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Impulsivity: Four ways five factors are not basic to addiction

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Abstract

Several impulsivity-related models have been applied to understanding the vulnerability to addiction. While there is a growing consensus that impulsivity is multifaceted, debate continues as to the precise number of facets and, more critically, which are most relevant to explaining the addiction-risk profile. In many ways, the current debate mirrors that which took place in the personality literature (e.g., Eysenck's 'Big Three' versus Costa and McCrae's 'Big Five'). Indeed, many elements of this debate are relevant to the current discussion of the role of impulsivity in addictive behavior. Specifically, 1) the use of factor analysis as an atheoretical 'truth-grinding machine'; 2) whether additional facets add explanatory power over fewer; 3) the delineation of specific neurocognitive pathways from each facet to addictive behaviors, and; 4) the relative merit of 'top-down' versus 'bottom-up' approaches to the understanding of impulsivity. Ultimately, the utility of any model of impulsivity and addiction lies in its heuristic value and ability to integrate evidence from different levels of analysis. Here, we make the case that theoretically-driven, bottom-up models proposing two factors deliver the optimal balance of explanatory power, parsimony, and integration of evidence.

Keywords: impulsivity, addiction, substance use, alcohol, urgency, UPPS

1. Introduction

Impulsivity, whether measured by self-report, observer-report, or behavioral performance, is a robust predictor of current and future problems with substance use (Dawe & Loxton, 2004; Jentsch & Taylor, 1999; Moeller et al., 2001; Moffitt et al., 2011; Nigg et al., 2006; Potenza, 2013; Tarter et al., 2003). In children, its association with future substance use remains even after controlling for other markers of risk, including low IQ, socioeconomic status, and parental history of substance dependence (Moffitt et al., 2011; Nigg et al., 2006; Tarter et al., 2003). Not surprisingly, the construct is of great interest to addiction scientists.

In addiction science, there is an emerging consensus that impulsive drug use involves two core processes observable at the neurophysiological, behavioral, cognitive, and trait. The first involves a heightened propensity or impulse to approach drugs and the second involves a reduced capacity to inhibit this approach behavior. The summary presented in Table 1 highlights the considerable overlap of different theoretical models in the importance placed on these two fundamental processes that have been derived from multiple researchers across diverse methodological investigations.

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Whilst a two-factor model is attractive in its parsimony, other researchers have proposed that a more useful way to consider impulsivity is to develop a more nuanced delineation of subtypes. This would have important implications for addiction science. In an attempt to “bring order to the myriad of measures and conceptions of impulsivity”, Whiteside and Lynam (2001, p. 684) drew upon the Five Factor Model of human personality (Costa & McCrae, 1992; Goldberg,

1993) as a framework for conceptualizing impulsivity. Employing factor analysis of self-report data, they constructed the four-factor UPPS impulsivity questionnaire consisting of: Urgency, (lack of) Premeditation, (lack of) Perseverance, and Sensation seeking. Subsequently, Cyders and colleagues (2007) argued that the UPPS model was incomplete, in that it did not incorporate impulsive behavior arising from positive mood states. They proposed individual differences in this tendency were important to consider in understanding risky behavior such as alcohol abuse, and used factor analysis to derive an additional scale to measure the construct. Thus, the Urgency subscale was renamed Negative Urgency and a new scale added, Positive Urgency. We refer to this extended model as the UPPS+P model.

Notably, UPPS Sensation Seeking and (lack of) Premeditation align somewhat with the core processes previously implicated in impulsive substance use, and impulsivity theories more generally (Table 1). However, as the authors themselves note, “(lack of) perseverance, like urgency, is not well represented in other measures of impulsivity” (Whiteside & Lynam, 2001, p. 685). The same could be said of Positive Urgency (Cyders et al., 2007). In debating the importance of these newly constructed impulsivity traits, the field finds itself in a situation strikingly similar to that which took place in the personality literature. In particular, the debate between Costa and McCrae (1992) and Eysenck (1992) in which the former argued that there were four main lines of evidence to support the five-factor model of personality. Eysenck’s reply argued against each of the proposed lines of evidence and concluded with a strong call for a science of personality based on theoretical predictions firmly rooted in biological processes.

