group in Group Set 1, Group Set 2 and Group Set 3 (n=80)

	Primary scales								
Group Sets	SOM	OC	IS	DEP	ANX	HOS	PHO	PAR	PSY
Set 1[a]									
ADD[b]	58.92	69.0	68.0	66.62	61.46	58.31	56.46	62.69	66.15
HME[c]	53.78	58.81	56.47	55.84	53.22	52.66	53.72	54.44	55.50
LE[d]	56.09	59.49	57.37	58.31	53.06	53.09	51.29	52.37	56.89
Set 2[a]									
ADD[b]	58.92	69.0	68.0	66.62	61.46	58.31	56.46	62.69	66.15
HMAS[e]	53.48	58.33	55.78	55.78	53.0	52.41	52.33	53.41	55.93
HMNAS[f]	55.40	61.40	60.20	56.20	54.40	54.0	61.20	60.0	53.20
LAS[g]	57.88	60.46	57.83	59.08	53.42	54.08	51.50	52.0	58.17
LNAS[h]	52.18	57.36	56.36	56.64	52.27	50.91	50.82	53.18	54.09
Set 3[a]									
ADD[b]	58.92	69.0	68.0	66.62	61.46	58.31	56.46	62.69	66.15
AS[i]	55.55	59.33	56.75	57.33	53.20	53.20	51.94	52.75	56.98
NAS[j]	53.19	58.63	57.56	56.50	52.94	51.88	54.06	55.31	53.81

Note Abbreviations within the table refer to the following groups; Group Set 1: addicted (ADD), high/medium engagement (HME), and low engagement (LE). Group Set 2: addicted (ADD), high/medium engagement who did endorse addictive symptoms (HMAS), high/medium engagement who did not endorse any addictive symptoms (HMNAS), low engagement who did endorse addictive symptoms (LAS), low engagement who did not endorse any addictive symptoms (LNAS). Group Set 3: addicted (ADD), sub-clinical group with some symptoms of addiction (AS), non-clinical group with no symptoms of addiction (NAS).

[a]*n* = 80. [b]*n* = 13. [c]*n* = 32. [d]*n* = 35. [e]*n* = 27. [f]*n* = 5. [g]*n* = 24. [h]*n* = 11. [i]*n* = 51. [j]*n* = 16.

Table 28

Mean Scores on the SCL-90-R Global Indices Scales of each Group in Group Set 1, Group Set 2 and Group Set 3 (n=80)

	Global indices		
Group sets	Global severity	Positive symptom distress index	Positive symptom total
Set 1[a]			
ADD[b]	67.23	60.23	65.54
HME[c]	56.63	52.22	57.25
LE[d]	57.69	52.91	58.31
Set 2[a]			
ADD[b]	67.23	60.23	65.54
HMAS[e]	56.22	51.96	56.81
HMNAS[f]	58.8	53.6	59.6
LAS[g]	58.38	53.58	58.96
LNAS[h]	56.18	51.45	56.91
Set 3[a]			
ADD[b]	67.23	60.23	65.54
AS[i]	57.24	57.82	52.73
NAS[j]	57.0	57.75	52.13

Note. Abbreviations within the table refer to the following groups; Group Set 1· addicted (ADD), high/medium engagement (HME), and low engagement (LE). Group Set 2: addicted (ADD), high/medium engagement who did endorse addictive symptoms (HMAS), high/medium engagement who did not endorse any addictive symptoms (HMNAS), low engagement who did endorse addictive symptoms (LAS), low engagement who did not endorse any addictive symptoms (LNAS). Group Set 3: addicted (ADD), sub-clinical group with some symptoms of addiction (AS), non-clinical group with no symptoms of addiction (NAS).
[a]n = 80. [b]n = 13 [c]n = 32. [d]n = 35. [e]n = 27. [f]n = 5. [g]n = 24. [h]n = 11. [i]n = 51. [j]n = 16.

Group Set 1 analyses. One way ANOVAs were calculated for scores on the primary and global indices scales scores (see Appendix S, Table S3). Significant main effects of Group were found on the following primary scale scores; Obsessive

Compulsive, $F(2, 77) = 6.80$, $p < .01$; Interpersonal Sensitivity, $F(2, 77) = 6.21$, $p < .01$; Depression, $F(2, 77) = 5.43$, $p < .01$; Anxiety, $F(2, 77) = 3.87$, $p < .05$; Paranoid Ideation, $F(2, 77) = 4.77$, $p < .05$; and Psychoticism, $F(2, 77) = 4.90$, $p < .01$. The main effect of Group for Somatization, Hostility, and Phobic Anxiety scale scores were not found to be significant. Significant main effects were established for all three global indices scores; Global Severity Index, $F(2, 77) = 5.88$, $p < .01$; Positive Symptom Distress Index, $F(2, 77) = 4.81$, $p < .05$; and Positive Symptom Total, $F(2, 77) = 4.15$, $p < .05$.

Figure 23 presents the scores obtained by each group on these global indices (as depicted in Table 28). Tukey HSD post hoc tests revealed that the ADD group experienced significantly greater symptoms than the LE group and HME group for the following psychopathology; Obsessive Compulsive symptoms (*p*s < .01), Interpersonal Sensitivity (*p*s < .01), Depression ($p < .05$, $p < .01$, respectively), Anxiety (*p*s < .05), Paranoid Ideation ($p < .01$, $p < .05$, respectively), and Psychoticism ($p < .05$, $p < .01$, respectively) (see Appendix S, Table S4).

The Global Severity Index Scale equates to depth of the disorder experienced, with depth representing the number of symptoms reported and intensity of perceived distress experienced. Post hoc tests indicated that this index was significantly elevated for the ADD group compared to LE and HME groups (*p*s < .01), suggesting that the ADD group experienced a greater depth of psychopathology. As can be seen in Figure 23, the ADD group experienced significantly greater symptom intensity as calculated by Positive Symptom Distress Index scores, and a significantly greater level of distress from the symptoms they experience compared to the LE and HME groups (*p*s < .05). Additionally, significant differences found between groups' scores on the Positive Symptom Total index, revealed that the ADD group endorsed a significantly greater number of symptoms in comparison to the LE and HME groups (*p*s < .05) (see Appendix S, Table S4).

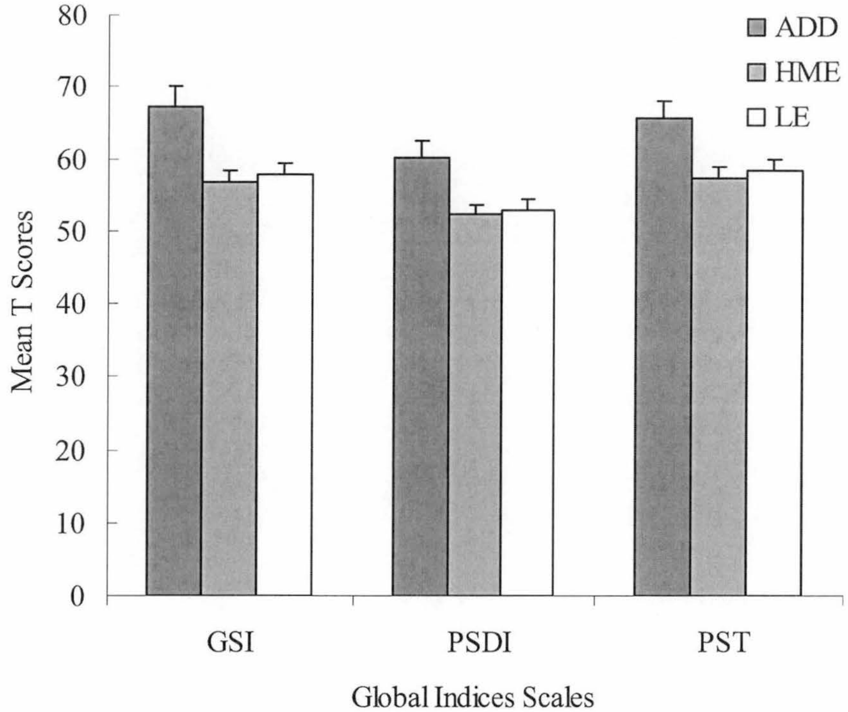

Figure 23. The mean T scores calculated for the Addicted (ADD), High/Medium Engagement (HME) and Low Engagement (LE) groups in Group Set 1 on the SCL-90-R Global Indices Scales: Global Severity Index Scale (GSI), Positive Symptom Distress Index Scale (PSDI), and Positive Symptom Total Index (PST). Vertical lines represent standard errors of the means.

Group Set 2 analyses. One-way ANOVAs were performed on the primary scales (see Table 27) and global indices scales (see Table 28) scores on the SCL-90-R (see Appendix S, Table S3). Significant main effects of Group were established on the following primary scales; Obsessive Compulsive symptoms, $F(4, 75) = 3.73, p < .01$; Interpersonal Sensitivity, $F(4, 75) = 3.28, p < .05$; Depression, $F(4, 75) = 2.78, p < .05$; Paranoid Ideation, $F(4, 75) = 2.83, p < .05$; and Psychoticism, $F(4, 75) = 2.77, p < .05$. The main effect established for Group in Group Set 1 on Anxiety scores did not reach significance for groups in Group Set 2. Consistent with Group Set 1 results, no significant main effects of Group were found for Group Set 2 on Somatization, Hostility, and Phobic Anxiety scale scores. One-way ANOVAs also revealed significant main effects for Group on two global indices scale scores (see Figure 24), specifically the measure of global severity (GSI), $F(4, 75) = 3.05, p < .05$ and symptom intensity (PSDI), $F(4, 75) = 2.53, p < .05$. A trend was established for the number of symptoms experienced (PST), $F(4, 75) = 2.24, p = .073$.

Tukey HSD tests indicated that the ADD group had higher scores on Obsessive Compulsive symptoms and Interpersonal Sensitivity compared to the LAS (*p*s < .05), LNAS (at $p < .05$ and $p = .062$, respectively) and HMAS (*p*s < .01) groups. The ADD group was also found to have significantly higher Depression and Psychoticism scores compared to the HMAS group (*p*s < .05), with a trend towards significance also established between lower levels of Psychoticism reported by the LNAS group ($p = .055$). The ADD group had significantly higher scores on Paranoid Ideation compared to the LAS group ($p < .05$) and the HMAS group tended towards significantly lower mean scores than the ADD group ($p = .070$) (see Appendix S, Table S4).

As shown in Figure 24, and supported by Tukey post hoc tests, the ADD group experienced a significantly greater depth of dysfunction with greater distress (GSI), greater symptom intensity (PSDI) and a greater breathe of symptomatology (PST) compared to the HMAS group (*p*s < .05). A trend was also established between higher global severity scores recorded for the ADD group compared to the LNAS ($p = .057$) and LAS ($p = .078$) groups (see Appendix S, Table S4).

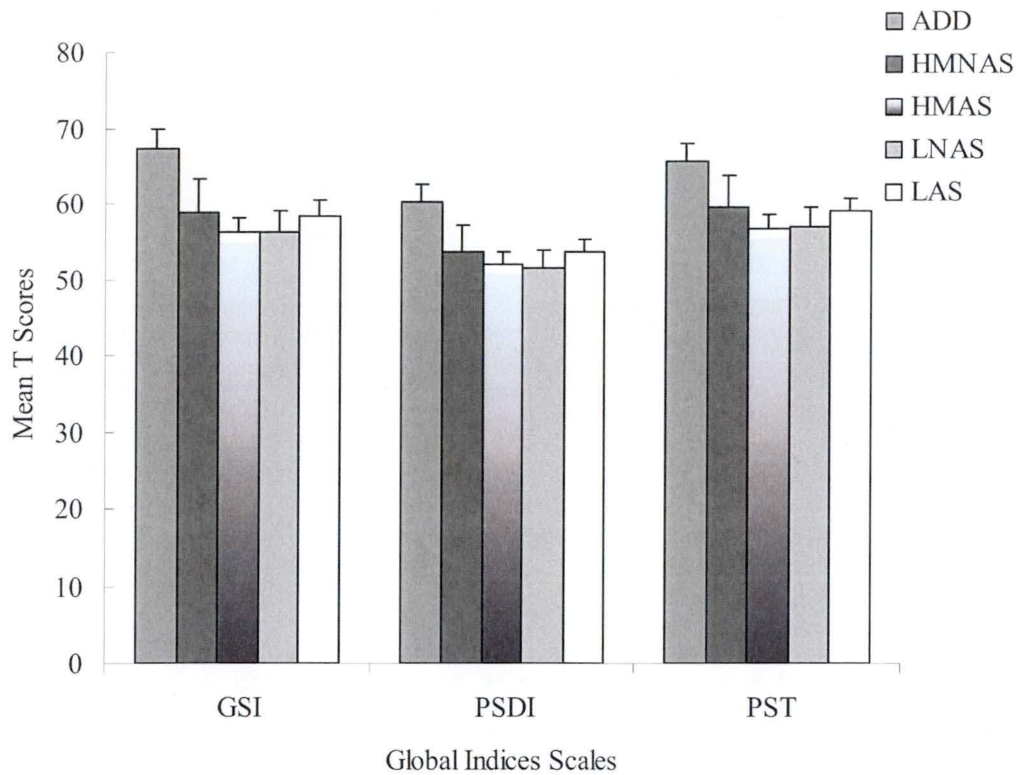

Figure 24. The mean T scores calculated for groups in Group Set 2 on each of the SCL-90-R Global Indices Scales; Global Severity Index Scale (GSI), Positive Symptom Distress Index Scale (PSDI), and Positive Symptom Total Index (PST). Group Set 2 groups include the Addicted (ADD), High/Medium Engagement group with some symptoms of addiction (HMAS), High/Medium Engagement group with no symptoms of addiction (HMNAS), Low Engagement group with some symptoms of addiction (LAS), and Low Engagement group with no addictive symptoms endorsed (LNAS). Vertical lines depict standard errors of the means.

Group Set 3 analyses. One way ANOVAs performed on the SCL-90-R primary scale scores (see Appendix S, Table S3) established a significant main effect of Group on the following scales; Obsessive Compulsive, $F(2, 77) = 6.79, p < .01$; Interpersonal Sensitivity, $F(2, 77) = 6.18, p < .01$; Depression, $F(2, 77) = 4.90, p < .01$; Anxiety, $F(2, 77) = 3.88, p < .05$; Paranoid Ideation, $F(2, 77) = 4.82, p < .05$; and Psychoticism,

$F(2, 77) = 5.35, p < .01$. In relation to scales assessing symptoms of somatization, hostility, and phobic anxiety, one-way ANOVAs revealed that Groups did not significantly differ according to these areas of psychopathology. Consistent with Group Set 1 and Group Set 2 results, analysis of scores on each of the global indices scales revealed significant main effects for Group on the Global Severity Index scale, $F(2, 77) = 5.77, p < .01$; Positive Symptom Distress Index, $F(2, 77) = 4.78, p < .01$; and Positive Symptom Total scale, $F(2, 77) = 4.02, p < .05$.

Follow up Tukey HSD tests revealed that the ADD group experienced a significantly greater level of dysfunction than the NAS and AS groups in relation to symptoms of Obsessive Compulsive ($ps < .01$), Interpersonal Sensitivity ($p < .05$, $p < .01$ respectively), Depression ($p < .05, p < .01$, respectively) and Psychoticism ($p < .01, p < .05$, respectively). The ADD group had a significantly higher Anxiety scale score than the AS group ($p < .05$), with a trend towards significance established with the less anxious NAS group ($p = .060$). A significant difference in level of paranoid ideation ($p < .01$) was established between the ADD and lower scoring AS group, and although the NAS group endorsed fewer paranoid ideation symptoms when compared to the ADD group the difference was not significant (see Appendix S, Table S4).

As shown in Figure 25, and confirmed by post hocs analyses, the ADD group had a significantly greater level of dysfunction and accompanying level of distress (GSI) than the NAS and AS groups ($p < .05, p < .01$ respectively) and greater distress from symptoms experienced (PSDI) ($ps < .05$). It was also established that the ADD group had a significantly greater breadth of symptomatology (PST) than the AS group, and a trend towards significance was established for the comparative difference with the NAS group ($p = .059$) (see Appendix S, Table S4).

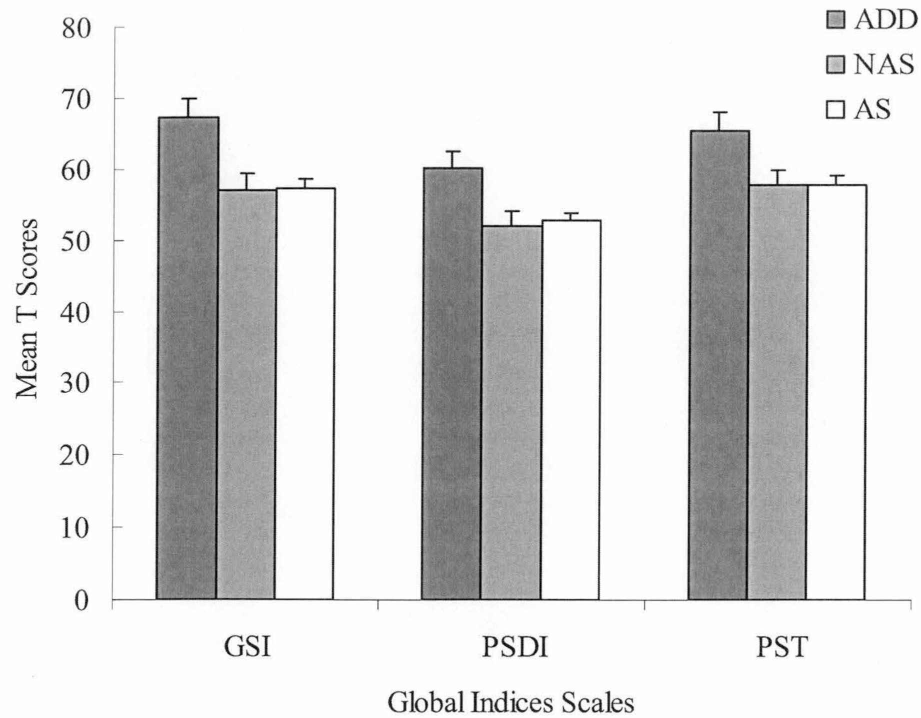

Figure 25. Mean T scores of Group Set 3 on each of the SCL-90-R Global Indices Scales; Global Severity Index Scale (GSI), Positive Symptom Distress Index Scale (PSDI), Positive Symptom Total Index (PST) for the Addicted (ADD), non-clinical group with no symptoms of addiction (NAS) and sub-clinical group with some symptoms of addiction (AS). Vertical lines depict standard errors to the means.

Summary of Psychopathology Results

The overall results indicate that the Addicted group had a greater level of psychopathology, particularly for symptoms of obsessive compulsiveness and interpersonal sensitivity which closely approximated a level of clinical dysfunction, with little differentiation for somatisation, hostility or phobia anxiety symptoms. The Addicted group endorsed significantly more symptoms of obsessive compulsiveness, interpersonal sensitivity, depression, anxiety, paranoid ideation and psychoticism, and had greater depth of dysfunction (GSI), more positive response style (PSDI) and overall experienced more symptoms (PST) compared to participants with high/medium and lower levels of engagement, and those with a sub-clinical and non-clinical level of addiction.

