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COMMENTARY

The essential role of theory in minimizing harm from emerging technologies. Lost in committee? Commentary on: Problematic risk-taking involving emerging technologies: A stakeholder framework to minimize harms (Swanton et al., 2019)

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ABSTRACT

A coherent framework for addressing risk arising from new technologies is needed. In proposing a framework of broad application and future focus, where empirical evidence is scarce, reliance on strong theory becomes all the more important. Some technologies are more prone to excessive engagement than others (i.e. more addictive). Some users are also more susceptible to excessive engagement than others. Impulsivity theory emphasises the importance of reinforcement magnitude in determining the risk associated with a new technology, and that an individual's sensitivity to reinforcement (*reward drive*) and capacity to inhibit previously reinforced behaviour (*rash impulsiveness*) determines their susceptibility to problematic engagement. Online gaming provides a good example of how such theory can be applied to facilitate intervention efforts and develop policy.

KEYWORDS

risk-taking, impulsivity, reward, gaming disorder, gaming addiction

A framework for identifying key issues and responses relating to problematic risk-taking involving new technologies, as provided by Swanton, Blaszczynski, Forlini, Starcevic, and Gainsbury (2019) is an important step forward. The notion of an overarching framework to facilitate faster identification of, and response to, potential harms from a wide range of new technologies is appealing, but not without significant challenges. Good health policy can be slow to develop because it requires high-quality evidence to guide it. Gathering such evidence inevitably takes time – years or even decades. Policy developed in the interim is informed to a greater extent by other sources, such as lower-quality evidence (e.g. anecdote, individual case report), theory and high-quality evidence amassed on different, but conceptually-related, phenomena. Judgements about what is conceptually-related, and what is not, are themselves informed by theory (e.g. can internet gaming disorder policy be informed by addiction research?). Theory also determines the focus of empirical research efforts (e.g. should clinical trials of behavioural or pharmacological intervention for internet gaming disorder be prioritised?). Here, we outline how greater attention to theory would benefit Swanton et al.'s (2019) new framework.

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SOME TECHNOLOGIES ARE MORE REWARDING THAN OTHERS

At the centre of Swanton et al.'s (2019) framework is 'problematic risk-taking', a construct similar to, but quite different from, *impulsivity* or *risk-taking* as conceptualised in other theories. This was intentional and hoped by the authors to facilitate a kind of

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interdisciplinary approach that would be less prone to conceptual 'blind spots' that may arise from a more 'unilateral' approach. Even the choice of the label 'problematic risk-taking' was to avoid reference to addiction but, in doing so, has also omitted the important role of *reinforcement* in the behaviour. Every major theory of impulsivity, risk-taking, or novelty/sensation seeking (which are built on multidisciplinary programs of research) has at its centre the motivation to pursue reinforcers, including in situations where it may be hazardous to do so (Barratt, 1972; Cloninger, 1987; Eysenck, 1993; Gullo, Loxton, & Dawe, 2014; Whiteside & Lynam, 2001; Zuckerman & Kuhlman, 2000). Impulsive or risk-taking behaviour, whether problematic or not, is motivated by the pursuit of conditioned or unconditioned reward stimuli (e.g. food, sex, social approval, resulting in positive reinforcement). It can also be motivated by *negative* reinforcement, the pursuit of relief from aversive physical or psychological states (i.e. punishment), such as pain or low mood. No matter the actual reinforcer, it is the expectation of reinforcement that motivates risk-taking and impulsive behaviour. The omission of a new technology's reinforcement potential or strength is an important limitation to Swanton et al.'s (2019) framework.

Some stimuli are inherently more reinforcing (rewarding and/or relieving) than others. For example, few would disagree that technology that allows for easier (online) access to video games or pornography is more likely to result in problematic use than technology that allows for easier dishwashing. Internet gaming and pornography are more reinforcing because they affect dopamine neurotransmission to a greater extent than dishwasher use or other activities (Gola et al., 2017; Koepp et al., 1998). In more strongly affecting dopamine neurotransmission, internet gaming and pornography cues can attain greater *incentive salience* than dishwasher cues, with thoughts about them more frequently capturing the attention of users and producing a stronger desire to seek the reward associated with use (Berridge & Robinson, 2016; Han, Kim, Lee, Min, & Renshaw, 2010; Robinson & Berridge, 2001). Incentive salience is a key phenomenon that underpins reinforcement (of substances and behaviours) that in turn can lead to disorders of regulation of use and consequent harms (Koob & Volkow, 2016; Saunders, Degenhardt, Reed, & Poznyak, 2019). With more intrusive thoughts and stronger motivational impulses comes greater difficulty inhibiting the use behaviour when it is inappropriate or harmful. The reward/reinforcement potential of any new technology is an important factor in determining how risky it will be for users (Saunders et al., 2017).