Many of the issues raised during the personality debate are relevant for addiction researchers studying impulsivity. Specifically, 1) the use of factor analysis as an atheoretical ‘truth-grinding’ machine; 2) whether additional facets of a construct add explanatory power over

fewer; 3) the delineation of specific neurocognitive pathways from each facet to addictive behavior, and; 4) the relative merit of ‘top-down’ versus ‘bottom-up’ approaches to the understanding of impulsivity and the integration of experimental evidence. Each of these issues will be discussed, in turn, with reference to current research into impulsivity and substance abuse. It is hoped that this will stimulate further refinements to the understanding impulsivity and highlight the importance of theoretical integration across fields.

2. Factor analysis is not a ‘truth-grinding’ machine

The UPPS and UPPS+P are models of impulsivity borne of factor analysis. Using this statistical technique, Whiteside and Lynam (2001) set out to distil the numerous conceptualizations of impulsivity into core facets common across measures. The Five Factor Model of personality, itself a product of factor analysis, was used as the framework within which to ‘anchor’ these facets within personality more broadly. It should be noted, however, that only three of the Big Five were included as anchors, those considered by the authors as most relevant to impulsivity (Extraversion, Neuroticism, and Conscientiousness). While factor analysis is an extraordinarily useful method of data reduction, it possesses significant shortcomings that limit its value in theory construction (Block, 1995; Eysenck, 1992).

One important limitation to factor analysis is its vulnerability to ‘prestructuring’ (Block, 1995). That is, that the number and nature of the factors derived depend on the variables included in the factor analysis. This can occur regardless of whether the selection was guided by theory or practical constraints. There is clear evidence of prestructuring in the construction of the UPPS and UPPS+P. After constructing the UPPS scales, Whiteside and Lynam (2001, Table 7, p. 684) conducted another factor analysis and found that the new UPPS Urgency scale loaded with all

NEO-PI-R Neuroticism subscales, the UPPS Sensation Seeking scale loaded with all NEO-PI-R Extraversion subscales, and both UPPS (Lack of) Premeditation and UPPS (Lack of) Perseverance scales loaded together with all NEO-PI-R Conscientiousness subscales. That is, the four new UPPS scales loaded onto the three factors initially taken from the Big Five and used as anchors. This same three-factor structure was later replicated by Smith et al. (2007). Thus, the inclusion of the three Big Five 'anchor' traits might have prestructured the UPPS. This could explain why its factor structure differed from previous factor analytic studies finding a two-factor structure (for a review, see Dawe & Loxton, 2004), and why it 'missed' Positive Urgency (Cyders et al., 2007).

The primary shortcoming of factor analysis is that there is no unequivocal basis for deciding on the number of factors to extract from the data or on the best approach to rotating them for interpretation (Block, 1995). The history of personality psychology provides a clear example of this. Costa and McCrae (1992) argued for their Big Five traits of Extraversion, Neuroticism, Openness to Experience, Conscientiousness, and Agreeableness as forming the basic structure of personality. By contrast, Eysenck argued the case for his Big Three traits of Extraversion, Neuroticism, and Psychoticism. The first two traits in each model are closely aligned. However, Eysenck (1992) argued that Agreeableness and Conscientiousness were too closely related to be considered distinct, and considered them to be subcomponents of his higher-order Psychoticism trait. However, he made the point that the subjectivity of factor analysis is such that there was no psychometric reason for preferring his conceptualization of these traits to any other. How high a correlation is too high for a given pair of variables to be considered distinct (or too low to be considered the same)? There is no clear answer to this and,

consequently, no clear consensus emerged on the structure of personality, nor could it through factor analysis.

Factor analysis is not an objective, ‘truth-grinding’ machine (Meehl, 1992). What you get out of it is determined by what you put into it. This is why two (Dawe & Loxton, 2004), three (Carver & White, 1994), four (Whiteside & Lynam, 2001), and five factor (Cyders et al., 2007) models of impulsivity can emerge from factor analysis, just as it did with personality before it (Markon, Krueger, & Watson, 2005). Factor analysis, like any tool, is best utilized when it is constrained by strong theory and a drive for parsimony. Biology provides a strong constraint on theorizing. As Eysenck (1992, p. 672) argued, “we need to anchor our dimensions of personality in something more concrete than the morass of factor analysis, and biology supplies us with the necessary tools.” This argument applies equally to impulsivity when subjected to factor analysis.