Discussion

The results of the present study showed that participants meeting the criteria for the proposed behavioural addictions, had a significantly higher level of psychoticism, were less likely to give socially desirable responses, and experienced greater psychological distress and symptoms of psychopathology. It was expected that results would reflect findings reported by researchers studying adults with substance abuse, pathological gambling, and Internet use (e.g., Blaszczynski et al., 1985; Blaszczynski & McConaghy, 1988; Yang et al., 2005) given that items assessing addiction measure dimensions of psychopathology. However, a lower level of dysfunction, similar to that of excessive Internet users investigated by Yang et al., was experienced by addicted participants in this study. The results suggest that although participants with these proposed behavioural addictions differed to participants with lower engagement and/or addiction symptomatology, a dichotomous distinction rather than continuum of pathology was established between groups. The personality and psychopathology scores of the addicted sample were also outside the clinical range, barring the number of symptoms of obsessive compulsiveness and interpersonal sensitivity that closely approximated clinical significance comparative to normative data.

In relation to personality differences, participants meeting a diagnosis of addiction had a significantly greater level of psychoticism than those with high engagement (in excess of eleven hours per week), and a sub-clinical level of addiction. The psychoticism scores of participants with sub-clinical addiction did not significantly differ from those with non-clinical behaviour, nor were there any significant differences between participants with high compared to low engagement. High psychoticism, indicative of pathology, has been associated with substance addiction and pathological gambling, however such scores have predominately accompanied elevated neuroticism (Blaszczynski et al., 1985) and extraversion (Arai et al., 1997). Contrary to past research on pathological gambling and alcoholism, the Addicted group in the present study did not differ significantly from other groups in relation to traits of extraversion or neuroticism. The results therefore appear to be more consistent with Kestenbaum and Weinstein's (1985) sample of adolescent high frequency video-arcade game players, who showed no significant differences on either extraversion or neuroticism dimensions. Individuals with exercise addiction have also been found in past research to score similarly to controls on measures of extraversion (Mathers & Walker, 1999).

Impulsivity and sensation seeking were not directly examined in the present study as current diagnostic measures assess physical activity rather than non-physical virtual sensation seeking, which is more related to computer game and Internet use (Chou et al., 2005). As an alternative to such assessment measures, level of impulsivity was inferred by scores on personality dimensions. Despite Blaszczynski, Stell, and McConaghy's (1997) findings of high correlations between impulsivity and EPQ-R Psychoticism and Neuroticism scales and SCL-90-R Positive Symptom Total score, in the present study no significant differences in neuroticism were found, nor was the level of psychoticism or total number of clinical symptoms endorsed within the clinical range for the Addicted group. As significant differences in extraversion were also not established between the Addicted group and remaining groups, the overall results question whether addicted participants in the present study were impulsive. As there was only one pathological gambler included in the Addicted group, it could be proposed that this non-clinical community sample of university students with addiction to the video-arcade games, computer games, and/or Internet differ to more externalizing pathological gamblers in terms of underlying personality (extraversion, neuroticism), impulsivity, sensation seeking and risk taking (Blaszczynski et al., 1997; Brown, 1986; Brown et al., 2004; Langewisch & Frisch, 1998; Moodie & Finnigan, 2005; Petry, 2001; Powell et al., 1999; Zuckerman, 1979). Similarly, risk-taking has been extensively reported among pathological gamblers in past research, however this relationship has not been associated as strongly with videogame play (Wood, Gupta et al., 2004) or Internet gambling (Parke & Griffiths, 2001).

Differences in the psychopathology of groups reported in Study 4 are consistent with past research. Participants in the Addicted group were found to have elevated symptoms of obsessive compulsiveness, interpersonal sensitivity, depression, anxiety, paranoid ideation and psychotocism (Blaszczynski & McConaghy, 1988; Cunningham-Williams et al., 1998). However, contrary to pathological and problem gamblers in the community (Cunningham-Williams et al., 1998) and inpatient settings (Blaszczynski & McConaghy, 1988) the present sample of addicted participants did not experience greater somatisation, hostility or phobic anxiety. Similarly, the study by Yang et al. (2005) investigating Korean high school students (mean age 16.2 years) with nil, minimal, moderate and excessive Internet use, revealed excessive users had higher scores across SCL-90-R scales with the exception of paranoid ideation, global severity and level of distress regarding positive symptoms (PSDI score), while no significant differences were established between those with lower levels of engagement.

Although the psychological presentation of the Addicted group did not reach clinical status, it appears that experiencing more symptoms and greater severity of psychopathology is a defining characteristic, or predisposing factor, for developing addiction, separating addiction from sub-clinical and non-clinical (no symptoms) addiction. In light of the absence of an effect of sub-clinical addiction or high engagement, it could be argued that symptoms of psychopathology are a result of addiction. The present non-clinical population of university students may not be representative of samples of pathological gamblers used in past research. Past studies have primarily included older adults and clinical populations receiving treatment (e.g., Ibánez et al., 2001). Greater severity of psychopathology is associated with increasing age (González-Ibáñez, Mora, Gutiérrez-Maldonado, Ariza, & Lourido-Ferreira, 2005) and prevalence of co-morbid psychiatric diagnoses is linked to the severity of the addictive behaviour (Ibánez et al., 2001).

Overall, the Addicted sample had a significantly greater level of psychoticism, psychological symptoms (and accompanying level of distress) and was significantly less likely to report socially desirable responses when compared to participants in the non-clinical and sub-clinical groups. Despite these results, the personality and psychopathology composition of the Addicted group did not represent an abnormal level of dysfunction. In summary, personality and psychopathology measures do not index a continuum of addiction and/or high/medium engagement, rather they establish a more dichotomous distinction between non-addicted samples (non-clinical and sub-clinical and low and high/medium engagers) and the Addicted group.

CHAPTER 12

General Discussion and Conclusion

This series of studies has provided a comprehensive examination of a broad range of activities thought to be potentially addictive, due to their ability to induce desired changes in both physiological arousal and subjective experience. Activities examined in this research project pertain specifically to gambling, video-arcade games, computer games, and the Internet. The study investigated whether engagement in these activities exists on a continuum with addiction, and the existence of a combined continuum of engagement and addiction symptomatology. A multilevel classification system similar to that developed by Shaffer and Hall (1996), was modified in the present studies to examine three incremental stages on the continuum of addiction symptomatology; non-clinical (no symptoms of addiction), sub-clinical (some symptoms) and clinical addiction. The thesis aimed to investigate whether the continuum hypothesis of addiction applies to these potentially addictive activities, and whether high engagement also exists on this continuum prior to the onset of clinical addiction. Studies 2 and 3 were the first psychophysiological studies of video-arcade game, computer game and Internet addiction. These studies established that trait markers for substance addiction also index sub-clinical and clinical addiction to the behavioural activities investigated, which has further implications for the existence of a single underlying addiction syndrome and notion of a general tendency to become addicted.

Study 1 indicates that there has been a shift in the interests of school-age and university students identified in previous studies (i.e., gambling and video-arcade games) to the present study where computer games and the Internet were more popular, consistent with findings reported by Griffiths and Hunt (1998). Furthermore, a higher prevalence of sub-clinical and clinical addiction to computer games and the Internet was established compared to off-line gambling and video-arcade games. There has also been an increase in the prevalence of sub-clinical computer game and Internet addiction compared to past research (e.g., Chih-Hung et al., 2005; Chou & Hsiao, 2000; Johansson & Gatestam, 2004). Youth who have a high/medium level of engagement in excess of 11 to 15 hours per week, and engage in the activities as a means of escaping negative feelings, were found to be more likely to be addicted to video-arcade games, computer games and the Internet. In accordance with past research, regular weekly participation was found to significantly predict video-arcade game addiction only (e.g., Fisher, 1994), whilst being male accounted for a significant proportion of variance in computer game addiction (Johansson & Gatestam, 2004). Internet addiction was significantly predicted by participation in interactive two-way Internet media, including participation in chat rooms, on-line games and gambling media. As the 95% confidence intervals of the odds ratio for each respective behavioural addiction were below one, results should generalize to a wider population of Australian youth. Similar to Young's (1998) findings on youth Internet addiction, a proportion of students addicted to video-arcade games, computer games and the Internet, were found to have spend the equivalent of full-time employment hours participating in each activity. Also of concern, a proportion of primary school students endorsed experiencing problems with limiting their behaviour and playing on-line games which both have been significantly associated with addiction.

Unfortunately no gold standard definition of behavioural addiction exists, nor does a valid set of criteria to assess addiction to activities other than gambling. Despite these shortcomings, the use of a multilevel classification system in Study 1 provided an opportunity to examine differences between participants with a non-clinical, sub-clinical and clinical level of addiction and associated risk factors for each stage on the continuum of addiction symptomatology. Of importance to future programs tailored at preventing youth behavioural addiction, the present study established that playing games or going on-line weekly for longer than 11 to 15 hours a week, participating for longer than intended and during time allocated for homework, are potential risk factors for sub-clinical addiction. Specific risk factors for behavioural addiction found by Study 1 were; engaging in more interactive based Internet media and on-line games, high engagement, preference for participating in the activity over spending time with friends and family, and engagement as a means of escaping pre-existing problems (e.g., depression).

In relation to Internet behaviour, previous research by Niemz et al. (2005) and Wang (2001) suggests that students enrolled in 'hard sciences' (e.g., engineering) typically spend longer on-line compared to students studying 'soft science' (i.e., psychology). The present sample of university students may therefore not give a true representation of the level of participation or prevalence of sub-clinical or clinical Internet addiction among university students or addiction to other activities assessed, as the sample consisted of mainly first year psychology students. Additionally, the use of 'off-line' questionnaires to assess Internet addiction to reduce sampling biases would have attracted fewer Internet addicts. This is consistent with the overall results for each activity investigated, which suggest this sample of students experience fewer serious symptoms of addiction to each activity; fewer withdrawal and tolerance symptoms, less disruption to interpersonal relationships and education due to their engagement, fewer lies and deception of the extent of their involvement and less indication of financial bail-out (assessed for gambling and video-arcade games only).

Results from Study 2 provide psychophysiological support for the validity of sub-clinical and clinical addiction to behavioural activities; gambling, video-arcade games, computer games, and the Internet. P3a amplitude was found to index significantly the dichotomous distinction between individuals with no addictive symptoms, compared to those with either a sub-clinical or clinical level of addiction. P3a amplitude however did not index level of engagement in activities, with little amplitude difference between participants with high engagement and low engagement. As P3b is a genetically mediated ERP component which indexes CNS disinhibition, it was expected that individuals with both sub-clinical and clinical addiction would show sequentially greater reductions in P3b amplitude. Contrary to the continuum hypothesis of addiction, reductions in the P3b amplitude of sub-clinical and addicted samples were similar, with both significantly lower than that of individuals with no symptoms of addiction. Similar to P3a results, P3b amplitude results suggest that a dichotomous distinction rather than a continuum of addiction symptomatology exists, whereby the level of cognitive resources available to process target stimuli, is reduced in participants who experience some symptoms of addiction, regardless of whether a diagnosis of addiction is met.

These results cast in doubt previous research employing dichotomous measures of addiction, that collectively group sub-clinical and non-clinical individuals in the one 'non-addicted' group, as the present study suggests that individuals with sub-clinical addiction are more similar to those meeting a diagnosis of addiction. Moreover, results on P3b amplitude suggest that this dichotomous distinction also applies to differences in one's level of engagement in activities, as individuals with high/medium level of engagement and/or sub-clinical addiction had significantly lower P3b amplitude compared to participants with no symptoms of addiction and/or a low level of engagement. It is however possible that the absence of any differences between the sub-clinical and addicted group was due to the cut off score for addiction being too low on the diagnositic measures employed in the study.

Contrary to the hypotheses of Study 3, no MMN amplitude differences were established among groups according to the continuum of engagement, combined continuum of addiction and engagement or continuum of addiction symptomatology hypotheses. As MMN amplitude indexes impulsivity and extraversion and frontal disinhibition, results from Study 3 therefore question whether these forms of behavioural addiction are indeed similar to substance addiction and pathological gambling, which are associated with impulsivity, externalizing pathology and disorders of disinhibition. It can be argued that addiction to video-arcade games, computer games, and the Internet may represent a subset of non-externalizing behavioural addictions. These results therefore contradict Iacono et al.'s (2003) statement that reductions in P3b amplitude are only present prior to the onset of externalizing disorders and not for non-externalizing disorders. However caution must given to such suggestions, as differences observed between P300 and MMN results may be due to differences in the modalities employed (i.e., visual vs. auditory).

Suggestions that these forms of behavioural addiction are not reflective of externalizing pathology were supported by the results of Study 4. In Study 4 the addicted sample was found not to have significantly elevated levels of extraversion or neuroticism (traits associated with impulsivity), nor was the level of psychoticism in the clinical range. Consistent with results reported in Study 1 that a significant proportion of addicted participants engage in behaviours to escape negative feelings, results in Study 4 suggest that the addicted sample had a significantly higher level of interpersonal sensitivity (near the clinical range), psychological distress and symptoms of psychopathology. Unlike psychophysiological measures (i.e., P3a and P3b assessed in Study 2), measures of personality and psychopathology provide a more traditional dichotomous distinction between non-addicted (non-clinical and sub-clinical) and addicted groups. However, this lower level of pathology could be due to a sampling bias, as Niemz et al.'s (2005) study of Internet addiction, found that students who were enrolled in 'soft sciences' such as psychology, as were the majority of the Addicted group, had lower levels of disordered Internet use compared to those in 'hard sciences' (e.g., engineering).

The current body of research has several strengths, particularly its large sample size of both male and female students, use of a multilevel classification system to differentiate participants with no symptoms of addiction, sub-clinical and clinical levels of addiction. Study 2 employed the most appropriate task paradigm for eliciting robust P3a and P3b components (Hill, Locke, & Steinhauer, 1999; Holguín et al., 1999). Another distinguishing feature of this thesis was that high engagement was not viewed as being equivalent to addiction. Unfortunately, given that participants with high engagement often experience some level of problems due to their involvement, the size of the HMNAS group was small and thus results were often non-significant and may not generalize to other populations. Although activities were grouped together due to sample size limitations, addiction was examined in isolation of alcohol and other substance addictions, thus providing a unique opportunity to study ERP results specifically related to these activities that were not confounded by the presence of co-occurring substance addictions. Furthermore, it was deemed appropriate that the addicted group consist of subjects with different behavioural addictions rather than to just one activity (e.g., Internet addiction) as behavioural addiction was the focus of examination and not addiction to one specific activity.

This thesis has added to the current body of literature on behavioural addiction, through firstly providing information regarding differences between normal, sub-clinical and clinical involvement in activities among a large population of Australian school-age and university students. Secondly, the study identified significant predictors and risk factors of behavioural addiction. Thirdly, psychophysiological evidence for sub-clinical and clinical addiction to a broad range of behaviours (gambling, video-arcade games, computer games, and the Internet) was established. Lastly, the personality and psychopathology characteristics of the addicted sample were found to be similar to previous research on pathological gambling and substance addiction. Exceptions to this were that a lower level of pathology was established among the present community sample of university students, and the addicted sample did not appear to be impulsive.

Results from Studies 2, 3 and 4 suggest that both substance and behavioural addictions are a manifestation of the same underlying syndrome, given that genetic trait markers of substance addiction, and similar personality and psychopathology characteristics, were present among individuals who experienced problems due to their involvement in behavioural activities investigated in the present series of studies. These factors, coupled with a pre-existing predisposition, may therefore interact to contribute to an individual becoming addicted to substances and/or activities. Given that similar genetic risk factors have found to exist among co-twins of sub-clinical and clinical pathological gamblers (Slutske et al., 2000), it is logical that both sub-clinical and addicted samples in this study were found to have reductions in P3b amplitude, suggesting therefore that such psychophysiological differences are not a by-product of addiction, but rather exist prior to the development of clinical addiction.

The notion of an addictive personality type has been marked by controversial debate and conflicting evidence as the majority of assumptions have not been based on empirical data (Cox, 1992; Kerr, 1996; Nathan, 1988; Rozin & Stoess, 1993). Results from this series of studies are consistent with Jacobs (1986) general theory of addiction, as participants who have an underlying predisposition to addiction, appear to seek participation, in order to induce changes in emotions as a mechanism of coping with distress. Intervention programs may best be served by teaching other coping skills and stress management strategies to students with a sub-clinical level of addiction and higher levels of engagement in these activities.

The results reported for the sub-clinical and clinical groups suggest that it is important to differentiate non-clinical, that is participants who experience no symptoms of addiction, from those with a sub-clinical level of addiction and from those who meet a diagnosis of addiction. Although psychophysiological results reported in Study 2 show a dichotomous distinction between participants with no symptoms (non-clinical group) compared to those who experience at least some symptoms of addiction (sub-clinical and clinical groups), results from Study 1 indicate that the frequency and duration of participation differs between all groups with varying levels of addiction symptomatology. Results from Studies 2, 3 and 4 also suggest that psychophysiological measures are a more sensitive measure of addiction and are able to detect more subtle differences between groups, compared to instruments assessing personality and psychopathology dimensions which were not found to differentiate non-clinical and sub-clinical samples. ERPs therefore appear to be able to distinguish individuals with a sub-clinical level of addiction, before the onset of behavioural addiction and accompanying personality and psychological changes.

Results on P3a and P3b amplitude reported in Study 2 suggest that reductions in these ERP components exist prior to the onset of behavioural addiction. Before a conclusion can be drawn regarding whether P3a and P3b index behavioural addiction, the results reported in this study need to be replicated and investigated among different populations, such as a community based sample of adults or young adults who do not attend university. Research in the area would also be furthered by the examination of a broader cluster of ERP components, such as the N400 which has been associated with predisposition to alcoholism (Porjesz & Begleiter, 1995), physiological differences in baseline arousal of sub-clinical and addicted samples, and event-related oscillations underlying ERPs which have previously been found to also index genetic vulnerability to alcoholism (Kamarajan et al., 2006; Rangaswamy, Porjesz, Chorlian et al., 2004).

In addition to psychophysiological measures, neuroscientific research employing fMRI techniques could examine whether the neurophysiology underlying video-arcade game, computer game, and Internet addiction is similar to that of substance addiction and pathological gambling. In light of the similarities between the neurobiology underlying substance addiction and pathological gambling (Bergh, Eklund, Sadersten, & Nordin, 1997; Comings et al., 1996; Ibáñez et al., 2002), later studies could examine whether significant differences in the level of cortical dopamine are also present among samples with sub-clinical and clinical addiction to video-arcade games, computer games, and the Internet.