SOME INDIVIDUALS ARE MORE SENSITIVE TO REWARD

Recognising the importance of reinforcement in problematic technology use makes the application of impulsivity theory clear when considering how to address risk. Individuals high in trait *reward drive/sensitivity*, a major dimension of impulsivity, will experience stronger reinforcement from using technology-related rewards, more quickly associate various cues with this reward, and form overly positive expectations about the benefits of such technology use, all resulting in stronger and more frequent motivational impulses (i.e. craving) to use it again and again (Dawe, Gullo, & Loxton, 2004; Gullo, Dawe, Kambouropoulos, Staiger, & Jackson, 2010; Robinson & Berridge, 2000). Reward drive is a biologically-based trait reflecting individual differences in the functioning of the mesolimbic dopamine system that are largely genetic in origin (Cloninger, 1987; Costumero et al., 2013; Dawe et al., 2004; Depue & Collins, 1999; Schreuders et al., 2018). Reward drive/sensitivity lies at the core of extraversion (Depue & Collins, 1999; Gray, 1970; Lucas & Diener, 2001), is most clearly articulated in Gray's Behavioural Approach System (BAS) (Gray, 1975), and is reflected to varying degrees in some conceptualisations of sensation seeking (Steinberg, 2008; Woicik, Stewart, Pihl, & Conrod, 2009), but less so in others (Zuckerman & Kuhlman, 2000).

High reward drive has been shown to longitudinally predict problems with various reinforcing substances (De Decker et al., 2017; Heinrich et al., 2016; Urošević et al., 2015) and individuals with internet gaming disorder are significantly higher in reward drive than healthy controls (Lee et al., 2017; Rho et al., 2017). Reward drive peaks during adolescence, presenting a unique period of risk for a range of problematic approach behaviours (Ernst et al., 2005; Galvan et al., 2006; Gullo & Dawe, 2008; Steinberg & Chein, 2015). Viewing new and emerging technologies through the lens of reinforcement potential would allow for faster identification of those more likely to be of potential harm (e.g. innovations in dishwasher technology are unlikely to be problematic). The application of impulsivity theory would allow for the identification of those individuals in society more susceptible to problematic use.

REGULATING REWARDED BEHAVIOUR

While some technologies hold greater reinforcement potential that others, the majority of users will not develop problems, even with frequent use. Large-scale survey studies estimate the prevalence of pathological online gaming as 1–15% among youth, with this varying greatly by region and age (Gentile, 2009; Saunders et al., 2017). Youths who play video games for up to 19 hours per week tend not to go on to become pathological gamers (Gentile et al., 2011). As is the case for highly reinforcing substances (Wagner & Anthony, 2007), while increased use of reinforcing technology does increase the likelihood of developing problems, the majority of users do not develop problems regulating their use. Successful regulation depends on the capacity to inhibit a strongly reinforced approach behaviour after the emergence of negative consequences, i.e. punishment (Patterson & Newman, 1993).

Most youth who play video games receive the associated reinforcement and not go on to become pathological gamers (Gentile et al., 2011). For others, the reinforced behaviour increases in frequency and intensity, resulting in punishment (e.g. poor grade on an exam). The experience (or even expectation) of such punishment produces an opposing motivation to inhibit the reinforced behaviour, thereby avoiding (potential) negative consequences (Gray & McNaughton, 2000; Patterson & Newman, 1993). Online gaming may be fun, but each hour spent playing leaves one less hour to spend studying for an exam or being with a boy/girlfriend. This may not, in-and-of-itself, be harmful or maladaptive, but it does increase the likelihood for negative consequences as more hours are being devoted to the use of an immediately-rewarding technology as opposed to other activities. Decision-making of this type, that involves immediate reward and delayed/uncertain punishment, is a focus of much theoretical work in the impulsivity field.

Theoretical accounts of impulsivity and risk-taking describe it as the tendency to engage in approach behaviour that leads to reward/relief (typically more immediate and more certain reward) despite potential punishment (typically more delayed and less certain punishment (Barratt, 1972; Cloninger, 1987; Eysenck, 1993; Gullo et al., 2014; Zuckerman & Kuhlman, 2000)). While some theories make no distinction between *impulsivity* and *risk-taking*, others propose the former is characterised more by the lack of awareness of potential negative consequences and the latter more by a willingness to 'take the risk' despite awareness of the consequences (Cross, Copping, & Campbell, 2011; Eysenck, Easting, & Pearson, 1984; Gullo & Dawe, 2008; Nigg, 2017; Zuckerman & Kuhlman, 2000). From a neuropsychological perspective, it is more parsimonious to view awareness of punishing stimuli and their motivational significance as both existing on a single continuum of 'punishment sensitivity' (Gray & McNaughton, 2000; McNaughton & Corr, 2004).