Practically, the addiction researcher is interested in the predictive value of the new impulsivity facets in understanding substance use. The UPPS+P dimensions of Sensation Seeking and (Lack of) Premeditation align closely with existing theories of impulsivity (Whiteside & Lynam, 2001). Of interest is the utility of the three newer facets. The key question being, does a five-factor conceptualization of impulsivity improve the understanding of addictive behavior over a more parsimonious, theoretically-driven two-factor account?

2. Ockham's razor: Do additional traits increase explanatory power?

Prior to considering the evidence for additional facets of impulsivity it is worth considering whether a two-factor model provides additional explanatory power over and above a single factor. The relationship between measures tapping into reward sensitivity and substance

use is well-established (e.g., Dissabandara et al., in press; Franken & Muris, 2006; Gullo & Dawe, 2008; Kabbani & Kambouropoulos, 2012; Kambouropoulos & Staiger, 2004; Knyazev, Slobodskaya, Kharchenko, & Wilson, 2004; Loxton & Dawe, 2001; Lyvers, Czerczyk, Follent, & Lodge, 2009; Lyvers, Duff, & Hasking, 2011; O'Connor & Colder, 2005; Pardo, Aguilar, Molinuevo, & Torrubia, 2007; Smerdon & Francis, 2011). So, too, is the relationship between measures tapping into disinhibition and substance use (e.g., George, Connor, Gullo, & Young, 2010; Howard, Kivlahan, & Walker, 1997; Moffitt et al., 2011; Tarter et al., 2003; Verdejo-García, Lawrence, & Clark, 2008; Wills, Windle, & Cleary, 1998). However, the key issue is whether there is evidence that both constructs add *unique* variance to the prediction of key aspects of the addiction profile. This has been a research question addressed in recent studies examining the unique contribution of two impulsivity-related traits.

Quinn and Harden (2013) found changes in (“rash”) Impulsivity predicted alcohol, marijuana and cigarette use in adolescence/young adulthood, whereas Sensation Seeking was only predictive of alcohol use. Also using a large, longitudinal dataset, Handley et al. (2011) found (rash) Impulsivity to uniquely predict externalizing problems (ADHD and conduct disorder), while Sensation Seeking uniquely predicted substance use. Castellanos-Ryan, Rubia and Conrod (2011) similarly found Sensation Seeking and a reward response bias were uniquely associated with binge-drinking in adolescents, whereas (rash) Impulsivity and deficits in response inhibition were associated with conduct disorder. Generally, these studies point to Sensation Seeking as associated with alcohol use, and Impulsivity/disinhibition associated with more problematic use, behavioral undercontrol, and conduct problems.

Similarly, studies that have tested the two-factor model proposed by Dawe and Loxton (2004) have found Reward Sensitivity/Drive and Rash Impulsiveness to be uniquely associated

with different drug use behavior and drug-related cognitions in adult and adolescent samples (Dissabandara et al., 2013; Egan, Kambouropoulos, & Staiger, 2010; S. M. George et al., 2010; Gullo, Dawe, Kambouropoulos, Staiger, & Jackson, 2010; Gullo, Ward, Dawe, Powell, & Jackson, 2011; Kabbani & Kambouropoulos, 2013; Loxton et al., 2008; Lyvers, Duff, Basch, & Edwards, 2012). Generally, while both traits are associated with drug use and hazardous drinking, Reward Sensitivity has been consistently associated with earlier age of drug use and positive drinking expectancies. Whereas, Rash Impulsiveness tends to be uniquely associated with high-risk substance use, such as poly-substance use, higher drug dose, cross-border use and reduced treatment seeking. Cognitively, Rash Impulsiveness is associated with perceived impaired control and lower drinking refusal self-efficacy.

This leads to the question as to whether additional variance above and beyond these two-factor models of impulsivity is accounted for by the additional UPPS+P traits. UPPS Sensation Seeking and (Lack of) Premeditation can be regarded as overlapping with other measures tapping reward sensitivity and disinhibition, respectively. However, an important caveat regarding Sensation Seeking is that, despite measuring a tendency to pursue activities that are exciting and rewarding, these scales typically also measure one's "openness to trying new experiences that may or may not be dangerous" (p. 686, Whiteside & Lynam, 2001). This latter aspect of the trait is separate from reward sensitivity and more closely relates to disinhibition, resembling Zuckerman's Sensation Seeking and "rash" impulsiveness (Carlson, Pritchard, & Dominelli, 2013; Dawe & Loxton, 2004; Zuckerman & Kuhlman, 2000). Therefore, while Sensation Seeking and Reward Sensitivity are not the same, they differ from (rash) Impulsivity in a similar way (see Table 1). This underscores the importance of multivariate analyses that examine unique variance.