Given that past researchers have reported reductions in P3b among sub-clinical populations (e.g., Carlson et al., 1999), that reductions in P3a and P3b amplitude act as genetic markers for substance addiction (e.g., Hill et al., 1995; Holguín et al., 1999), that pathological gambling is a genetically mediated disorder (Slutske et al., 2000), and that Study 2 established significant reductions in the P3a and P3b amplitude in participants with a sub-clinical level of behavioural addiction, further research could examine whether a genetic vulnerability exists to developing a broad range of behavioural addictions. This line of research would need to investigate the offspring of parents with computer game and Internet addiction to determine whether reductions in P3a and P3b amplitude are also reduced among these 'at risk' children. If significant reductions were established, genetic research could provide further evidence for the existence of a single underlying addiction syndrome – indexed by the P300 component. Before conclusions can be drawn as to the utility of the P3b as an index of an addiction syndrome (to both activities and substances), research employing longitudinal designs will need to be conducted, controlling for confounding variables know to influence ERP recordings. Studies would need to be based on large sample sizes with equal proportions of male and female participants, and comparisons drawn to controls matched for similar personality and psychopathology characteristics, level of engagement in the activities investigated, intelligence, age and gender.

As research on video-arcade game, computer game, and Internet addiction is relatively lacking, further studies could investigate whether externalizing behaviours positively associated with youth problem gambling are also related to these behavioural addictions. Given that the sample of university students involved in Studies 2, 3 and 4 were screened for externalizing pathology and high substance use, it would be beneficial if later research investigated whether alcohol, tobacco and illicit drug use, antisocial behaviour, sexual behaviour, delinquency, sensation seeking and impulsivity are significantly related to a sub-clinical or clinical level of addiction to each of these potentially addictive activities.

Although results from Study 1 were based on a large sample of male and female students from Grades 4 to 12 from both rural and urban areas in Southern, Northern and North-West Tasmania, future research would benefit from employing a longitudinal design to examine the same group of students over time, to determine if problems persisted after adolescence and/or whether preference and involvement in activities changes with maturity. Assessment of non-essential Internet use compared to essential use and the type of media used (e.g., on-line games, chat-rooms), would also assist in differentiating between academic related work and recreational activity and what specific media students become addicted to (Beard & Wolf, 2001; Lin & Tsai, 2002; Young, 1998). Finally, research that is not limited by time or monetary constraints could use clinical interviews that overcome limitations of screening measures and give equal weighting to symptoms of addiction (Derevensky & Gupta, 2004). Future clinical interviews could assess physical and health consequences of excessive use, such as obesity, exercise regime, eating habits (e.g., skipping meals), sleeping patterns and prevalence of fatigue and exhaustion.

In conclusion the results of these studies generally suggest that a dichotomous distinction, as opposed to strict continuum of pathology, exists between individuals with low engagement and/or no symptoms of addiction, compared to those with a higher level of engagement and/or addiction symptomatology to gambling, video-arcade games, computer games, and the Internet. Results established for P3b amplitude suggest that that there is little difference in the underlying psychophysiology of participants with a high to medium engagement in activities compared to those meeting a diagnosis of addiction. However, it is unclear whether addiction is preceded by a high/medium level of engagement in activities, as participants in the high/medium engagement group predominately experienced a sub-clinical level of addiction.

Results established for P3a, P3b and MMN amplitude suggest that neither sub-clinical nor clinical levels of behavioural addiction are not indexed by pre-attentive bottom-up processing of incoming stimuli. Results also suggest that sub-clinical and addicted samples were not impulsive, nor did they show significant frontal disinhibition (as discussed by Holguín et al., 1999; van der Stelt et al., 1997). A sub-clinical and clinical level of addiction to these activities was found to be indexed by only higher-order, top-down controlled processing, which required the employment of attentional resources to evaluate incoming stimuli. As P3a differences were only established between non-clinical compared to sub-clinical and addicted samples, and MMN results did not reach significance, results from Studies 2 and 3 suggest that fronto-temporal circuitry and the orienting response has a limited role in the manifestation of addiction to these behavioural activities. It appears that hippocampus and cortical neuronal networks in the medial temporal and parietal cortices may play a larger role in behavioural addiction.

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Appendix A

University Sample's Data for Study 1

Table A1

Percentage of University Students (N = 705) from Different Countries of Origin

Country of origin	% Total	Country of origin	% Total
Australia	84.4	Russia	0.3
England	2.6	Sweden	0.3
Malaysia	1.4	Turkey	0.3
Singapore	1.3	Bosnia	0.1
New Zealand	1.1	Brazil	0.1
Sudan	0.9	Cambodia	0.1
Chile	0.7	Czeh Republic	0.1
Korea	0.4	Denmark	0.1
Philippines	0.4	Fiji	0.1
United States of America	0.4	Greece	0.1
South Africa	0.4	Palestine	0.1
Canada	0.3	Papua New Guinea	0.1
China	0.3	Scotland	0.1
East Timor	0.3	Sierre Leone	0.1
Hong Kong	0.3	Spain	0.1
India	0.3	Sri Lanka	0.1
Ireland	0.3	Thailand	0.1
Japan	0.3	Ukraine	0.1
Poland	0.3		

Note. Five students did respond to this item.

Table A2

Percentage of University Students (N = 705) Enrolled in Different University Courses

University course	% Total	University course	% Total
Single degree		Double degree	
Arts	51.0	Arts/ Law	11.9
Science	10.9	Arts / Science	2.8
Education	5.1	Arts / Commerce	2.0
Medicine	4.8	Science / Law	0.6
Social Science	3.4	Science / Commerce	0.4
Commerce	1.3	Arts / Music	0.4
Engineering	1.3	Arts / Computing	0.3
Bachelor of Psychology	0.3	Arts / Education	0.3
Health Science	0.1	Arts / Fine Arts	0.1
Science Graduate Diploma	0.1	Commerce / Information Systems	0.1
Social Work	0.1	Commerce / Law	0.1
Other	0.3	Computing / Information Systems	0.1
		Science / Computing	0.1

Note. Eleven students did respond to this item.

Table A3

Number of Years at Students (N = 705) had Spent at University

No. of years	*n*	% Total
< 1	576	81.7
1	48	6.8
2	48	6.8
> 3	29	4.1

Note. Four students did not respond to this item.

Table A4

Average Hours per Week University Students (N = 705) Spent Studying

Hours of study	*n*	% Total
0 - 5	185	26.2
6 - 10	274	38.9
11 - 15	125	17.7
16 - 20	66	9.4
21 -25	24	3.4
26 - 30	14	2.0
> 30	8	1.1

Note. Nine students did not respond to this item.

Appendix B

School Sample's Data for Study 1

Table B1

Number of Primary and Secondary Schools and Colleges Participating in Study 1 from Urban and Rural Areas, according to their Median Weekly Family Income

Median weekly family income	Primary		Secondary		College	
	Urban (n = 337)	Rural (n = 61)	Urban (n = 625)	Rural (n = 388)	Urban (n = 263)	Rural (n = 88)
\$600 - 699	1	1	-	4	-	-
\$700 - \$799	1	-	-	-	-	-
\$800 - \$999	1	-	4	-	3	2
\$1000 - \$1499	2	-	-	-	-	-

Note. Median weekly family incomes are based on 2001 Census data on Tasmanian regions (Australian Bureau of Statistics, 2001). Median weekly family income for Tasmania was \$700-\$799; Australia \$800-\$999.

Table B2

The Total Number of Students, Males and Females, Participating in Study 1

Grade	Number of Students		
	Total	Male	Female
Primary			
3	16	5	8
4	98	52	46
5	151	75	76
6	115	56	58
Total	380	188	188
Secondary			
7	261	161	100
8	219	143	76
9	196	108	88
10	312	105	207
Total	990	519	471
College			
11	131	62	68
12	196	84	112
13	7	2	5
Total	335	148	186

Table B3

Percentage of Primary, Secondary and College Students with Access to Computers and the Internet at Home and at School

Location	Primary (n = 374)	Secondary (n = 242)	College (n = 371)
Home			
Computer	90.5	90.3	97.9
Internet	69.7	72.5	86.9
School			
Computer	94.5	98.1	98.8
Internet	97.6	97.3	98.5

Appendix C

University Questionnaire

COMPUTER GAME AND INTERNET QUESTIONNAIRE

University Questionnaire

School of Psychology, University of Tasmania

Instructions:

The questionnaire is divided into 5 sections; general information, and computer game, video arcade game, Internet use, and gambling. If you do not engage in one of these activities, leave the section blank and proceed to the next section. For each question please put a tick (✔) in the appropriate box.

PART 1:

1. How old are you (in years)? ____________________________________

2. Are you female or male?
   Female ❐ Male ❐

3. What is your current living arrangement?
   Living alone ❐
   Living with family members ❐
   Living with your partner ❐
   Share accommodation ❐
   Living in a residential college ❐

4. What degree are you currently studying?
   Arts ❐
   Arts Science ❐
   Arts Law ❐
   Science Law ❐
   Science ❐
   Social Science ❐
   Medicine ❐

5. How many years have you been attended University?
   Less than one year ❐
   1 year ❐
   2 years ❐
   3 years or more ❐

6. Approximately, how many hours a week on average do you spend studying (non-contact hours)?
   0-5 hours ❐
   6-10 hours ❐
   11-15 hours ❐
   16-20 hours ❐
   21-25 hours ❐
   26-30 hours ❐
   30 hours or more ❐

7. Please specify your Country of Origin ____________________________________

8. Do you have a computer at home?
   Yes ❐ No ❐

9. If you do have a computer at home, does it have the Internet?
   Yes ❐ No ❐

COMPUTER GAMES

PART 2: Only answer PART 2 if you have played COMPUTER GAMES in your lifetime. For each question please put a tick (✔) in appropriate box.

1. Do you play computer games?
   Yes ❐ No ❐

2. What type of system do you use to play computer games? [Tick as many as apply]
   - Playstation or Playstation2 ❒
   - Miscrosoft XBOX ❒
   - Games on a computer (PC Games / MAC Games) ❒
   - Nintendo (GameCube, GameBoy, SuperNintendo) ❒
   - Games on the Internet ❒
   - Other games that are not listed ❒

3. Are you currently playing a new computer game?
   Yes ❒ No ❒

4. What are the reason(s) behind your computer game use?

Fun and excitement	❒	Boredom or loneliness	❒
Thrill of winning	❒	To test my skills	❒
Recreation and relaxation	❒	To try new things	❒
Entertainment	❒	To use up spare time	❒
Other reasons not listed	❒		

5. How frequently do you play computer games?

Less than once a week	❒	5-6 times a week	❒
1-2 times a week	❒	7 or more times a week	❒
3-4 times a week	❒		

6. How old were you when you first started playing computer games?

Younger than 5 years	❒	15-19 years	❒
5-9 years	❒	20-24 years	❒
10-14 years	❒	25 years or older	❒

7. How many hours a WEEK do you on average spend playing computer games?

Less than 1 hour a week	❒	16-20 hours a week	❒
2-5 hours a week	❒	21-25 hours a week	❒
6-10 hours a week	❒	26-30 hours a week	❒
11-15 hours a week	❒	More than 30 hours a week	❒

8 Do you play computer games during time that you have allocated for studying/ doing University related work?
   Yes ❒ No ❒

9. Do you prefer to play computer games over spending time with your friends/family?
   Yes ❒ No ❒

10. Do you often think about playing or anticipating the next time you can play computer games?
    Yes ❒ No ❒

11. Do you feel the need to play computer games with increasing amounts of time in order to achieve satisfaction/enjoyment?
    Yes ❒ No ❒

12. Have you repeatedly made unsuccessful efforts to control, cut back, or stop playing computer games?
    Yes ❒ No ❒

13. Do you feel restless, moody, depressed, or irritable when attempting to cut down or stop playing computer games?
    Yes ❒ No ❒

14. Do you play computer games longer than originally intended?
    Yes ❒ No ❒

15. Have you jeopardised or risked the loss of a significant relationship, job, educational or career opportunity because of playing computer games?
    Yes ❒ No ❒

16. Have you lied to family members, a therapist, or others to conceal the extent to which you play computer games?
Yes ❒ No ❒

17. Do you play computer games as a way of escaping from problems or relieving feelings of helplessness, guilt, anxiety or depression?
Yes ❒ No ❒

VIDEO ARCADE GAMES

<u>PART 3:</u> Only answer PART 3 if you have played VIDEO ARCADE GAMES in your lifetime. Video arcade games are played on coin-operated machines, eg. games at TimeZone. For each question please put a tick (✓) in the appropriate box.

1. Do you play video arcade games?
Yes ❒ No ❒

2 Why do you play video arcade games? [You can tick more than one reason]

Fun and excitement	❒	Boredom or loneliness	❒
Thrill of winning	❒	To test my skills	❒
Recreation and relaxation	❒	To try new things	❒
Entertainment	❒	To use up spare time	❒

3. How often do you play video arcade games?

Less than once a week	❒	5-6 times a week	❒
1-2 times a week	❒	7 or more times a week	❒
3-4 times a week	❒		

4. How many hours a WEEK do you on average spend playing video arcade games?

Less than 1 hour a week	❒	16-20 hours a week	❒
2-5 hours a week	❒	20-25 hours a week	❒
6-10 hours a week	❒	26-30 hours a week	❒
11-15 hours a week	❒	More than 30 hours a week	❒

5. How old were you when you first started playing video arcade games?

Younger than 5 years	❒	15-19 years	❒
5-9 years	❒	20-24 years	❒
10-14 years	❒	25 years or older	❒

6. Do you play video arcade games during time that you have allocated for studying/ doing University related work?
Yes ❒ No ❒

7. Do prefer to play video arcade games over spending time with your friends/family?
Yes ❒ No ❒

8. As video game playing progresses, do you become more and more preoccupied with relieving past playing experiences, studying video game playing, planning the next opportunity to play, or thinking of ways to get money to play?
Yes ❒ No ❒

9. Do you need to spend more and more money on video arcade games in order to achieve the desired excitement?
Yes ❒ No ❒

10. Do you become restless or irritable when attempting to cut down or stop playing arcade games?
Yes ❒ No ❒

11 Do you play video games as a way of escaping from problems or intolerable feeling states?
Yes ❒ No ❒

12. After spending money or your time playing video games, do you often play another day in order to get a higher score?
Yes ❒ No ❒

13. Have you lied to your family and/or friends to protect and conceal the extent to which you play video arcade games?
    Yes ❐ No ❐

14. Have you committed illegal (eg. stolen) or unaccepted acts in order to finance video game playing?
    Yes ❐ No ❐

15. Have you had disagreements or arguments with family or close friends and jeopardized your education because of video game playing?
    Yes ❐ No ❐

16. Do you need another individual to provide money to relieve a desperate financial situation produced by video game playing?
    Yes ❐ No ❐

INTERNET

PART 4: Only answer PART 4 if you have used the INTERNET in your lifetime. For each question please put a tick (✓) in the appropriate box.

1. Do you use the Internet?
   Yes ❐ No ❐

2. What do you do on the Internet? [Tick as many as apply]
   - WWW Searches/surfing ❐
   - FTP downloading of software ❐
   - Newsgroups/discussion forums ❐
   - E-mail ❐
   - Chat rooms and Internet relay chat (IRC) ❐
   - Play games ❐
   - Gambling (eg. Poker or roulette on the Internet) ❐
   - University related work ❐
   - Cybersex or adult resources ❐
   - Other things not listed ❐

3. Why do you use the Internet? [You can tick more than one reason]
   - Fun and excitement ❐
   - Thrill of winning ❐
   - Recreation and relaxation ❐
   - Entertainment ❐
   - To meet people ❐
   - Boredom or loneliness ❐
   - To test my skills ❐
   - To try new things ❐
   - To use up spare time ❐
   - Other reasons not listed ❐

4. How often do you use the Internet?
   - Less than once a week ❐
   - 1-2 times a week ❐
   - 3-4 times a week ❐
   - 5-6 times a week ❐
   - 7 or more times a week ❐

5. How many hours a WEEK do you on average spend using the Internet?
   - Less than 1 hour a week ❐
   - 2-5 hours a week ❐
   - 6-10 hours a week ❐
   - 11-15 hours a week ❐
   - 16-20 hours a week ❐
   - 20-25 hours a week ❐
   - 26-30 hours a week ❐
   - More than 30 hours a week ❐

6. How old were you when you first started using the Internet?
   - Younger than 5 years ❐
   - 5-9 years ❐
   - 10-14 years ❐
   - 15-19 years ❐
   - 20-24 years ❐
   - 25 years or older ❐

7. Do you use the Internet (for non-academic purposes) during time that you have allocated for studying/ doing University related work?
   Yes ❐ No ❐

8. Do you like to use the Internet more than spending time with your friends/family?
   Yes ❐ No ❐

9. Do you feel preoccupied with the Internet (think about previous on-line activity or anticipate next on-line sessions)?
   Yes ❐ No ❐

10. Do you feel the need use the Internet with increasing amounts of time in order to achieve satisfaction or for it to be enjoyable?
    Yes ❐ No ❐

11. Have you repeatedly made unsuccessful efforts to control, cut back, or stop Internet use?
    Yes ❐ No ❐

12. Do you feel restless, moody, depressed, or irritably when attempting to cut down or stop Internet use?
    Yes ❐ No ❐

13. Do you stay on-line longer than originally intended?
    Yes ❐ No ❐

14. Have you jeopardised or risked the loss of a significant relationship, job, educational or career opportunity because of your Internet use?
    Yes ❐ No ❐

15. Have you lied to family members, a therapist, or others to conceal the extent of your involvement with the Internet?
    Yes ❐ No ❐

16. Do you use the Internet as a way of escaping from problems or relieving feelings of helplessness, guilt, anxiety or depression?
    Yes ❐ No ❐

GAMBLING

<u>PART 5:</u> Only answer PART 5 if you have engaged in GAMBLING activities in your lifetime (including Internet gambling). For each question put a tick (✓) in the appropriate box

1. Do you gamble?
   Yes ❐ No ❐

2. What following types of gambling have you engaged in during your lifetime? [Tick as many as apply]
   - Playing cards for money ❐
   - Betting on horses, dogs or other animals ❐
   - Bet on sports ❐
   - Played dice games for money ❐
   - Went to the Casino (legal or otherwise) ❐
   - Played the numbers or bet on the lottery ❐
   - Played bingo ❐
   - Played the stock and/or commodities market ❐
   - Played slot machines or poker machines ❐
   - Played a game of skill (eg. Pool) for money ❐
   - Other activity not listed ❐

3. Why do you gamble? [You can tick more than one reason]

Fun and excitement	❐	Boredom or loneliness	❐
Thrill of winning	❐	To test my skills	❐
Recreation and relaxation	❐	To try new things	❐
Entertainment	❐	To use up spare time	❐
To meet people	❐	Other reasons not listed	❐
To win money quickly	❐		

4. How often do you gamble?

Less than once a week	❐	5-6 times a week	❐
1-2 times a week	❐	7 or more times a week	❐
3-4 times a week	❐		

5 How many hours a WEEK do you on average spend engaging in gambling activities?

Less than 1 hour a week	❐	16-20 hours a week	❐
2-5 hours a week	❐	20-25 hours a week	❐
6-10 hours a week	❐	26-30 hours a week	❐
11-15 hours a week	❐	More than 30 hours a week	❐

6. Do you engage in gambling during time that you have allocated for studying/ doing University related work?
Yes ❐ No ❐

7. Do you prefer to gamble over spending time with your friends/family?
Yes ❐ No ❐

8. As gambling progresses, do you become more and more preoccupied with relieving past gambling experiences, studying a system, planning the next venue, or thinking of ways to get money?
Yes ❐ No ❐

9. Do you need to gamble with more and more money in order to achieve the desired excitement?
Yes ❐ No ❐

10. Do you become restless or irritable when attempting to cut down or stop gambling?
Yes ❐ No ❐

11 Do you gamble as a way of escaping from problems or intolerable feeling states?
Yes ❐ No ❐

12. After losing money gambling, do you often return another day in order to get even?
Yes ❐ No ❐

13. Have you lied to your family, employers, friends or a therapist to protect and conceal the extent of your involvement with gambling?
Yes ❐ No ❐

14. Have you committed illegal acts, such as forgery, fraud, theft or embezzlement, or unaccepted acts in order to finance gambling
Yes ❐ No ❐

15. Have you jeopardized or lost a significant relationship, marriage, education, job, or career because of gambling?
Yes ❐ No ❐

16. Do you need another individual to provide money to relieve a desperate financial situation produced by gambling?
Yes ❐ No ❐

Appendix D

Primary Questionnaire

COMPUTER GAME AND INTERNET SURVEY

Primary School

School of Psychology, University of Tasmania

Instructions:

For each question please put a tick (✓) in the box that is the correct answer for you.