Individual differences in punishment sensitivity reflects the threshold of activation of the brain's defence system. This system comprises, among other structures, the hippocampus, dentate gyrus, entorhinal cortex, subicular area (subiculum), amygdala, orbitofrontal and cingulate cortices (Bechara, 2004; Gray & McNaughton, 2000). Individuals low in punishment sensitivity would only respond to cues predictive of more immediate and certain negative consequences (e.g. 'If I fail one more exam, which is tomorrow, I will have to repeat 10th grade'). Individuals high in punishment sensitivity would experience significant inhibitory motivation in response to cues of less immediate and certain negative consequences (e.g. 'I don't want to play video games on weekdays because it *might* affect my studies').

The preceding discussion should not be read to suggest that impulsivity is simply the combination of high reward sensitivity and low punishment sensitivity, and the evidence bears this out (Depue & Collins, 1999; Smillie, Pickering, & Jackson, 2006). Differences in the temporal nature of reward and punishment cues, as well as the frequency/probability of their occurrence need to be taken into account. This is another area that we believe Swanton and colleagues' (2019) conceptualisation of risk-taking would benefit from further development.

Contemporary models of impulsivity, as well as models of addictive behaviour more specifically, recognise the importance of the differences in exposure to reward and punishment as a consequence of the focal behaviour, and how this changes over time. Addictive behaviour often begins with engagement in an action that results only in reward (e.g. playing video games online). This behaviour is repeated and rewarded many times with little or no punishment, and this reinforcement schedule can remain for several years, even in the case of illicit drugs (Wagner & Anthony, 2007). As the frequency and/or duration of the focal behaviour increases, in this case, online gaming, the likelihood of punishment increases as it begins to interfere with activities of daily living: gaining adequate sleep, physical activity, hydration, nutrition (Achab et al., 2011; Chuang, 2006; Mihara, Nakayama, Osaki, & Higuchi, 2016). These punishments occur within the context of a well-established, dominant, approach-to-reward behavioural pattern and not processed by the brain in the same way as punishments that occur without this learning history (Bechara, 2004; Fellows, 2007; Gray & McNaughton, 2000; Patterson & Newman, 1993). Importantly, there are significant biologically-based individual differences in the motivational impact of punishments introduced to previously rewarded behaviour (Dawe et al., 2004; Gullo, Jackson, & Dawe, 2010; Patterson & Newman, 1993). This is the focus of the second major dimension of impulsivity, *rash impulsiveness*, which also has relevance to understanding risky use of new technology.

Rash impulsiveness is a biologically-based trait that reflects individual differences in the ability to modify or inhibit prepotent approach behaviours in light of potential negative consequences (Dawe & Loxton, 2004; Gullo & Dawe, 2008). It is conceptually similar to impulsiveness as defined by Eysenck and Eysenck (1978) and Barratt (1972), and is analogous to Cloninger's (1987) *novelty seeking*, and Zuckerman's *impulsive-sensation seeking* (Zuckerman & Kuhlman, 2000). Individual differences in the trait result from variations in the functioning of the orbitofrontal and anterior cingulate cortices, including their connections to various limbic brain regions such as the striatum (Gullo & Dawe, 2008). There is evidence that both dopamine and serotonin play a major role in the functioning of neural systems underlying the trait (Cools, Roberts, & Robbins, 2008; Gullo et al., 2014; Leyton et al., 2002). Rash impulsiveness is conceptually similar to Swanton and colleagues' (2019) problematic risk-taking, but has the added benefit of a detailed neuropsychological, behavioural and measurement profile that draws on over 50 years of research. It also obviates the need for a 'problematic' qualifier, which itself is problematic.