PART 1:

1. How old are you?

8	☐	11	☐
9	☐	12	☐
10	☐	13	☐

2. Are you a boy or girl?
   Girl ☐ Boy ☐

3. What grade are you in at school?
   4 ☐
   5 ☐
   6 ☐

4. If you have any brothers or sisters, please write down their first names and their ages in order from the oldest to the youngest in the space below. Put a tick next to brothers or sisters who live at home.
   ____

5. Do you have a computer at home?
   Yes ☐ No ☐

6. If you do have a computer at home, does it have the Internet?
   Yes ☐ No ☐

7. Do you use computers at school?
   Yes ☐ No ☐

8. If you have a computer at school, does it have the Internet?
   Yes ☐ No ☐

COMPUTER GAMES

PART 2: **Answer PART 2 if you have played COMPUTER GAMES in your lifetime.** For each question put a tick (✓) in the box that is the correct answer for you.

1. Do you play computer games?
   Yes ☐ No ☐

2. What type of system do you play computer games on? [You can tick more than one]
   Playstation or Playstation2 ☐
   Miscrosoft XBOX ☐
   Games on a computer (PC Games / MAC Games) ☐
   Nintendo (GameCube, GameBoy, SuperNintendo) ☐
   Games on the Internet ☐
   Other games that are not listed ☐

3. Have you got a new computer game that you are playing at the moment?
   Yes ☐ No ☐

4. Why do you play computer games? [You can tick more than one reason]

Fun and excitement	❒	Boredom or no-one to play with	❒
The excitement of winning	❒	To test my skills	❒
To use up free time	❒	To do something different	❒
Entertainment	❒		

5. How often do you usually play computer games?

Less than once a week	❒	5-6 times a week	❒
1-2 times a week	❒	7 or more times a week	❒
3-4 times a week	❒		

6. How many hours a DAY do you usually spend playing computer games?

Less than 1 hour a day	❒	7-9 hours a day	❒
1-3 hours a day	❒	10 or more hours a day	❒
4-6 hours a day	❒		

7. How old were you when you first started playing computer games?

Younger than 5 years	❒	8-10 years old	❒
5-7 years old	❒	11 years or older	❒

8. Do you play computer games without anyone else knowing?
   Yes ❒ No ❒

9. Do you play computer games when you should be doing your homework?
   Yes ❒ No ❒

10. Have you lied to your parents about how long or how often you play computer games?
    Yes ❒ No ❒

11. Do you like to play computer games more than spending time with your friends?
    Yes ❒ No ❒

12. Do you feel a strong need to play computer games, at least a few times a month? This strong need would mean that you would give up important things so that you could play computer games.
    Yes ❒ A little bit ❒ No ❒

13 Does your body feel uncomfortable or restless when you don't play computer games for awhile?
    Yes ❒ A little bit ❒ No ❒

14. When you are playing computer games do you find it hard to stop playing?
    Yes ❒ A little bit ❒ No ❒

15. Do you have to play computer games for longer than before for it to be as much fun?
    Yes ❒ A little bit ❒ No ❒

VIDEO ARCADE GAMES

<u>PART 3:</u> **Only answer PART 3 if you have played VIDEO ARCADE GAMES in your lifetime.** Video arcade games are played on machines that need money, for example the games at TimeZone. For each question please put a tick (✓) in the box that is the correct answer for you.

1. Do you play video arcade games?
   Yes ❒ No ❒

2. Why do you play video arcade games? [You can tick more than one reason]

Fun and excitement	❒	Boredom or no-one to play with	❒
The excitement of winning	❒	To test my skills	❒
Something to do in my free time	❒	To do something different	❒
Entertainment	❒		

3. How often do you usually play video arcade games?
   Less than once a week ❒ 5-6 times a week ❒
   1-2 times a week ❒ 7 or more times a week ❒
   3-4 times a week ❒

4. How many hours a DAY do you usually spend playing video arcade games?
   Less than 1 hour a day ❒ 7-9 hours a day ❒
   1-3 hours a day ❒ 10 or more hours a day ❒
   4-6 hours a day ❒

5. How old were you when first started playing video arcade games?
   Younger than 5 years ❒ 8-10 years old ❒
   5-7 years old ❒ 11 years or older ❒

6. Do you play video arcade games without anyone else knowing?
   Yes ❒ No ❒

7 Do you play video arcade games when you should be doing your homework?
   Yes ❒ No ❒

8. Have you lied to your parents about how long or how often you play video arcade games?
   Yes ❒ No ❒

9. Do like to play video arcade games more than spending time with your friends?
   Yes ❒ No ❒

10. Do you feel a strong need to play video arcade games, at least a few times a month? This strong need would mean that you would give up important things so that you could play computer games.
    Yes ❒ A little bit ❒ No ❒

11. Does your body feel uncomfortable or restless when you don't play video arcade games for awhile?
    Yes ❒ A little bit ❒ No ❒

12. When you are playing video arcade games do you find it hard to stop playing?
    Yes ❒ A little bit ❒ No ❒

13. Do you have to play video arcade games for longer than before for it to be as much fun?
    Yes ❒ A little bit ❒ No ❒

INTERNET

PART 4: Only answer PART 4 if you have used the INTERNET in your lifetime. For each question please put a tick (✓) in the box that is the correct answer for you.

1. Do you use the Internet?
   Yes ❒ No ❒

2 What do you do on the Internet? [You can tick more than one activity]
   WWW Searches ❒
   E-mail ❒
   Use the Chat rooms ❒
   Play games ❒
   Look up things for my school work ❒
   Other things not listed ❒

3. Why do you use the Internet? [You can tick more than one reason]
   Fun and excitement ❒ Boredom or no-one to play with ❒
   The excitement of winning ❒ To test my skills ❒
   Something to do in my free time ❒ To do something different ❒
   Entertainment ❒

4. How often do you usually use the Internet?
   - Less than once a week ❐
   - 1-2 times a week ❐
   - 3-4 times a week ❐
   - 5-6 times a week ❐
   - 7 or more times a week ❐

5. How many hours a DAY do you usually spend using the Internet?
   - Less than 1 hour a day ❐
   - 1-3 hours a day ❐
   - 4-6 hours a day ❐
   - 7-9 hours a day ❐
   - 10 or more hours a day ❐

6. How old were you when you first started using the Internet?
   - 5-6 years ❐
   - 7-8 years ❐
   - 9-10 years ❐
   - 11-12 years ❐

7. Do you use the Internet without anyone else knowing?
   Yes ❐ No ❐

8. Do you use the Internet when you should be doing your homework?
   Yes ❐ No ❐

9. Have you lied to your parents about how long or how often you use the Internet?
   Yes ❐ No ❐

10. Do you like to use the Internet more than spending time with your friends?
    Yes ❐ No ❐

11. Do you feel a strong need to use the Internet, at least a few times a month? This strong need would mean that you would give up important things so that you could play computer games.
    Yes ❐ A little bit ❐ No ❐

12. Does your body feel uncomfortable or restless when you don't play use the Internet for awhile?
    Yes ❐ A little bit ❐ No ❐

13. When you are using the Internet do you find it hard to stop/ log off?
    Yes ❐ A little bit ❐ No ❐

14. Do you have to use the Internet for longer than before for it to be as much fun?
    Yes ❐ A little bit ❐ No ❐

Thank you for filling out this survey

Appendix E

Secondary Questionnaire

COMPUTER GAME AND INTERNET QUESTIONNAIRE

Secondary School

School of Psychology, University of Tasmania

Dear Student,

You have been invited to take part in a study conducted by Naomi Thomas who is supervised by Dr Frances Martin in the School of Psychology at the University of Tasmania. The purpose of the study is to look at the frequency and amount of time school students spend playing computer games and using the Internet. The questions below will ask you about your engagement in these activities. You do not have to participate if you do not wish to, and you may stop at any time. All information that is collected is confidential and only looked at by Dr Frances Martin and Naomi Thomas. Please do not to write your name on the questionnaire.

Thank you for your time

Instructions:

The questionnaire is divided into 4 sections; general information, and computer game, video arcade game and Internet use. If you do not engage in one of these activities, leave the section blank and proceed to the next section. For each question please put a tick (✔) in the appropriate box for you.

PART 1:

1. How old are you?

12	❐	15	❐
13	❐	16	❐
14	❐	17	❐

2. Are you female or male?

Female ❐ Male ❐

3. What grade are you in at school?

7	❐	9	❐
8	❐	10	❐

4. If you have any brothers or sisters, please write down their first names and their ages in order from the oldest to the youngest in the space below. Put a tick next to brother or sisters who live at home.

____

5. Do you have a computer at home?

Yes ❐ No ❐

6. If you do have a computer at home, does it have the Internet?

Yes ❐ No ❐

7. Do you use computers at school?

Yes ❐ No ❐

8. If you have a computer at school, does it have the Internet?

Yes ❐ No ❐

COMPUTER GAMES

PART 2: Only answer PART 2 if you have played COMPUTER GAMES in your lifetime. For each question put a tick (✔) in the box that is the correct answer for you.

1. Do you play computer games?

Yes ❐ No ❐

2. What type of system do you use to play computer games? [Tick as many as apply]

Playstation or Playstation2	❑
Miscrosoft XBOX	❑
Games on a computer (PC Games / MAC Games)	❑
Nintendo (GameCube, GameBoy, SuperNintendo)	❑
Games on the Internet	❑
Other games that are not listed	❑

3. Have you got a new computer game that you are currently playing?
Yes ❑ No ❑

4. Why do you play computer games? [You can tick more than one reason]

Fun and excitement	❑	Boredom or loneliness	❑
The excitement of winning	❑	To test my skills	❑
Relaxation	❑	To try new things	❑
Entertainment	❑	To use up spare time	❑
Other reasons not listed	❑		

5. How often do you play usually computer games?

Less than once a week	❑	5-6 times a week	❑
1-2 times a week	❑	7 or more times a week	❑
3-4 times a week	❑		

6. How many hours a WEEK do you usually spend playing computer games?

Less than 1 hour a week	❑	16-20 hours a week	❑
2-5 hours a week	❑	21-25 hours a week	❑
6-10 hours a week	❑	26-30 hours a week	❑
11-15 hours a week	❑	More than 30 hours a week	❑

7. How old were you when you first started playing computer games?

Younger than 5 years	❑	8-10 years	❑	14-16 years	❑
5-7 years	❑	11-13 years	❑		

8. Do you play computer games when you should be doing your homework?
Yes ❑ No ❑

9. Do you like to play computer games more than spending time with family/friends?
Yes ❑ No ❑

10. Do you often think about playing computer games or the next time you will be able to play computer games?
Yes ❑ No ❑

11. Do you feel you have to play computer games for a longer amount of time than you did in the past to get the same amount of enjoyment?
Yes ❑ No ❑

12. Have you tried more than once to stop or cut down how much you play computer games but it hasn't worked?
Yes ❑ No ❑

13. Do you feel restless or moody when attempting to cut down or stop playing computer games?
Yes ❑ No ❑

14. Do you play computer games longer than you had planned to?
Yes ❑ No ❑

15. Have you risked losing an important relationship (for example with a family member or friend) or has your school work been affected (not done homework or missed school) because of your use of computer games?
Yes ❑ No ❑

16. Have you lied to family members or others so they don't find out how much you play computer games?
Yes ❐ No ❐

17. Do you play computer games as a way of escaping from your problems or stopping yourself from feeling upset?
Yes ❐ No ❐

VIDEO ARCADE GAMES

PART 3: Only answer PART 3 if you have played VIDEO ARCADE GAMES in your lifetime. Video arcade games are played on machines that need money, for example the games at TimeZone For each question please put a tick (✓) in the box that is the correct answer for you.

1 Do you play video arcade games?
Yes ❐ No ❐

2. Why do you play video arcade games? [You can tick more than one reason]
Fun and excitement ❐ Boredom or loneliness ❐
The excitement of winning ❐ To test my skills ❐
Relaxation ❐ To try new things ❐
Entertainment ❐ To use up spare time ❐
Other reasons not listed ❐

3. How often do you usually play video arcade games?
Less than once a week ❐ 5-6 times a week ❐
1-2 times a week ❐ 7 or more times a week ❐
3-4 times a week ❐

4. How many hours a WEEK do you usually spend playing video arcade games?
Less than 1 hour a week ❐ 16-20 hours a week ❐
2-5 hours a week ❐ 20-25 hours a week ❐
6-10 hours a week ❐ 26-30 hours a week ❐
11-15 hours a week ❐ More than 30 hours a week ❐

5. How old were you when you first started playing video arcade games?
Younger than 5 years ❐ 8-10 years ❐ 14-16 years ❐
5-7 years ❐ 11-13 years ❐

6. Do you play video arcade games when you should be doing your homework?
Yes ❐ No ❐

7. Do like to play video arcade games more than spending time with family/friends?
Yes ❐ No ❐

8. When you are playing a video game, do you start to think more and more about past games, learning about how to play video games, planning when you can play next, or thinking of ways to get money to play?
Yes ❐ No ❐

9. Do you need to spend more and more money on video arcade games in order to get excited?
Yes ❐ No ❐

10. Do you become restless when you try to play less or stop playing video arcade games?
Yes ❐ No ❐

11 Do you play video games so that you don't have to think about things that worry you or to stopping yourself from feeling upset?
Yes ❐ No ❐

12. After spending money or your time playing video games, do you often go back and play another day in order to get a higher score?
Yes ❐ No ❐

13. Have you lied to your family or friends so they don't find out how much you play video arcade games?
Yes ❐ No ❐

14. Have you done things that will get you into trouble (eg stolen) in order to get money for video game playing?
Yes ❐ No ❐

15. Have you had arguments with family or close friends and not done as well at school (not done homework or missed school) because of your video game playing?
Yes ❐ No ❐

16. Do you need someone else to give you money so that you can pay back money you borrowed for playing video games?
Yes ❐ No ❐

INTERNET

PART 4: Only answer PART 4 if you have used the INTERNET in your lifetime. For each question please put a tick (✓) in the box that is the correct answer for you.

1. Do you use the Internet?
Yes ❐ No ❐

2. What do you do on the Internet? [Tick as many as apply]
WWW Searches ❐
E-mail ❐
Use the Chat rooms ❐
Play games ❐
Look up things for my school work ❐
Other things not listed ❐

3. Why do you use the Internet? [You can tick more than one reason]
Fun and excitement ❐ Boredom or loneliness ❐
The excitement of winning ❐ To test my skills ❐
Relaxation ❐ To try new things ❐
Entertainment ❐ To use up spare time ❐
Other reasons not listed ❐

4. How often do you usually use the Internet?
Less than once a week ❐ 5-6 times a week ❐
1-2 times a week ❐ 7 or more times a week ❐
3-4 times a week ❐

5. How many hours a WEEK do you usually spend using the Internet?
Less than 1 hour a week ❐ 16-20 hours a week ❐
2-5 hours a week ❐ 20-25 hours a week ❐
6-10 hours a week ❐ 26-30 hours a week ❐
11-15 hours a week ❐ More than 30 hours a week ❐

6. How old were you when you first started using the Internet?
Younger than 5 years ❐ 8-10 years ❐ 14-16 years ❐
5-7 years ❐ 11-13 years ❐

7. Do you use the Internet when you should be doing your homework?
Yes ❐ No ❐

8. Do you like to use the Internet more than spending time with family/friends?
   Yes ☐ No ☐

9. Do think about using the Internet a lot?
   Yes ☐ No ☐

10. Do you feel you need to spend more time using the Internet in order for it to be enjoyable?
    Yes ☐ No ☐

11. Have you tried more that once to stop or cut back on how much you use the Internet but it hasn't worked?
    Yes ☐ No ☐

12. Do you feel restless or upset when you try to cut down or stop using the Internet?
    Yes ☐ No ☐

13. Do you stay on-line longer than originally intended?
    Yes ☐ No ☐

14. Have you risked losing an important relationship (for example with a family member or friend) or has your school work been affected (not done homework or missed school) because of your use of the Internet?
    Yes ☐ No ☐

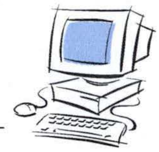
15 Have you lied to family members or others so they don't find out how much you use the Internet?
    Yes ☐ No ☐

16. Do you use the Internet so that you don't have to think about your problems or to stop yourself from feeling upset?
    Yes ☐ No ☐

Thank you for filling out this survey

Appendix F

College Questionnaire



COMPUTER GAME AND INTERNET QUESTIONNAIRE

College Students

School of Psychology, University of Tasmania

Dear Student,

You have been invited to take part in a study conducted by Naomi Thomas who is supervised by Dr Frances Martin in the School of Psychology at the University of Tasmania. The purpose of the study is to look at the frequency and amount of time school students spend playing computer games and using the Internet. The questions below will ask you about your engagement in these activities. You do not have to participate if you do not wish to, and you may stop at any time. All information that is collected is confidential and only looked at by Dr Frances Martin and Naomi Thomas. Please do not to write your name on the questionnaire.

Thank you for your time

<u>Instructions:</u>

The questionnaire is divided into 4 sections; general information, and computer game, video arcade game and Internet use. If you do not engage in one of these activities, leave the section blank and proceed to the next section. For each question please put a tick (✓) in the appropriate box for you.

<u>PART 1:</u>

1. How old are you?
   16 ❐ 18 ❐
   17 ❐ 19 ❐

2. Are you female or male?
   Female ❐ Male ❐

3. What grade are you in at school?
   11 ❐ 12 ❐

4. If you have any brothers and/or sisters, please list their first names and their ages in order from the oldest to the youngest in the space below. Put a tick next to siblings who live at home.

   ____

5. Do you have a computer at home?
   Yes ❐ No ❐

6. If you do have a computer at home, does it have the Internet?
   Yes ❐ No ❐
7. Do you use computers at school?
   Yes ❐ No ❐

8. If you have a computer at school, does it have the Internet?
   Yes ❐ No ❐

COMPUTER GAMES

<u>PART 2:</u> Only answer PART 2 if you have played COMPUTER GAMES in your lifetime. For each question please put a tick (✓) in the appropriate box.

1. Do you play computer games?
   Yes ❐ No ❐

2. What type of system do you use to play computer games? [Tick as many as apply]
   - Playstation or Playstation2 ❒
   - Miscrosoft XBOX ❒
   - Games on a computer (PC Games / MAC Games) ❒
   - Nintendo (GameCube, GameBoy, SuperNintendo) ❒
   - Games on the Internet ❒
   - Other games that are not listed ❒

3. Are you currently playing a new computer game?
   Yes ❒ No ❒

4. What are the reason(s) behind your computer game use?
   - Fun and excitement ❒
   - Thrill of winning ❒
   - Recreation and relaxation ❒
   - Entertainment ❒
   - Other reasons not listed ❒
   - Boredom or loneliness ❒
   - To test my skills ❒
   - To try new things ❒
   - To use up spare time ❒

5. How frequently do you play computer games?
   - Less than once a week ❒
   - 1-2 times a week ❒
   - 3-4 times a week ❒
   - 5-6 times a week ❒
   - 7 or more times a week ❒

6. How old were you when you first started playing computer games?
   - Younger than 5 years ❒
   - 5-8 years ❒
   - 9-12 years ❒
   - 13-16 years ❒
   - 16 years or older ❒

7. How many hours a WEEK do you on average spend playing computer games?
   - Less than 1 hour a week ❒
   - 2-5 hours a week ❒
   - 6-10 hours a week ❒
   - 11-15 hours a week ❒
   - 16-20 hours a week ❒
   - 21-25 hours a week ❒
   - 26-30 hours a week ❒
   - More than 30 hours a week ❒

8. Do you play computer games instead of doing your homework?
   Yes ❒ No ❒

9. Do you prefer to play computer games more than spending time with family/friends and family?
   Yes ❒ No ❒

10. Do you often think about playing or anticipating the next time you can play computer games?
    Yes ❒ No ❒

11. Do you feel the need to play computer games with increasing amounts of time in order to achieve satisfaction?
    Yes ❒ No ❒

12. Have you repeatedly made unsuccessful efforts to control, cut back, or stop playing computer games?
    Yes ❒ No ❒

13. Do you feel restless, moody, depressed, or irritable when attempting to cut down or stop playing computer games?
    Yes ❒ No ❒

14. Do you play computer games longer than originally intended?
    Yes ❒ No ❒

15. Have you jeopardised or risked the loss of a significant relationship, educational or career opportunity because of playing computer games?
    Yes ❒ No ❒

16. Have you lied to family members, a therapist, or others to conceal the extent to which you play computer games?
    Yes ❒ No ❒

17. Do you play computer games as a way of escaping from problems or relieving feelings of helplessness, guilt, anxiety or depression?
    Yes ❒ No ❒

VIDEO ARCADE GAMES

<u>PART 3:</u> Only answer PART 3 if you have played VIDEO ARCADE GAMES in your lifetime. Video arcade games are played on coin-operated machines, eg. games at TimeZone. For each question please put a tick (✓) in the appropriate box.

1. Do you play video arcade games?
   Yes ❒ No ❒

2. Why do you play video arcade games? (You can tick more than one reason)

Fun and excitement	❒	Boredom or loneliness	❒
Thrill of winning	❒	To test my skills	❒
Recreation and relaxation	❒	To try new things	❒
Entertainment	❒	To use up spare time	❒
Other reasons not listed	❒		

3. How often do you play video arcade games?

Less than once a week	❒	5-6 times a week	❒
1-2 times a week	❒	7 or more times a week	❒
3-4 times a week	❒		

4. How many hours a WEEK do you on average spend playing video arcade games?

Less than 1 hour a week	❒	16-20 hours a week	❒
2-5 hours a week	❒	20-25 hours a week	❒
6-10 hours a week	❒	26-30 hours a week	❒
11-15 hours a week	❒	More than 30 hours a week	❒

5. How old were you when you first started playing video arcade games?

Younger than 5 years	❒	13-16 years	❒
5-8 years	❒	16 years or older	❒
9-12 years	❒		

6. Do you play video arcade games when you should be doing your homework?
   Yes ❒ No ❒

7. Do you prefer to play video arcade games more than spending time with your family and/or friends?
   Yes ❒ No ❒

8. When you are playing a video game, do you become more and more preoccupied with relieving past playing experiences, studying video game playing, planning the next opportunity to play, or thinking of ways to get money to play?
   Yes ❒ No ❒

9. Do you need to spend more and more money on video arcade games in order to achieve the desired excitement?
   Yes ❒ No ❒

10. Do you become restless or irritable when attempting to cut down or stop playing arcade games?
    Yes ❒ No ❒

11. Do you play video games as a way of escaping from problems or intolerable feeling states?
    Yes ❒ No ❒

12. After spending money or your time playing video games, do you often play another day in order to get a higher score?
    Yes ❐ No ❐

13. Have you lied to your family and/or friends to protect and conceal the extent to which you play video arcade games?
    Yes ❐ No ❐

14. Have you committed illegal (eg. stolen) or unaccepted acts in order to finance video game playing?
    Yes ❐ No ❐

15. Have you had disagreements or arguments with family members or close friends and jeopardized your education because of video game playing?
    Yes ❐ No ❐

16 Do you need someone else to give you money to relieve a desperate financial situation produced by video game playing?
    Yes ❐ No ❐

INTERNET

PART 4: Only answer PART 4 if you have used the INTERNET in your lifetime. For each question please put a tick (✓) in the appropriate box.

1. Do you use the Internet?
   Yes ❐ No ❐

2. What do you do on the Internet? [Tick as many as apply]
   WWW Searches/surfing ❐
   FTP downloading of software ❐
   Newsgroups/discussion forums ❐
   E-mail ❐
   Chat rooms and Internet relay chat (IRC) ❐
   Play games ❐
   Gambling (eg. Poker or roulette on the Internet) ❐
   Look up things for my school work ❐
   Cybersex or adult resources ❐
   Other things not listed ❐

3. Why do you use the Internet? [You can tick more than one reason]

Fun and excitement	❐	Boredom or loneliness	❐
Thrill of winning	❐	To test my skills	❐
Recreation and relaxation	❐	To try new things	❐
Entertainment	❐	To use up spare time	❐
To meet people	❐	Other reasons not listed	❐

4. How often do you use the Internet?

Less than once a week	❐	5-6 times a week	❐
1-2 times a week	❐	7 or more times a week	❐
3-4 times a week	❐		

5. How many hours a WEEK do you on average spend using the Internet?

Less than 1 hour a week	❐	16-20 hours a week	❐
2-5 hours a week	❐	20-25 hours a week	❐
6-10 hours a week	❐	26-30 hours a week	❐
11-15 hours a week	❐	More than 30 hours a week	❐

6. How old were you when you first started using the Internet?

Younger than 5 years	❐	13-16 years	❐
5-8 years	❐	16 years or older	❐
9-12 years	❐		

7. Do you use the Internet when you should be doing your homework?
   Yes ❐ No ❐

8. Do you prefer to use the Internet more than spending time with your family and/or friends?
   Yes ❐ No ❐

9. Do you feel preoccupied with the Internet (think about previous on-line activity or anticipate next on-line sessions)?
   Yes ❐ No ❐

10. Do you feel the need use the Internet with increasing amounts of time in order to achieve satisfaction or for it to be enjoyable?
    Yes ❐ No ❐

11. Have you repeatedly made unsuccessful efforts to control, cut back, or stop Internet use?
    Yes ❐ No ❐

12. Do you feel restless, moody, depressed, or irritably when attempting to cut down or stop Internet use?
    Yes ❐ No ❐

13. Do you stay on-line longer than originally intended?
    Yes ❐ No ❐

14. Have you jeopardised or risked the loss of a significant relationship, educational or career opportunity because of your Internet use?
    Yes ❐ No ❐

15. Have you lied to family members, a therapist, or others to conceal how much you use the Internet?
    Yes ❐ No ❐

16. Do you use the Internet as a way of escaping from problems or relieving feelings of helplessness, guilt, anxiety or depression?
    Yes ❐ No ❐

Thank you for filling out this questionnaire

Appendix G

Study 1 Information Sheet for University Students

University of Tasmania Letter Head

Study Title: Examination of Engagement in Psychologically Addictive Behaviours

Dear Student,

You are invited to participate in a study undertaken by Naomi Thomas, supervised by Dr Frances Martin (Senior Lecture), as a part of a PhD (Clinical) thesis with the Department of Psychology at the University of Tasmania. The study has been approved by the Northern Tasmanian Social Sciences Human Research Ethics Committee. The primary purpose of the study is to investigate the level of engagement in a range of behaviours and use of substances among university students. It is intended that outcomes of the study will increase awareness on students' participation in potentially addictive behaviours, and in doing so, may lead to an increase in support services available to for students experiencing problems due to their engagement in such activities.

If you are willing to participate in the study you will be required to answer a 10 minute questionnaire. As your participation is voluntary, you may withdraw at anytime without prejudice. Once you have completed the questionnaire it can be returned via mail (pre-paid envelope will be provided) or alternatively put in the marked locked mailbox outside Sue Ross' office (Rm 132, Humanities Building). The questionnaire comprises of items examining participation in different behavioural activities; gambling, Internet, computer and video arcade games.

Your responses will be treated with the utmost confidentiality, and will remain anonymous as your name is not to be written on the questionnaire. All results will be stored on a password computer in the Psychology department. Findings from this study will be accessible on the School of Psychology website, and may appear in written publications, however your name will not be identified. All data will be kept for 5 years in a locked filing cabinet in the Psychology department, after which it will be destroyed.

If you are interested in participating in a future study, please write a contact telephone number in the space provided on the consent form. This second study will take approximately 1.5 hours and involve (1) a short questionnaire assessing the nature of your participation (if any) in gambling, the Internet and video games, and (2) take measures of your electrical brain activity (EEG) to a computer-generated task.

If you found participation in the study distressing the University Counselling Service is available to you on the Top Floor of the TUU Building, phone 6226 2697. If you have any queries or concerns regarding the study please contact Dr Frances Martin (email: F.Martin@utas.edu.au) or Naomi Thomas (email njthomas@utas.edu.au), while ethical complaints should be directed to the Northern Tasmania Social Sciences HREC Chair (Prof Roger Fay, 63243576) or Executive Officer (Amanda McAully, 62262763).

Thank you for your time,

Dr Frances Martin (Chief Investigator)

Naomi Thomas (Student Investigator)

[Please keep this Information Sheet for your personal record]

Appendix H

Study 1 Information Sheet and Consent Form for Principals and Parents

University of Tasmania Letter Head

Examination of Engagement in Computer/Video Games and the Internet

Date

Dear Principal,

This letter is to invite [School's name] to participate in a state wide research project investigating the level of engagement in computer/video games and the Internet among Tasmanian school students from Grades 4 to 12. Naomi Thomas, under the supervision of Dr Frances Martin is conducting the study as a part of her PhD(Clinical) thesis with the School of Psychology at the University of Tasmania. The study aims to provide information on the type of activities engaged in, the reason why students are participating in such activities and the academic and social consequences of their behaviour. Currently no research has been conducted in this area on Australian school students despite the increasing accessibility to these activities.

The study focuses on Grade [input grade] students and will be conducted during Term 1 or Term 2 2005, at a time convenient for your school. The study will involve the following procedures. Parents will be given an information sheet that will outline the nature of the study and ask them to contact the school if they do not wish their child to participate in the study. Students whose parents do not withdraw their child from participation will be asked to complete a 20-minute (maximum) questionnaire during class time.

Attached to this letter is a copy of the questionnaire for your own reference, and for interested teachers and parents to view. An information sheet will be given to teachers briefing them on the nature of the study the how to implement the study. Teachers will be asked to give students information sheets for their parents, to outline the purpose of study and format of the questionnaire to students, and to issue and collect questionnaires. Students will be asked not to write their name on the questionnaire to ensure anonymity and all questionnaires will be coded and responses treated with the utmost confidentiality. Results will be stored on a password protected computer in the School of Psychology for 5 years, after which time raw data will be destroyed. On completion of the study, results will be accessible via the School of Psychology website (www.scieng.utas.edu.au/pyschol/), and may appear in written publications, however no student or school will be identifiable.

We encourage your school to advertise the study in your school newsletter and inform parents to contact the school if they wish their child to be exempt from the study. The study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee and by the Tasmanian Education Department. If you have any ethical complaints they should be directed to the HREC (Tas) Network Executive Officer (Amanda McAully, 62262763). If you have any queries regarding the study please contact Dr Frances Martin (phone: 62262262, email: F.Martin@utas.edu.au) or Naomi Thomas (phone 62267110, email: njthomas@utas.edu.au).

Participation in our study in voluntary. If you are willing for your school to participate, please fill out the enclosed consent form and return it to Naomi Thomas at the School of Psychology. Naomi will then contact you in the near future to discuss the project further and to arrange for the delivery of questionnaires. Your school's participation would be greatly appreciated.

Thank you for consideration,

Dr Frances Martin
(Chief Investigator)

Naomi Thomas
(Student Investigator)

[Please keep this Information Sheet for your personal record]

University of Tasmania Letter Head

Examination of Engagement in Computer/Video Games and the Internet

Date

Dear Parent/Care giver,

Your child has been invited to participate in a study undertaken by Naomi Thomas, supervised by Dr Frances Martin (Senior Lecturer), as a part of a PhD(Clinical) thesis with the School of Psychology at the University of Tasmania. The study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee and by the Tasmanian Education Department, and your child's school principal has agreed for the school to be involved. The primary purpose of the study is to investigate the level of engagement in a range of behaviours (e.g., computer game playing, Internet use) among students in Tasmania. The study aims to increase awareness of students' participation in these activities, the reason why students are participating, and the academic and social consequences of their behaviour.

If you are willing for your child to participate in the study they will be asked to complete a 20-minute questionnaire during class time. The questionnaire includes items addressing demographic information, level of engagement in each activity and the consequences of their behaviour. The questionnaire is available for perusal at the school. As your child's participation is voluntary, they may withdraw at any time without any negative effects. Their class teacher will issue and collect all questionnaires. Their responses will be treated with the utmost confidentiality, and will remain anonymous as their name is not to be written on the questionnaire. All results will be stored on a password-protected computer in the School of Psychology for 5 years, after which time raw will be destroyed. This information sheet has been forwarded by your child's school and the investigator does not have access to your address. On completion of the study, results will be accessible on the School of Psychology website (www.scieng.utas.edu.au/psychol/), and may appear in written publications, however no student or school will be identified.

If do not wish your child to participate in this study, please notify your child's school and they will be exempt from the study. If you have any queries or concerns regarding the study please contact Dr Frances Martin (email: F.Martin@utas.edu.au) or Naomi Thomas (email: njthomas@utas.edu.au), while ethical complaints should be directed to the HREC (Tas) Network Executive Officer (Amanda McAully, 62262763).

Thank you for your time,

Dr Frances Martin
(Chief Investigator)

Naomi Thomas
(Student Investigator)

[Please keep this Information Sheet for your personal record]

University of Tasmania Letter Head

STATEMENT OF INFORMED CONSENT

Examination of Engagement in Psychologically Addictive Behaviours

For the Principal/Parent:

1. I have read and understood the 'Information Sheet' for this study.
2. The nature of the study has been explained to me, and I understand it will take students/my child approximately 20 minutes to complete the questionnaire.
3. I understand that in the study students/my child will be asked to answer questions relating to their participation computer games and use of the Internet.
4. I understand that there are no foreseeable risks or discomforts associated with this study.
5. I understand that all research data will be securely stored and treated as confidential.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered for the study may be published provided that student/my child cannot be identified as a subject.

6\. I agree for students/my child to participate in this investigation and understand that they can withdraw at any time without prejudice.

Name of Principal / Parent ______________________________

Signature of Principal / Parent ____________________ Date __________

Appendix I

Teacher Instructions for Study 1

Examination of the Level of Engagement in Video-arcade Games, Computer Games and the Internet among School-aged Children

Background Information:

This study is investigating the level of engagement in computer/video games and the Internet among Tasmanian school students. Naomi Thomas, under the supervision of Dr Frances Martin is conducting the study in the School of Psychology at the University of Tasmania. The outcomes of the study will provide information on the type of activities engaged in, the reason why students are participating in such activities and the consequences of their behaviour.

It is expected that the entire procedure will take 30 minutes of class time. You will be asked to outline to students the nature of the study and format of the questionnaire, to collect consent forms and to issue and collect questionnaires. Two envelopes will be provided for completed consent forms and questionnaires. Below is a list of instructions outlining your involvement in the study.

Thank you for assisting in this study, your help is greatly appreciated.

Naomi Thomas

(Doctor of Clinical Psychology Student)

Study Instructions:

1. Place completed consent forms in the allocated A4 envelope.
2. When all expected consent forms are returned begin the study. Firstly, give students instructions about the study (see 'Instructions for Students').
3. Distribute questionnaires to students who volunteer to participate and have parental consent. The questionnaire will take 20 minutes to complete.
4. Collect completed questionnaires and place them in the allocated envelope.
5. Return questionnaires and consent forms to the allocated box in the Office.

Instructions for Students:

'Our class has been asked to be in a study by Naomi Thomas and Dr Frances Martin at the University of Tasmania. Naomi is running a study that asks questions about whether school children play computer/video games or use the Internet, how many times a week they play these games and why they play these games. If you have brought back the form from your parents you can answer these questions on the survey that I will be handing out shortly. You do not have to answer the questions if you do not want and you can stop at any time. To answer the questions you need to put a tick in the box that is the right answer for you, and for some questions you may be able to tick more than one box (*may need to give an example, e.g., Part 2 question 4*). If you don't know the answer you can leave the question blank. Only Naomi Thomas will look at your completed surveys.

Appendix J

Study 1 Gambling Data

Table J1

Reason(s) University Students (n = 387) Gave for Why they Gamble

Reason for participation	*n*	% Students
Thrill of winning	217	56.1
Fun & excitement	212	54.8
Entertainment	206	53.2
Win money	109	28.2
Recreation / relaxation	99	25.6
Try new things	61	15.8
Spare time	44	11.4
Test skills	39	10.1
Other reason	31	8.0
Boredom / loneliness	20	5.2
Meet people	14	3.6

Table J2

Frequency at which University Students (n = 387) Gamble per Week

Weekly frequency	*n*	% Students
< 1	346	89.4
1 - 2 times	36	9.3
3 - 4 times	2	0.5
5 - 6 times	2	0.5
7 or more	1	0.3

Table J3

Number of Hours per Week University Students (n = 387) Spend Gambling

Hours per week	*n*	% Students
< 1	359	92.8
2 - 5	21	5.4
6 - 10	2	0.5
11 - 15	1	0.3
> 16 - 20	0	0

Table J4

Percentage of University Students (n = 387) Endorsing Symptoms of Addiction to Gambling

Symptom of addiction	*n*	% Students
Chase loses	33	8.5
Salience / preoccupation	26	6.7
Tolerance	21	5.4
Lies / deception	18	4.7
Escape negative feelings	12	3.1
Withdrawal	9	2.3
Financial bail-out	5	1.3
Illegal acts	4	1.0
Disruption to relationships	2	0.5

Table J5

Percentage of University Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to Gambling, and Males and Females at each Level

Level of addiction	Total	Male	Female
Non-clinical[a]	81.7	27.2	78.8
Sub-clinical[b]	16.0	39.3	60.7
Clinical[c]	2.3	22.2	77.8

Note. Student in the clinical group meet the criteria for addiction to gambling.
[a] $n = 316$. [b] $n = 62$. [c] $n = 9$.