PROBLEMS WITH 'PROBLEMATIC' RISK-TAKING

Placing *problematic* risk-taking at the centre of any new framework for emerging technologies introduces a number of conceptual problems. As defined by Swanton and colleagues (2019, p. 2–3), 'In the context of the online environment, problematic risk-taking is defined as engaging with online content in a way that compromises the individual, leading her/him to experience harms'. Firstly, it defines the behaviour more narrowly by its negative consequences, limiting its application in prevention and early intervention. As discussed above, the negative consequences of risk-taking are typically delayed and infrequent. A teenager engaging in 10+ hours per day of online gaming is taking a health risk, and this behaviour is cause for concern, even if they are yet to experience any harms (Saunders et al., 2017). Frequent, intensive gaming of this sort is very likely characterised by motivation for short-term reinforcement without due consideration for potential future punishment, the likelihood of which would presumably be escalating at such high levels of use. This distinction between characteristic features of a behaviour and evidence of harms is reflected in the provisional diagnostic criteria for Internet Gaming Disorder set out in DSM-5 (American Psychiatric Association, 2013), as well as the current criteria for substance use disorders. An individual could receive a diagnosis based on characteristic behavioural features (e.g. tolerance, preoccupation), which warrant clinical intervention, prior to the experience of significant harm (American Psychiatric Association, 2013). The latest (eleventh) revision of the International Classification of Diseases (ICD-11) has three central features of Gaming Disorder, with a separate but obligatory requirement for impairment to have occurred (World Health Organization, 2019). Secondly, *risk* is defined as the potential for harm in the future, making the term 'problematic risk taking' tautological (World Health Organization, 2009). Removing the 'problematic' qualifier and placing the well-supported concepts of risk-taking and impulsivity, as described above, at the centre of Swanton and colleagues' (2019) framework would enable more effective application in prevention and more clearly distinguish non-problematic from problematic engagement with a technology.

NOTHING SO PRACTICAL AS A GOOD THEORY

With regard to online gaming, it is helpful to distinguish impulsivity or risk-taking from problematic gaming or (Internet) Gaming Disorder. Even before the availability of online gaming, it was clear from theory and research into other behaviours characterised by highly probable, immediate reward and less probable, delayed punishment that individuals high in impulsivity would be at greater risk of developing problems (Dawe & Loxton, 2004). Indeed, the association between high impulsivity and internet gaming disorder is now empirically well-established (Şalvarlı & Griffiths, 2019). As found with substance use disorder before it, impulsivity prospectively predicts the emergence of internet gaming disorder symptoms (Gentile et al., 2011) and both reward drive and rash impulsiveness have been shown to independently contribute to internet gaming disorder risk (Lee et al., 2017; Rho et al., 2017). Online gaming affects the neural substrates of reward drive and rash impulsiveness, with game-playing increasing ventral striatal dopamine release (Koepp et al., 1998), and the anterior cingulate cortex being among the most affected brain regions in those with internet gaming disorder (Lee, Namkoong, Lee, & Jung, 2018; Yuan et al., 2011). Impulsivity is a clear risk factor for problem gaming and can be reliably assessed well before harm emerges, even in early childhood and its risk would be expected to apply to any new technology that provides access to highly probable, immediate rewards and less probable, delayed punishments (Dawe et al., 2004; Gullo & Dawe, 2008).

Anchoring a new framework with established models of impulsivity can also inform intervention research. The neurophysiological and behavioural processes of impulsivity greatly overlap with those identified in addictive behaviour (Dawe et al., 2004). These shared underlying processes provide a 'bridge' to conceptually relate any new technology that facilitates delivery of high, immediate reward and delayed/uncertain punishment to these established research programs. The parallels between the role of impulsivity traits in problematic gaming and substance use (and gambling) identify promising points of intervention. Interventions targeting game-related craving show similar neurophysiological effects to those seen in addiction (Saunders et al., 2017; Zhang et al., 2016); as in addiction, cognitive-behavioural interventions have the strongest evidence base (King et al., 2017); and key dysfunctional cognitions identified in problems gamers also resemble those seen in addiction (Marino & Spada, 2017; Moudiab & Spada, 2019). Based on impulsivity theory and past research in substance use, we can hypothesize that reward drive and rash impulsiveness would differentially affect the development of reinforcing technology-related cognitions and behaviours (Fowler, Gullo, & Elphinston, 2020; Gullo, Dawe, et al., 2010; Papinczak et al., 2019), and that this, in turn, would result in some early intervention approaches being more effective than others, particularly for different personality profiles (Conrod, 2016; Patton, Connor, Sheffield, Wood, & Gullo, 2019). Given the similarity in key neurobehavioural processes, existing theory can provide a strong foundation for intervention research and policy development in the absence of specific empirical evidence on any new technology.

There is a large body of evidence, from multiple disciplines, showing that individuals differ in their susceptibility to harm from stimuli associated with high immediate reward and delayed/uncertain punishment. This has clear implications for key stakeholder groups (see Table 1 in Swanton et al., 2019). While the use of new, reinforcing technologies will have their differences, the similarities to other addictive behaviours warrants care to be taken when introduced to the community. This extends from those closely connected to users (family, teachers) who can monitor and assess risk (Bonnaire & Phan, 2017), to industry stakeholders who design the technology (Fitz et al., 2019) and governments that regulate it (Gainsbury & Wood, 2011). Researchers have an important role in developing public policy around new technologies, which includes informing stakeholders (and remembering themselves) that in the absence of specific high-quality evidence that, 'There is nothing so practical as a good theory' (Lewin, 1951).

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