Table J6

Percentage of University Students with a Non-clinical, Sub-clinical or Clinical Level of Addiction Participating in Each Gambling Activity

Media	Non-clinical[a]	Sub-clinical[b]	Clinical[c]
Slot machines	73.4	88.7	88.9
Casino	66.5	83.9	100
Lottery	50.0	69.4	77.8
Bet on animals	47.8	58.1	77.8
Cards	34.2	51.6	44.4
Skill games	25.0	40.3	33.3
Bet on sports	20.6	32.3	33.3
Bingo	18.4	32.3	66.7
Other activity	7.9	16.1	22.2
Stock/commodities	4.7	11.3	11.1
Bet on dice games	4.1	9.7	22.2

Note. Student in the clinical group meet the criteria for addiction to gambling.
[a] $n = 316$ [b] $n = 62$. [c] $n = 9$.

Appendix K

Study 1 School Data

Table K1

Average Number of Hours Primary Students Spend Engaging in Each Activity per Day

Hours per day	Computer games[a]	Video-arcade games[b]	Internet[c]
< 1	56.4	83.5	68.7
1 - 3	34.5	12.4	26.7
4 - 6	6.4	2.5	3.2
7 - 9	0.8	0	0.5
10 or more	1.9	0.4	0.3

Note. Values represent percentage of primary students
[a]*n* = 374. [b]*n* = 242. [c]*n* = 371.

Table K2

Percentage of the Total Sample, and Males and Females, from Each School Group Addicted to Computer Games, Video-arcade Games and the Internet

Education sample	Computer games	Video-arcade games	Internet
Secondary			
Total	7.0	7.0	5.2
Male	9.9	9.0	5.7
Female	3.5	4.0	4.7
College			
Total	3.3	1.5	5.6
Male	5.5	2.9	6.3
Female	1.3	2.0	4.4
University			
Total	2.6	0.3	3.2
Male	5.1	0.8	4.2
Female	1.5	0	2.8

Appendix L

Study 1: Video-Arcade Game Statistical Analysis

Table L1

Percentage of Students Reporting Aspects of Addiction to Video-Arcade Games

Symptoms of addiction	Secondary [a]	College [b]	University [c]
Chase loses	19.0	9.3	12.8
Salience / anticipation	13.6	4.9	1.0
Tolerance	12.8	6.3	3.6
Escape negative feelings	12.2	7.8	2.0
Withdrawal	6.5	2.4	0.8
Disruption to relationships	5.5	2.0	0.3
Financial bail-out	5.5	1.0	0.8
Lies / deception	4.0	2.4	0.5
Illegal acts	3.7	3.4	0.3

[a]$n = 674$. [b]$n = 205$. [c]$n = 362$.

Table L2

Percentage of Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to Video-Arcade Games, and Males and Females at each Level

Level of Addiction	Total	Male	Female
Non-clinical [a]	73.2	45.3	54.7
Sub-clinical [b]	22.4	61.1	38.9
Clinical [c]	4.2	75.5	24.5

Note. The sample is of students from university, secondary schools and colleges. Clinical group meet the criteria for addiction to video-arcade games.
[a]$n = 931$. [b]$n = 287$. [c]$n = 53$.

Table L3

Summary of Pearson's Chi-square Test for Group (N = 1271) by Regular Video-Arcade Play

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	182.77	.001	.041	.38

Table L4

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to Regular Video-Arcade Game Play

Comparison	*df*	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Clinical	1	181.12	.05	***	.43
Non-clinical vs. Sub-clinical	1	69.74	.025	***	.24
Sub-clinical vs. Clinical	1	32.56	.0167	***	.31

Note Regular video-arcade game play was defined as playing at least once a week. From the overall two-way contingency table, χ^2 (2, $N = 1271$) = 182.767, $p < .001$, the proportion of regular gamers with a non-clinical level of addiction (no symptoms) was 7% ($n = 65$); 24.7% sub-clinical gamers ($n = 71$); 64.2% of addicted gamers ($n = 34$)
*** $p < .001$.

Table L5

Summary of Pearson's Chi-square Test for Group (N = 1271) by High/medium Level of Engagement in Video-Arcade Games

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	128.36	.001	.016	.32

Table L6

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups with Varying Levels of Addiction according to High/Medium Level of Engagement in Video-Arcade Games

Comparison	*df*	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Sub-clinical	1	142.37	.05	***	.089
Sub-clinical vs. Clinical	1	33.83	.025	***	.38
Non-clinical vs. Clinical	1	9.62	.0167	**	.32

Note. High/Medium level of engagement represents playing for at least 11 – 15 hours per week. Analysis was invalid as more than 20% of cells had expected counts less than 5. The clinical group meet the criteria for addiction to video-arcade games

** $p < .01$. *** $p < .001$.

Table L7

Logistic Regression Analysis of Video-Arcade Game Addiction as a Function of Individual Differences and Participation Characteristics

				95% Confidence Interval for Odds Ratio	
Variables	*B* (SE)	Wald	Odds Ratio	Lower	Upper
Constant	1.44 (.70)	4.23	4.24	-	-
Sex	0.66 (.40)	2.68	1.93	0.88	4.22
Regular participation	-1.55 (.38)	16.64***	0.21	0.1	0.45
High/medium engagement	-1.27 (.61)	4.28*	0.28	0.084	0.94
Participation before age 5	0.56 (.46)	1.50	0.57	0.23	1.40
Escape negative emotions	-3.46 (.37)	16.64***	0.032	0.015	0.065

Note $R^2 = .45$. Model χ^2 (4, $N = 1267$) = 197.86, $p < .001$. Dashes represent coefficients that were not calculated by the analysis.

*$p < .05$. ***$p < .001$.

Appendix M

Study 1: Computer Game Statistical Analysis

Table M1

Percentage of Secondary, College and University Students Reporting Aspects of Addiction to Computer Games

Symptoms of addiction	Secondary [a]	College [b]	University [c]
Playing longer than intended	48.5	51.3	52.7
Salience / anticipation	23.4	23.2	12.3
Escape negative feelings	21.0	17.6	15.3
Lack of control	13.7	7.5	7.2
Tolerance	11.9	10.5	5.8
Withdrawal	9.0	5.2	3.8
Disruption to relationships	8.0	5.2	2.6
Lies / deception	7.8	4.6	3.4

[a]$n = 946$. [b]$n = 306$. [c]$n = 583$.

Table M2

Percentage of Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to Computer Games, and Males and Females, at each Level

Level of Addiction	Total	Male	Female
Non-clinical[a]	39.8	32.3	67.7
Sub-clinical[b]	55.2	52.7	47.3
Clinical[c]	5.0	74.7	25.3

Note The sample includes students from university, secondary schools and colleges but excludes those from primary schools. The clinical group meet the criteria of computer game addiction.
[a]$n = 731$. [b]$n = 1031$. [c]$n = 91$.

Table M3

Participation in Each Computer Game Media by Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to Computer Games

Media	Non-clinical[a]	Sub-clinical[b]	Clinical[c]
PlayStation	61.9	66.3	75.8
PC games	59.9	77.3	76.9
Internet games	51.1	62.7	79.1
Nintendo	22.1	35.1	61.5
Xbox	20.8	29.0	39.6

Note. The values represent percentages of students (secondary, college, university only) who had played each type of computer game activity at least once in their lifetime.
[a]$n = 946$. [b]$n = 306$. [c]$n = 583$.

Table M4

Summary of Pearson's Chi-square Test for Group ($N = 1834$) by Engagement in On-line Games

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	39.73	.001	.00	.15

Table M5

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to Lifetime Participation in On-line Computer Games

Comparison	*df*	χ^2	Required p-value	Significance	Cramér's V
Non-clinical vs. Clinical	1	25.60	.05	***	.18
Non-clinical vs. Sub-clinical	1	23.37	.025	***	.12
Sub-clinical vs. Clinical	1	9.80	.0167	**	.094

Note Lifetime participation was defined as having played computer games at least once in their life. From the overall two-way contingency table, χ^2 (2, N = 1834) = 39.73, $p < .001$, Cramér's V = .15, the proportion of students with non-clinical level of addiction (no symptoms) who had played on-line games was 51.1% (n = 373); 62.7% sub-clinical gamers (n = 635); 79.1% of clinically addicted gamers (n = 72)
** $p < .001$. ***$p < .001$.

Table M6

Summary of Pearson's Chi-square Test for Group (N = 1835) by Regular Computer Play

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	252.41	.001	.23	.37

Table M7

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to Regular Computer Game Participation

Comparison	df	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Sub-clinical	1	211.14	.05	***	.35
Non-clinical vs. Clinical	1	91.86	.025	***	.33
Sub-clinical vs. Clinical	1	14.51	.0167	***	.12

Note. Regular computer game play was defined as playing at least once a week. From the overall two-way contingency table, χ^2 (2, N = 1835) = 252.41, $p < .001$, Cramér's V = .37, the proportion of regular gamers with a non-clinical level of addiction (no symptoms) was 38.3% (n = 280); 73.1% sub-clinical gamers (n = 740); 91.2% of clinically addicted gamers (n = 83).
***$p < .001$.

Table M8

Summary of Pearson's Chi-square Test for Group (N = 1835) x High/Medium Level of Engagement in Computer Games

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	122.78	.001	.00	.26

Table M9

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to the Proportion of Computer Gamers with a High/Medium Level of Engagement

Comparison	df	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Clinical	1	135.53	.05	***	.41
Sub-clinical vs. Clinical	1	59.92	.025	***	.23
Non-clinical vs. Sub-clinical	1	29.92	.0167	***	.13

Note. High/medium engagement is defined as playing computer games for 11 – 15 hours or more per week. From the overall two-way contingency table, χ^2 (2, N = 1835) = 122.78, $p < .001$, Cramér's V = .26, the proportion of non-clinical students with a high/medium level of engagement was 7% (n = 51); 15.6% sub-clinical gamers (n = 158); 48.4% of addicted gamers (n = 44).
***$p < .001$.

Table M10

Summary of Logistic Regression Analysis of Variables Predicting Computer Game Addiction

Variables	*B* (SE)	Wald	Odds ratio	95% Confidence interval for odds ratio: Lower	Upper
Constant	-0.82 (.37)	5.07	4.4	-	-
Sex	0.69 (.28)	5.97*	1.99	1.15	3.46
On-line games	-0.55 (.30)	3.36	0.58	0.32	1.04
Off-line games	0.85 (.71)	1.45	2.35	0.58	9.42
Regular participation	-0.79 (.42)	3.50	0.45	0.20	1.04
High/medium engagement	-1.10 (.26)	17.30***	0.33	0.20	0.56
Start before age 5	0.14 (.30)	0.22	1.15	0.64	2.08
Escape negative emotions	-3.13 (.31)	104.74***	0.044	0.024	0.080

Note. $R^2 = .35$. Model χ^2 $(7, N = 1825) = 251.94, p < .001$. Dashes indicate coefficients that were not calculated by the analysis.

*$p < .05$. ***$p < .001$

Appendix N

Study 1: Internet Statistical Analysis

Table N1

Percentage of Secondary, College and University Students who Reported Experiencing Symptoms of Internet Addiction

Symptoms of addiction	Secondary[a]	College[b]	University[c]
On-line longer than intended	53.7	55.4	62
Salience / anticipate	21.0	24.8	12.1
Escape negative feelings	15.5	11.1	7.3
Tolerance	11.9	10.5	5.2
Lack of control	11.6	9.0	6.8
Lies / deception	9.9	6.8	4.6
Withdrawal	7.0	6.5	3.9
Disruption to relationships	6.7	5.0	3.0

[a]*n* = 974. [b]*n* = 323. [c]*n* = 694.

Table N2

Percentage of Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction to the Internet, and Males and Females at each Level

Level of Addiction	Total	Male	Female
Non-clinical[a]	36.5	45.5	54.5
Sub-clinical[b]	58.9	39.7	60.3
Clinical[c]	4.6	51.1	48.9

Note. The sample includes students from university, secondary schools and colleges but excludes those from primary schools. Clinical group meet the criteria for addiction to the Internet.
[a]*n* = 727. [b]*n* = 1173. [c]*n* = 91.

Table N3

Percentage of Students with a Non-clinical, Sub-clinical and Clinical Level of Addiction Engaging in Different Internet media

Media	Non-clinical[a]	Sub-clinical[b]	Clinical[c]
WWW	85.8	89.1	95.6
Email	85.7	92.5	95.6
On-line games	49.7	55.3	82.2
Chat-rooms	27.8	47.9	70.0

Note. The values represent percentages of students (secondary, college, university only) engaging in each media at least once in their lifetime. Clinical group meet the criteria for addiction to the Internet.
[a]*n* = 727. [b]*n* = 1173. [c]*n* = 91.

Table N4

Summary of Pearson's Chi-square Test for Group (N = 1991) x Engagement in Interactive Internet Media

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	70.04	.001	.00	.19

Table N5

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to the Proportion Engaging in Interactive Internet Media

Comparison	*df*	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Clinical	1	43.98	.05	***	.23
Non-clinical vs. Sub-clinical	1	39.70	.025	***	.15
Sub-clinical vs. Clinical	1	20.86	.0167	***	.13

Note. From the overall two-way contingency table, χ^2 (2, N = 1991) = 70.04, $p < .001$, Cramér's V = .19, the proportion students with a non-clinical level of addiction (no symptoms) engaging in interactive media was 58 9% (n = 428); 72.8% sub-clinical gamers (n = 854); 94.5% of addicted gamers (n = 86).
*** $p < .001$.

Table N6

Summary of Pearson's Chi-square Test for Group (N = 1991) by Regular Internet Use

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	22.08	.001	.019	.11

Table N7

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to the Proportion of Students with Regular Internet Use

Comparison	*df*	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Sub-clinical	1	19.53	.05	*	.10
Non-clinical vs. Clinical	1	4.63	.025	*ns*	.075
Sub-clinical vs. Clinical	1	0.63	.0167	*ns*	.022

Note. Regular Internet use is defined as accessing the Internet at least once a week. From the overall two-way contingency table, χ^2 (2, N = 1991) = 22.08, $p < .001$, Cramér's V = .11, the proportion of regular users with a non-clinical level of addiction (no symptoms) was 91.3% (n = 664); 96 2% sub-clinical (n = 1128); 97.8% clinically addicted (n = 89).
* $p < .05$.

Table N8

Summary of Pearson's Chi-square Test for Group (N = 1991) by a High/Medium Level of Engagement in the Internet

Variable	*df*	χ^2	*p*	Lambda Value	Cramér's *V*
Group	2	203.48	.001	.025	.32

Table N9

Summary of the Pearson's Chi-square Pairwise Comparisons of Groups according to the Proportion of Students with High/Medium Engagement in the Internet

Comparison	*df*	χ^2	Required *p*-value	Significance	Cramér's *V*
Non-clinical vs. Clinical	1	224.28	.05	***	.52
Non-clinical vs. Sub-clinical	1	90.65	.025	***	.22
Sub-clinical vs. Clinical	1	70.32	.0167	***	.24

Note. High/medium engagement is defined as participation in excess of 11 – 15 hours per week. From the overall two-way contingency table, χ^2 (2, N = 1991) = 203.48, $p < .001$, Cramér's V = .32, the proportion of students with a high/medium level of engagement in the non-clinical group was 8.1% (n = 59); 25.7% sub-clinical (n = 302); 67% of addicted (n = 61).
*** $p < .001$.

Table N10

Logistic Regression Analysis of Internet Addiction as a Function of Individual Differences and Participation Characteristics

Variables	*B* (SE)	Wald	Odds ratio	95% Confidence interval for odds ratio	
				Lower	Upper
Constant	-0.031 (.50)	0.004	0.97	-	-
Sex	0.32 (.26)	1.57	1.38	0.83	2.27
Interactive media	-1.18 (.49)	5.80*	0.31	0.12	0.80
Regular participation	-0.048 (.81)	0.003	0.95	0.19	4.68
High/medium engagement	-1.48 (.26)	32.11***	0.23	0.14	0.38
Start before age 5	0.27 (.49)	0.29	0.77	0.29	2.00
Escape negative emotions	-3.02 (.27)	124***	0.049	0.029	0.083

Note $R^2 = .36$. Model χ^2 $(6, N = 1981) = 263.65, p < .001$. Dashes indicate coefficients that were not calculated by the analysis.

$*p < .05$. $***p < .001$.

Appendix O

Study 2 Participant Information

The Number of Participants from the Addicted Group Engaging in the Activity(ies) they were Addicted to at either a High, Medium, or Low Level

	Level of Engagement		
Activity	High	Medium	Low
Single Addiction (*n* = 9)	-	-	-
Computer Games	-	1	1
Video-Arcade Games	-	-	-
Internet	4	3	-
Gambling	-	-	-
Two Addictions (*n* = 3)			
Computer Games (&) Internet	-	2	-
*Video-arcade games (&) Internet	1	-	1

Note. The * included in the table indicates that the participant addicted to these two activities had a low level of engagement in video-arcade games and high level of engagement in the Internet. High engagement is indicative of engaging in at least one activity for between 16 and 30^+ hours per week, medium engagement 11 to 15 hours per week, and low engagement less than five hours per week.

Appendix P

Study 2 Medical Questionnaire, Information Sheet and Consent Form

Medical and History Questionnaire

University of Tasmania
School of Psychology

Medical History

Are you currently suffering from anxiety or depression?

....

Do you have a heart condition or any other serious physical condition?

....
.

Are you currently taking any prescription medication? If so, what medication?

....

Have you in the past taken any medications for psychological conditions(s)? If so, what medications?

....

Note: It is a formal requirement of the Ethics Committee of the University of Tasmania that the information provided on this questionnaire be held under security to comply with confidentiality regulations and to protect your privacy. You can be assured that information will be available only to the principal researcher and not to any other party. The questionnaire will be destroyed following selection of volunteers for the project.

Have you ever had or are you now suffering from any of the following (please circle):

Fits or Convulsions	*Yes*	*No*
Epilepsy	*Yes*	*No*
Giddiness	*Yes*	*No*
Concussion	*Yes*	*No*
Severe Head injury	*Yes*	*No*
Loss of Consciousness	*Yes*	*No*

Drinking and Smoking History

On how many days last week did you drink alcohol?	None	☐
	One or two days	☐
	Three or four days	☐
	Five or six days	☐
	Every day	☐
Do you usually drink…	Never	☐
	During weekdays	☐
	Friday night	☐
	Week ends	☐
How many drinks would you usually have at one time?	One or two	☐
	Three to five	☐
	Five to eight	☐
	Eight to twelve	☐
	More than twelve	☐
Do you get drunk?	Never	☐
	Rarely	☐
	Once a month	☐
	Once a week	☐
	More frequently	☐
How often do you smoke cigarettes?	Never	☐
	Less than 5 per week	☐
	Less than 5 per day	☐
	5 to 9 per day	☐
	10 to 19 per day	☐
	20 to 39 per day	☐
	Over 40 per day	☐

Do you or have you in the past used marijuana (please circle): *Yes* *No*

a) Have you used marijuana in the last two weeks? *Yes* *No*

b) Have you used any other form of illicit drug in the last 6 months? *Yes* *No*

Have you ever had treatment for drug or alcohol problems? *Yes* *No*

Are you predominately right handed? *Yes* *No*

Vision & Hearing

Do you have any difficulties with vision? (please specify)

………………………………………………………………………………………………

If yes, are these difficulties corrected? (i.e. glasses/contacts)

………………………………………………………………………………………………

Do you have any known difficulties with hearing? (please specify)

………………………………………………………………………………………………

If yes are these difficulties corrected?

………………………………………………………………………………………………

Do you ever find that you do not hear what people say? (please describe)

………………………………………………………………………………………………

Did you suffer from repeated ear infections, or go to hospital to have tubes/grommets inserted in the ear at any time in your childhood?

………………………………………………………………………………………………

Handedness

For each of the activities below, please tell us:

1. Which hand do you prefer for that activity?
2. Do you *ever* use the other hand for the activity?

	Preferred hand?		Ever use other hand?	
Writing	L	R	Y	N
Drawing	L	R	Y	N
Throwing	L	R	Y	N
Using scissors	L	R	Y	N
Using a toothbrush	L	R	Y	N
Using a knife (without fork)	L	R	Y	N
Using a spoon	L	R	Y	N
Using a broom (upper hand)	L	R	Y	N
Striking a match	L	R	Y	N
Opening a box (lid)	L	R	Y	N

Do you ever confuse left and right? *Yes* *Sometimes* *Never*

How many people in your immediate family are left handed?

………………………………………………………………………………………………

University of Tasmania Letter Head

Psychophysiological Examination of Engagement and Addiction to Psychologically Addictive Behaviours

Dear Student,

You are invited to participate in the second stage of research undertaken by Naomi Thomas, supervised by Dr Frances Martin (Senior Lecturer), as a part of a PhD(Clinical) thesis with the Department of Psychology at the University of Tasmania. Approved for the study was obtained by the Northern Tasmanian Social Sciences Human Research Ethics Committee. The study is being conducted in order to investigate whether underlying cognitive processes differ among students who have different levels of engagement in multiple activities; gambling, the Internet and computer/video games. These cognitive processes will be measured by electrical brain activity (EEG), recorded during a computer-generated task.

You have been selected for this study on the basis of your participation or lack of participation in multiple activities and because you meet the selection criteria, as you are aged between 18 and 35 years, right-handed and have normal or corrected vision. In total the study will take approximately 2 hours (2 hours of research participation time). As your participation is voluntary, you may withdraw from the study at anytime without prejudice.

If you are willing to participate in the study you will be asked to complete 2 psychological questionnaires and a questionnaire assessing the nature of your participation (if any) in gambling, the Internet and computer/video games. In the second task you will be required to respond to stimuli on a computer-generated task while your electrical brain activity (EEG) is recorded. Before beginning the third task, Event-Related-Potential (ERP) measurement equipment will be fitted, including a skullcap and electrodes. If you have sensitive skin you must inform the investigator.

Your responses and EEG data will be treated with the utmost confidentiality, and will remain anonymous as your name is **NOT** to be written on any of the questionnaires. All results will be stored on a password computer in the School of Psychology. Group results from this study will be accessible on the School of Psychology website, and may appear in written publications, however your name will not be identified.

If you found participation in the study distressing the University Counselling Service is available to you on the Top Floor of the TUU Building, phone 6226 2697. If you have any queries or concerns regarding the study please contact Dr Frances Martin (email: F.Martin@utas.edu.au) or Naomi Thomas (email: njthomas@utas.edu.au), while ethical complaints should be directed to the Executive Officer of the Tasmanian HREC office (Amanda McAully, 62262763).

Thank you for your time,

Dr Frances Martin
(Chief Investigator)

Naomi Thomas
(Student Investigator)

[Please keep this Information Sheet for your personal record]

University of Tasmania Letter Head

STATEMENT OF INFORMED CONSENT

Psychophysiological Examination of Engagement and Addiction to Psychologically Addictive Behaviours

For the participant:

1. I have read and understood the 'Information Sheet' for this study.
2. The nature and possible effects of the study have been explained to me, and I understand that the study will take approximately 2 hours.
3. I understand that in the study I will be required to (1) respond to different stimuli presented on a computer screen while having my brain activity (EEG) measured, and (2) complete questionnaires.
4. I understand that there are no foreseeable risks or discomforts associated with this study. However, if I experience any distress whilst completing the questionnaire I am aware that I can discontinue at anytime, and have been given with the contact details of the University Counselling Service.
5. I understand that all research data will be securely stored and treated as confidential.

7. Any questions that I have asked have been answered to my satisfaction.

8. I agree that research data gathered for the study may be published provided that I cannot be identified as a subject.

8. I agree to participate in this investigation and understand that I may withdraw at any time without academic or other prejudice.

Name of participant ______________________________

Signature of participant ____________________ Date __________

For the investigators

I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Name of chief investigator ______________________________

Signature of chief investigator ____________________ Date __________

Name of student investigator ______________________________

Signature of student investigator ____________________ Date __________

Appendix Q

Study 2 P3a and P3b Statistical Analysis

Table Q1

Preliminary ANOVAs Assessing the Effect of Sex on P3a and P3b Amplitude and Latency Data Reported in Study 2

Variables	*df*	MS Effect	*F*	*p*	Significance
			P3a Amplitude		
GROUP SET 1					
Sex x Group	2.0	11.36	0.044	.96	*ns*
Sagittal x Sex x Group	2.0	9.31	0.38	.68	*ns*
Coronal x Sex x Group	3.54	14.34	0.36	.82	*ns*
Sagittal x Coronal x Sex x Group	5.36	1.83	0.35	.89	*ns*
GROUP SET 2					
Sex x Group	4.0	99.23	0.40	.81	*ns*
Sagittal x Sex x Group	4.0	40.81	1.74	.15	*ns*
Coronal x Sex x Group	6.96	14.59	0.36	.92	*ns*
Sagittal x Coronal x Sex x Group	10.7	2.14	0.41	.95	*ns*
GROUP SET 3					
Sex x Group	2.0	155.02	0.65	.53	*ns*
Sagittal x Sex x Group	2.0	6.12	0.25	.78	*ns*
Coronal x Sex x Group	3.52	19.14	0.49	.72	*ns*
Sagittal x Coronal x Sex x Group	5.44	2.14	0.43	.84	*ns*
			P3a Latency		
GROUP SET 1					
Sex x Group	2.0	2810.08	0.46	.63	*ns*
Sagittal x Sex x Group	2.0	640.27	0.73	.48	*ns*
Coronal x Sex x Group	5.51	1559.55	1.21	.30	*ns*
Sagittal x Coronal x Sex x Group	5.06	849.98	1.11	.36	*ns*
GROUP SET 2					
Sex x Group	4.0	2758.049	0.45	.77	*ns*
Sagittal x Sex x Group	4.0	532.43	0.59	.67	*ns*
Coronal x Sex x Group	10.82	1206.19	0.90	.54	*ns*
Sagittal x Coronal x Sex x Group	10.35	777.66	1.06	.40	*ns*
GROUP SET 3					
Sex x Group	2.0	5429.60	0.90	.41	*ns*
Sagittal x Sex x Group	2.0	502.08	0.58	.56	*ns*
Coronal x Sex x Group	5.36	1012.02	0.76	.59	*ns*
Sagittal x Coronal x Sex x Group	5.13	622.73	0.84	.53	*ns*
			P3b Amplitude		
GROUP SET 1					
Sex x Group	2.0	71.54	0.68	.51	*ns*
Sagittal x Sex x Group	2.0	15.26	0.99	.38	*ns*
Coronal x Sex x Group	3.82	3.61	0.68	.60	*ns*
Sagittal x Coronal x Sex x Group	3.83	1.84	1.06	.38	*ns*
GROUP SET 2					
Sex x Group	4.0	54.64	0.57	.69	*ns*
Sagittal x Sex x Group	4.0	1.18	0.33	.86	*ns*
Coronal x Sex x Group	5.15	9.14	0.82	.54	*ns*
Sagittal x Coronal x Sex x Group	6.45	3.59	0.54	.79	*ns*
GROUP SET 3					
Sex x Group	2.0	70.69	0.73	.48	*ns*
Sagittal x Sex x Group	2.0	1.28	0.37	.69	*ns*
Coronal x Sex x Group	2.62	18.18	1.71	.18	*ns*
Sagittal x Coronal x Sex x Group	3.26	3.27	0.50	.70	*ns*

Variables	*df*	MS Effect	*F*	*p*	Significance
			P3b Latency		
GROUP SET 1					
Sex x Group	2.0	32125.26	2.29	.11	*ns*
Sagittal x Sex x Group	2.0	1405.97	0.51	.60	*ns*
Coronal x Sex x Group	3.91	497.56	0.36	.83	*ns*
Sagittal x Coronal x Sex x Group	3.61	2201.59	1.66	.17	*ns*
GROUP SET 2					
Sex x Group	4.0	10450.22	0.77	.55	*ns*
Sagittal x Sex x Group	4.0	6639.32	2.57	.05	*
Coronal x Sex x Group	7.82	855.05	0.61	.77	*ns*
Sagittal x Coronal x Sex x Group	7.19	1215.70	0.89	.52	*ns*
GROUP SET 3					
Sex x Group	2.0	10226.12	0.72	.49	*ns*
Sagittal x Sex x Group	2.0	1093.89	0.95	.39	*ns*
Coronal x Sex x Group	3.73	1646.14	0.88	.47	*ns*
Sagittal x Coronal x Sex x Group	3.87	2434.11	1.51	.21	*ns*
			P3b Latency Post hoc		
Sagittal x Sex x Group for Set 2*					
Central x Sex	1.0	7013.67	0.68	.41	*ns*
Parietal x Sex	1.0	10234.67	1.40	.24	*ns*

Note. * represents a significant interaction.

Table Q2

ANOVAs on the Behavioural Data of Each Group Set according to Reaction Time and Percentage of Responds Made to Hits and False Alarms

Group Set	*df*	MS Effect	*F*	*p*	Significance
			Reaction time (hits)		
Set 1	2.0	0.0010	0.12	.89	*ns*
Set 2	4.0	0.0050	1.094	.37	*ns*
Set 3	2.0	0.010	2.16	.12	*ns*
			Reaction time (false alarms)		
Set 1	2.0	0.010	0.57	.57	*ns*
Set 2	4.0	0.020	1.14	.34	*ns*
Set 3	2.0	0.039	2.28	.11	*ns*
			Percent of responses (hits)		
Set 1	2.0	188.44	1.055	.35	*ns*
Set 2	4.0	99.83	0.55	.70	*ns*
Set 3	2.0	56.43	0.31	.73	*ns*
			Percent of responses (false alarms)		
Set 1	2.0	48.66	0.38	.69	*ns*
Set 2	4.0	203.93	1.67	.17	*ns*
Set 3	2.0	315.57	2.61	.080	*ns*

Table Q3

Three-way ANOVAs conducted on P3a Amplitude and Latency Data and Breakdown ANOVAs of Significant Interactions

Variables	*df*	MS Effect	*F*	*p*	Significance
			P3a Amplitude		
GROUP SET 1					
Group	2.0	4.89	0.002	.99	*ns*
Sagittal x Group	2.0	35.84	1.51	.23	*ns*
Coronal x Group	3.50	32.70	0.79	.52	*ns*
Sagittal x Coronal x Group	5.43	3.76	0.75	.60	*ns*
GROUP SET 2					
Group	4.0	488.51	2.0	.10	*ns*
Sagittal x Group	4.0	21.85	0.90	.47	*ns*
Coronal x Group	6.92	61.76	1.53	.16	*ns*
Sagittal x Coronal x Group	10.84	5.33	1.07	.39	*ns*
GROUP SET 3					
Group	2.0	923.76	3.86	.025	*
Sagittal x Group	2.0	12.29	0.55	.58	*ns*
Coronal x Group	3.53	99.26	2.53	.050	*
Sagittal x Coronal x Group	5.47	7.48	1.53	.18	*ns*
			P3a Amplitude Post hoc		
Coronal x Group for Group Set 3*					
Far Left	2.0	136.85	5.87	.004	*
Left	2.0	251.67	3.83	.026	*
Midline	2.0	494.96	4.24	.018	*
			P3a Latency		
GROUP SET 1					
Group	2.0	6514.46	1.11	.34	*ns*
Sagittal x Group	2.0	92.32	0.11	.90	*ns*
Coronal x Group	5.43	410.79	0.31	.92	*ns*
Sagittal x Coronal x Group	5.07	362.38	0.48	.79	*ns*
GROUP SET 2					
Group	4.0	6682.54	1.14	.34	*ns*
Sagittal x Group	4.0	210.74	0.24	.91	*ns*
Coronal x Group	10.73	496.92	0.37	.97	*ns*
Sagittal x Coronal x Group	10.30	780.55	1.07	.39	*ns*
GROUP SET 3					
Group	2.0	3114.85	0.52	.60	*ns*
Sagittal x Group	2.0	404.49	0.48	.62	*ns*
Coronal x Group	5.29	575.35	0.43	.84	*ns*
Sagittal x Coronal x Group	5.14	1039.75	1.43	.21	*ns*

Note. * represents a significant main effect or interaction.

Table Q4

Group Pairwise Comparisons Conducted on Group Set 3 P3a Amplitude Data Following Significant Group Main Effect and Coronal x Group Interaction

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
		Between-subjects		
Group*				
ADD x NAS	-2.90	1.87	.37	*ns*
ADD x AS	0.99	1.57	1.0	*ns*
NAS x AS	3.89	1.40	.021	*
		Coronal x Group		
Far Left x Group*				
ADD x NAS	-3.12	1.30	.058	*ns*
ADD x AS	0.19	1.096	1.0	*ns*
NAS x AS	3.31	0.98	.003	*
Left x Group*				
ADD x NAS	-4.12	2.19	.19	*ns*
ADD x AS	0.38	1.84	1.0	*ns*
NAS x AS	4.50	1.64	.023	*
Midline x Group*				
ADD x NAS	-4.69	2.92	.34	*ns*
ADD x AS	1.68	2.45	1.0	*ns*
NAS x AS	4.69	2.92	.34	*ns*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), Sub-clinical group with some symptoms of addiction (AS), and Non-clinical group with no symptoms of addiction (NAS).

Table Q5

Three-way ANOVAs Conducted on P3b Amplitude and Latency Data and Breakdown ANOVAs of Significant Interactions

Variables	*df*	MS Effect	*F*	*p*	Significance
			P3b Amplitude		
GROUP SET 1					
Group	2.0	685.66	6.07	.004	*
Sagittal x Group	2.0	2.91	0.19	.83	*ns*
Coronal x Group	3.83	10.99	2.086	.088	trend
Sagittal x Coronal x Group	3.83	1.52	0.87	.48	*ns*
GROUP SET 2					
Group	4.0	637.47	6.36	< .001	*
Sagittal x Group	4.0	16.77	1.094	.38	*ns*
Coronal x Group	7.69	12.70	2.54	.014	*
Sagittal x Coronal x Group	7.65	1.83	1.051	.400	*ns*
GROUP SET 3					
Group	2.0	856.62	7.89	.001	*
Sagittal x Group	2.0	31.43	2.098	.13	*ns*
Coronal x Group	3.87	11.84	2.28	.066	trend
Sagittal x Coronal x Group	3.82	2.76	1.61	.18	*ns*
			P3b Amplitude Post hocs		
Coronal x Group for Group Set 1*					
Left	2.0	211.60	6.96	.002	*
Midline	2.0	345.07	6.24	.003	*
Right	2.0	150.03	4.011	.022	*
Coronal x Group for Group Set 2*					
Left	4.0	179.47	6.58	< .0001	*
Midline	4.0	324.25	6.66	<.0001	*
Right	4.0	158.16	4.66	.002	*
Coronal x Group for Group Set 3*					
Left	2.0	235.51	7.91	.001	*
Midline	2.0	429.24	8.081	.001	*
Right	2.0	214.74	6.011	.004	*
			P3b Latency		
GROUP SET 1					
Group	2.0	28252.02	1.93	.15	*ns*
Sagittal x Group	2.0	235.84	0.087	.92	*ns*
Coronal x Group	3.87	2196.69	1.59	.18	*ns*
Sagittal x Coronal x Group	3.64	520.66	0.39	.80	*ns*
GROUP SET 2					
Group	4.0	47692.84	3.60	.01	*
Sagittal x Group	4.0	276.88	0.10	.98	*ns*
Coronal x Group	7.76	1450.85	1.037	.41	*ns*
Sagittal x Coronal x Group	7.27	792.70	0.60	.76	*ns*
GROUP SET 3					
Group	2.0	51413.68	3.66	.03	*
Sagittal x Group	2.0	551.074	0.204	.82	*ns*
Coronal x Group	3.87	1460.37	1.041	.38	*ns*
Sagittal x Coronal x Group	3.65	1043.30	0.80	.52	*ns*

Note * represents a significant main effect or interaction

Table Q6

Group Pairwise Comparisons on P3b Amplitude Data for Group Set 1 Following a Significant Group Main Effect and Coronal x Group Interaction

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
		Between-subjects		
Group*				
ADD x HME	0.61	1.47	1.0	*ns*
ADD x LE	-2.93	1.45	.14	*ns*
LE x HME	3.54	1.054	.004	*
		Coronal x Group		
Left x Group*				
ADD x HME	0.42	1.32	1.0	*ns*
ADD x LE	-2.95	1.30	.078	trend
LE x HME	3.37	0.95	.002	*
Midline x Group*				
ADD x HME	0.94	1.78	1.0	*ns*
ADD x LE	-3.44	1.75	.16	*ns*
LE x HME	-0.94	1.78	1.0	*ns*
Right x Group*				
ADD x HME	0.46	1.46	1.0	*ns*
ADD x LE	-2.40	1.44	.30	*ns*
LE x HME	-2.86	1.051	.024	*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), High/medium Engagement group (HME), and Low Engagement group (LE).

Table Q7

Group Pairwise Comparisons of Group Set 2P3b Amplitude Data Following a Significant Group Main Effect and Coronal x Group Interaction

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
		Between-subjects		
Group*				
LNAS x ADD	5.94	1.67	.006	*
LNAS x HMNAS	4.19	2.18	.58	*ns*
LNAS x HMAS	6.99	1.42	<.0001	*
LNAS x LAS	4.52	1.45	.025	*
		Coronal x Group		
Left x Group*				
LNAS x ADD	5.26	1.51	.008	*ns*
LNAS x HMNAS	2.74	1.97	1.0	*ns*
LNAS x HMAS	6.23	1.28	< .0001	*
LNAS x LAS	3.47	1.31	.097	*ns*
Midline x Group*				
LNAS x ADD	7.24	2.014	.006	*
LNAS x HMNAS	5.48	2.63	.402	*ns*
LNAS x HMAS	8.69	1.71	< .0001	*
LNAS x LAS	5.70	1.74	.016	*
Right x Group*				
LNAS x ADD	5.32	1.68	.022	*
LNAS x HMNAS	4.33	2.19	.52	*ns*
LNAS x HMAS	6.05	1.43	.001	*
LNAS x LAS	4.38	1.46	.036	*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), High/medium Engagement group with no symptoms of addiction (HMNAS), High/medium Engagement group with symptoms of addiction (HMAS), Low Engagement group with no symptoms of addiction (LNAS), and Low Engagement group with symptoms of addiction (LAS). Only pairwise comparisons involving LNAS group were included in the table as all other group comparisons did not reach statistical significance.

Table Q8

Group Pairwise Comparisons of Group Set 3P3b Amplitude Data Following a Significant Group Main Effect and Coronal x Group Interaction

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
		Between-subjects		
Group*				
ADD x NAS	-4.71	1.60	.013	*
ADD x AS	-0.12	1.37	1.0	*ns*
NAS x AS	4.60	1.19	.001	*
		Coronal x Group		
Left x Group*				
ADD x NAS	-4.46	1.46	.009	*
ADD x AS	-0.33	1.24	1.0	*ns*
NAS x AS	4.12	1.081	.001	*
Midline x Group*				
ADD x NAS	-5.63	1.94	.015	*
ADD x AS	0.039	1.65	1.0	*ns*
NAS x AS	5.67	1.44	.001	*
Right x Group*				
ADD x NAS	-4.05	1.59	.039	*
ADD x AS	-0.056	1.36	1.0	*ns*
NAS x AS	3.99	1.18	.003	*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), Sub-clinical group with some symptoms of addiction (AS), and Non-clinical group with no symptoms of addiction (NAS).

Table Q9

Pairwise Comparisons of Group Set 2 P3b Latency Data Following a Significant Group Main Effect

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
LNAS x ADD	-55.74	19.19	0.048	*
LNAS x HMNAS	-64.12	25.017	0.12	*ns*
LNAS x HMAS	-55.96	16.31	0.01	*
LNAS x LAS	-52.56	16.62	0.023	*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), High/medium Engagement group with no symptoms of addiction (HMNAS), High/medium Engagement group with symptoms of addiction (HMAS), Low Engagement group with no symptoms of addiction (LNAS), and Low Engagement group with symptoms of addiction (LAS). Only pairwise comparisons involving LNAS group were included in the table as all other group comparisons did not reach statistical significance.

Table Q10

Group Pairwise Comparisons of Group Set 3 P3b Latency Data Following a Significant Main Effect of Group

Pairwise Comparison	Mean Difference	Std. Error	*p*	Significance
ADD x NAS	36.88	18.25	0.14	*ns*
ADD x AS	1.38	15.53	1.0	*ns*
NAS x AS	-35.50	13.55	0.032	*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to the Addicted group (ADD), Sub-clinical group with some symptoms of addiction (AS), and Non-clinical group with no symptoms of addiction (NAS).

Appendix R

Study 3 MMN Statistical Analysis

Table R1

Preliminary ANOVAs Assessing the Effect of Sex on MMN Amplitude and Latency Data Reported in Study 3

Variables	*df*	MS Effect	*F*	*p*	Significance
			MMN Amplitude		
GROUP SET 1					
Sex x Group	2.0	11.10	0.53	.59	*ns*
Sagittal x Sex x Group	2.0	0.97	0.52	.60	*ns*
Coronal x Sex x Group	3.99	1.35	0.34	.85	*ns*
Sagittal x Coronal x Sex x Group	4.95	0.62	1.37	.24	*ns*
GROUP SET 2					
Sex x Group	4.0	22.16	1.12	.36	*ns*
Sagittal x Sex x Group	4.0	0.88	0.45	.77	*ns*
Coronal x Sex x Group	8.074	4.66	1.20	.30	*ns*
Sagittal x Coronal x Sex x Group	9.86	0.67	1.49	.15	*ns*
GROUP SET 3					
Sex x Group	2.0	9.85	0.47	.63	*ns*
Sagittal x Sex x Group	2.0	0.93	0.50	.61	*ns*
Coronal x Sex x Group	3.96	0.99	0.25	.91	*ns*
Sagittal x Coronal x Sex x Group	4.99	0.40	0.87	.50	*ns*
			MMN Latency		
GROUP SET 1					
Sex x Group	2.0	6707.25	1.69	.19	*ns*
Sagittal x Sex x Group	2.0	554.0	1.21	.31	*ns*
Coronal x Sex x Group	3.62	545.63	0.37	.81	*ns*
Sagittal x Coronal x Sex x Group	5.52	882.99	1.76	.12	*ns*
GROUP SET 2					
Sex x Group	4.0	3031.86	0.73	.58	*ns*
Sagittal x Sex x Group	4.0	289.58	0.61	.66	*ns*
Coronal x Sex x Group	7.24	837.70	0.56	.79	*ns*
Sagittal x Coronal x Sex x Group	11.45	504.27	1.06	.40	*ns*
GROUP SET 3					
Sex x Group	2.0	663.12	0.16	.85	*ns*
Sagittal x Sex x Group	2.0	372.34	0.81	.45	*ns*
Coronal x Sex x Group	3.62	876.95	0.59	.65	*ns*
Sagittal x Coronal x Sex x Group	5.89	439.66	0.94	.47	*ns*

Table R2

Three-way ANOVAs conducted on MMN Amplitude and Latency Data for each Group Set

Variables	*df*	MS Effect	*F*	*p*	Significance
			MMN Amplitude		
GROUP SET 1					
Group	2.0	2.51	0.12	.89	*ns*
Sagittal x Group	2.0	1.90	1.03	.36	*ns*
Coronal x Group	4.04	3.28	0.85	.50	*ns*
Sagittal x Coronal x Group	5.003	0.59	1.27	.28	*ns*
GROUP SET 2					
Group	4.0	18.35	0.89	.47	*ns*
Sagittal x Group	4.0	1.26	0.67	.62	*ns*
Coronal x Group	8.061	1.93	0.49	.86	*ns*
Sagittal x Coronal x Group	10.016	0.41	0.87	.57	*ns*
GROUP SET 3					
Group	2.0	1.99	0.095	.91	*ns*
Sagittal x Group	2.0	1.86	1.007	.37	*ns*
Coronal x Group	4.049	2.20	0.57	.69	*ns*
Sagittal x Coronal x Group	5.054	0.67	1.46	.20	*ns*
			MMN Latency		
GROUP SET 1					
Group	2.0	500.72	0.13	.88	*ns*
Sagittal x Group	2.0	6.47	0.014	.99	*ns*
Coronal x Group	3.67	866.58	0.61	.65	*ns*
Sagittal x Coronal x Group	5.72	479.86	1.012	.42	*ns*
GROUP SET 2					
Group	4.0	1317.18	0.33	.86	*ns*
Sagittal x Group	4.0	141.20	0.30	.88	*ns*
Coronal x Group	7.38	1113.16	0.78	.61	*ns*
Sagittal x Coronal x Group	11.92	746.99	1.63	.085	*ns*
GROUP SET 3					
Group	2.0	400.31	0.1	.91	*ns*
Sagittal x Group	2.0	111.50	0.24	.79	*ns*
Coronal x Group	3.66	702.99	0.49	.73	*ns*
Sagittal x Coronal x Group	5.90	853.98	1.83	.096	*ns*

Appendix S

Study 4 Personality and Psychopathology Statistical Analyses

Table S1

ANOVAS Conducted for each Group Set according to Group Scores on the Primary and Global Indices Scales of the SCL-90-R

Scale	*df*	MS Effect	*F*	*p*	Significance
Group Set 1					
Psychoticism	2.0	8.58	3.10	.051	*
Extraversion	2.0	19.21	1.68	.19	*ns*
Neuroticism	2.0	23.23	1.80	.17	*ns*
Lie	2.0	21.63	4.05	.021	*
Group Set 2					
Psychoticism	4.0	6.01	2.18	.079	*trend*
Extraversion	4.0	10.44	0.89	.47	*ns*
Neuroticism	4.0	23.11	1.83	.13	*ns*
Lie	4.0	12.21	2.26	.071	*trend*
Group Set 3					
Psychoticism	2.0	8.71	3.15	.048	*
Extraversion	2.0	4.97	0.42	.66	*ns*
Neuroticism	2.0	13.40	1.02	.37	*ns*
Lie	2.0	21.41	4.00	.022	*

Note. * represents a significant main effect of Group.

Table S2

Pairwise Comparisons of Groups in Group Set 1, 2 and 3 Following Significant Main Effect of Group on the Psychotocism and Lie Scales of the EPQ-R

Pairwise comparison	Mean Difference	Std. Error	*p*	Significance
		Group Set 1*		
Psychoticism				
ADD x HME	1.36	0.55	.04	*
ADD x LE	1.03	0.54	.14	*ns*
HME x LE	0.33	0.41	.70	*ns*
Lie				
ADD x HME	-2.12	0.76	.019	*
ADD x LE	-1.82	0.75	.045	*
HME x LE	-0.29	0.57	.86	*ns*
		Group Set 2*		
Psychoticism				
ADD x HMNAS	1.96	0.95	.25	*ns*
ADD x HMAS	1.28	0.56	.16	*ns*
ADD x LNAS	0.46	0.68	.96	*ns*
ADD x LAS	1.29	0.57	.17	*ns*
HMNAS x HMAS	-0.69	0.89	.94	*ns*
HMAS x LNAS	-0.81	0.59	.65	*ns*
HMAS x LAS	0.02	0.47	1.0	*ns*
Lie				
ADD x HMNAS	-2.79	1.33	.23	*ns*
ADD x HMAS	-2.02	0.79	.086	*ns*
ADD x LNAS	-1.36	0.95	.62	*ns*
ADD x LAS	-2.04	0.80	.092	*ns*
HMNAS x HMAS	0.77	1.25	.97	*ns*
HMAS x LNAS	0.66	0.83	.93	*ns*
HMAS x LAS	-0.02	0.65	1.0	*ns*
		Group Set 3*		
Psychoticism				
ADD x AS	1.29	0.52	.040	*
ADD x NAS	0.86	0.63	.36	*ns*
AS x NAS	-0.42	0.49	.66	*ns*
Lie				
ADD x AS	-2.03	0.72	.017	*
ADD x NAS	-1.74	0.88	.12	*ns*
AS x NAS	0.29	0.68	.90	*ns*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to groups in Group Set 1: Addicted (ADD), High/medium Engagement (HME); Low Engagement (LE); Group Set 2: Addicted (ADD), High/medium Engagement with no symptoms of addiction (HMNAS), High/medium Engagement with symptoms of addiction (HMAS), Low Engagement with no symptoms of addiction (LNAS), and Low Engagement with symptoms of addiction (LAS). All other group comparisons for Group Set 2 did not reach statistical significance and thus are not reported. Group Set 3: Addicted (ADD); Sub-clinical with some symptoms of addiction (AS); Non-clinical with no symptoms of addiction (NAS).

Table S3

ANOVAS Conducted on Group Scores on the SCL-90-R Primary and Global Indices Scales

Scale	*df*	MS Effect	*F*	*p*	Significance
			Group Set 1		
Primary scales					
Somatization	2.0	128.81	1 20	.31	*ns*
Obsessive compulsive	2 0	530.44	6.80	.002	*
Interpersonal sensitivity	2.0	672.67	6.21	.003	*
Depression	2.0	540.36	5.43	.006	*
Anxiety	2.0	377.70	3.87	.025	*
Hostility	2.0	161.88	1.81	.17	*ns*
Phobic anxiety	2.0	137.18	1.81	.17	*ns*
Paranoid ideation	2.0	509.97	4.77	.011	*
Psychoticism	2.0	552.83	4.90	.010	*
Global indices					
Global severity	2.0	559.42	5.88	.004	*
Positive symptom distress	2.0	322.52	4.81	.011	*
Positive symptom total	2.0	334.96	4.15	.019	*
			Group Set 2		
Primary scales					
Somatization	4.0	129.41	1.21	.31	*ns*
Obsessive compulsive	4.0	293.20	3.73	.008	*
Interpersonal sensitivity	4.0	361.04	3.28	.016	*
Depression	4.0	281.66	2.78	.033	*
Anxiety	4.0	193.39	1.94	.11	*
Hostility	4.0	102 61	1.13	.35	*ns*
Phobic anxiety	4 0	152.38	2 08	.092	*ns*
Paranoid ideation	4.0	303.46	2.83	.030	*
Psychoticism	4.0	315.58	2.77	.033	*
Global indices					
Global severity	4.0	295.79	3.05	.022	*
Positive symptom distress	4.0	172.63	2.53	.047	*
Positive symptom total	4.0	183.58	2.24	.073	*trend*
			Group Set 3		
Primary scales					
Somatization	2.0	118.38	1.10	.34	*ns*
Obsessive compulsive	2.0	529.70	6.79	.002	*
Interpersonal sensitivity	2.0	669.93	6.18	.003	*
Depression	2.0	493.57	4.90	.010	*
Anxiety	2.0	377.89	3.88	.025	*
Hostility	2.0	170.97	1.91	.16	*ns*
Phobic anxiety	2.0	115.10	1.51	.23	*ns*
Paranoid ideation	2.0	514.43	4.82	.011	*
Psychoticism	2.0	597.89	5.35	.007	*
Global Indices					
Global severity	2.0	550.35	5.77	.005	*
Positive symptom distress	2.0	320.67	4.78	.011	*
Positive symptom total	2.0	325.52	4.02	.022	*

Note * represents a significant main effect of Group.

Table S4

Pairwise Comparisons of Groups in Group Set 1, 2 and 3 Following Significant Group Main Effect according to Scores on the Primary and Global Indices Scales of the SCL-90-R

	Primary scales						Global indices scales		
Pairwise comparison	OC	IS	DEP	ANX	PAR	PSY	GSI	PSDI	PST
					Group Set 1*				
ADD x HME									
Mean Difference	10.19	11.53	10.77	8.24	8 25	10.65	10.61	8.01	8 29
Std Error	2.91	3.42	3.28	3.25	3.40	3.50	3.21	2.69	2.95
p	.002	.003	004	.035	.046	.009	004	.011	.017
Significance	*	*	*	*	*	*	*	*	*
ADD x LE									
Mean Difference	9.51	10.63	8.30	8.40	10.32	9.27	9.55	7.32	7.22
Std. Error	2.87	3.38	3.24	3.21	3.36	3.45	3.17	2.66	2.92
p	.004	.007	.033	028	.008	.024	.010	.020	.041
Significance	*	*	*	*	*	*	*	*	*
HME x LE									
Mean Difference	0.67	0.90	2.47	-0.16	-2.07	1.39	1.06	0.70	1.06
Std. Error	2 16	2.55	2.44	2.42	2.53	2.60	2.39	2.00	2.20
p	.95	.93	.57	.99	.69	.86	.90	.94	.88
Significance	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
					Group Set 2*				
ADD x HMNAS									
Mean Difference	7.60	7.80	10.42	-	2.69	12.95	8.43	6.63	5.94
Std. Error	4.67	5.52	5.30	-	5.45	5.61	5.18	4.35	4.76
p	.48	.62	.293	-	.988	.154	.485	.549	.724
Significance	*ns*	*ns*	*ns*	-	*ns*	*ns*	*ns*	*ns*	*ns*
ADD x HMAS									
Mean Difference	10.67	12.22	10.84	-	9.28	10.23	11.01	8.27	8.72
Std. Error	2.99	3.54	3 40	-	3.50	3.60	3.32	2.79	3.06
p	.006	.008	.017	-	.07	.045	.012	.032	.043
Significance	*	*	*	-	*	*	*	*	*
ADD x LNAS									
Mean Difference	11.64	11 64	9.98	-	9.51	12.06	11.05	8.78	8.63
Std. Error	3.63	4.30	4.13	-	4.24	4.37	4.03	3.38	3.71
p	.017	.062	.122	-	.176	.055	.057	.082	.148
Significance	*	*trend*	*ns*	-	*ns*	*trend*	*trend*	*ns*	*ns*
ADD x LAS									
Mean Difference	8.54	10.17	7.53	-	10.69	7.99	8.86	6.65	6.58
Std. Error	3.05	3.61	3.47	-	3.57	3.67	3.39	2.84	3.12
p	.05	.047	.202	-	.029	.201	.078	.145	.226
Significance	*	*	*ns*	-	*	*ns*	*trend*	*ns*	*ns*
HMAS x HMNAS									
Mean Difference	3.07	4.42	0.42	-	6.59	2.73	2.58	1.64	2.79
Std. Error	4.32	5.11	4.91	-	5.04	5 19	4.79	4.02	4 41
p	.953	.91	1.00	-	.687	.985	.983	.994	.969
Significance	*ns*	*ns*	*ns*	-	*ns*	*ns*	*ns*	*ns*	*ns*

Pairwise comparison	Primary scales						Global indices scales		
	OC	IS	DEP	ANX	PAR	PSY	GSI	PSDI	PST
					Group Set 2*				
HMAS x LNAS									
Mean Difference	0.97	-0.59	-0.86	-	0.23	1.84	0.04	0.51	-0.09
Std. Error	3.17	3.75	3.60	-	3.70	3.82	3.52	2.95	3.24
p	.998	1.00	.999	-	1.00	.989	1.00	1.00	1.00
Significance	*ns*	*ns*	*ns*	-	*ns*	*ns*	*ns*	*ns*	*ns*
HMAS x LAS									
Mean Difference	-2.13	-2.06	-3.31	-	1.41	-2.24	-2.15	-1.62	-2.14
Std. Error	2.49	2.94	2.826	-	2.90	2.99	2.76	2.32	2.54
p	.912	.956	.769	-	.989	.944	.936	.956	.916
Significance	*ns*	*ns*	*ns*	-	*ns*	*ns*	*ns*	*ns*	*ns*
					Group Set 3*				
ADD x AS									
Mean Difference	9.67	11.25	9.28	8.27	9.95	9.17	10.00	7.51	7.71
Std. Error	2.74	3.24	3.12	3 07	3.21	3.28	3.04	2.54	2.8
p	.002	.002	.011	.023	.008	.018	.004	.012	.020
Significance	*	*	*	*	*	*	*	*	*
ADD x NAS									
Mean Difference	10.38	10.44	10.12	8.52	7.38	12.34	10.23	8.11	7.79
Std. Error	3 30	3.89	3.75	3.69	3.86	3.95	3.65	3.06	3.36
p	.007	.024	.023	.060	.142	.007	017	.026	.059
Significance	*	*	*	*	*	*	*	*	*
AS x NAS									
Mean Difference	0.71	-0.82	0.83	0.26	-2 57	3.17	0.24	0.60	0.07
Std. Error	2.53	2.98	2.88	2.83	2.96	3.03	2.80	2.35	2.58
p	.958	.959	.955	.995	663	.550	.996	.965	1.00
Significance	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

Note. * represents a significant pairwise comparison. Abbreviations used in the table refer to groups in Group Set 1: Addicted (ADD); High/medium Engagement (HME); Low Engagement (LE); Group Set 2: Addicted (ADD), High/medium Engagement with no symptoms of addiction (HMNAS), High/medium Engagement with symptoms of addiction (HMAS), Low Engagement with no symptoms of addiction (LNAS), and Low Engagement with symptoms of addiction (LAS). All other group comparisons for Group Set 2 did not reach statistical significance and thus are not reported. Group Set 3: Addicted (ADD); Sub-clinical with some symptoms of addiction (AS); Non-clinical with no symptoms of addiction (NAS). Dashes indicate analyses not reported because the main effect of group was not significant.