Stautz and Cooper (2013) reviewed an extensive literature examining the relationship between UPPS+P traits and alcohol consumption/problems in adolescents. They also included Reward Sensitivity as a separate trait. Generally, they found all impulsivity-related traits were associated with drinking, with Sensation Seeking and Positive Urgency showing the largest correlations with alcohol consumption, and Positive and Negative Urgency showing strongest relationships with problematic use. Coskunpinar, Dir, and Cyders (in press) conducted a similar meta-analysis, but did not limit their focus to adolescents. They too found all UPPS+P traits were significantly associated with alcohol use, but found (Lack of) Perseverance (rather than Sensation Seeking) to be most strongly associated with alcohol consumption. Sensation Seeking was more strongly correlated with binge drinking, while (Lack of) Premeditation, Negative and Positive Urgency were more strongly associated with alcohol problems and dependence.

It should be noted that, in addition to the UPPS+P scales, both meta-analyses included studies containing measures believed to be tapping similar constructs to those included in Whiteside and Lynam (2001) and Cyders et al.'s (2007) questionnaires. However, there was some inconsistency in the selection and classification of appropriate measures between the two groups of researchers. For instance, the Impulsiveness scale from the Karolinska Scales of Personality was included as a measure of (Lack of) Premeditation by Stautz and Cooper (2013), but not Coskunpinar et al. (in press). Such classifications are understandably difficult, as most measures were never intended to provide clear distinctions between five facets of impulsivity.

While both meta-analytic studies provide an important contribution to the literature, neither can speak to the true explanatory value of UPPS+P traits, due to the often sizable overlap between scales (correlations as high as .73 and .76; Carlson et al., 2013; Stojek & Fischer, 2013). A clearer indication of their additive value comes from analyses that examine only the unique

variance in substance use accounted for by each trait, as in multiple regression. A number of studies that have investigated the UPPS+P traits do not do this. In fact, studies of impulsivity and substance use do not commonly do this (see Gullo et al., 2011, for a discussion). A summary of studies that have explored the unique role UPPS+P traits in substance use is presented in Table 2. This summary was limited to only those that administered the UPPS or UPPS+P questionnaire, given the lack of consensus in classifying past impulsivity measures within the UPPS framework, and the lack of any alternative Positive Urgency scale.

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As shown in Table 2, there was no study in which all five UPPS+P traits made a unique contribution to addictive behavior. For instance, Adams, Kaiser, Lynam, Charnigo, and Milich (2012) found that (Lack of) Premeditation, Sensation Seeking, and Negative Urgency each made a unique contribution to problematic drinking in college students. These contributions were of approximately equal magnitude. Other studies tend to find only one or two impulsivity traits to contribute significantly to alcohol use/problems in college drinkers (usually [Lack of] Premeditation and Negative Urgency). Two clinical studies that examined the unique contribution of UPPS traits failed to find any that acted as unique predictors of drinking problems (Verdejo-García, Bechara, Recknor, & Pérez-García, 2007; Whiteside, Lynam, Miller, & Reynolds, 2005). However, Negative Urgency was a unique predictor of drug use. Of the five traits, Negative Urgency was one of the most consistent predictors of substance use in non-clinical samples. The majority of studies reviewed in Table 2, though, are cross-sectional. Therefore, it is possible that Negative Urgency's unique association with substance use is not

causal, but rather an effect of the negative consequences of heavy, problematic substance use (Hicks, Durbin, Blonigen, Iacono, & McGue, 2011; Zuckerman & Kuhlman, 2000). The findings of prospective studies can help to answer the question of temporal precedence.

Four studies have examined the unique prospective relationships between UPPS+P and substance use. Cyders, Flory, Rainer, and Smith (2009), Zapolski et al. (2009) and Stojek and Fischer (2013) recruited large samples of mostly female college students. Cyders et al. found that Positive Urgency uniquely predicted increases in drinking quantity and alcohol problems over a (approximately) 9-month period, while Sensation Seeking uniquely predicted increases in drinking frequency. Analyzing a subset of this sample, Zapolski et al. found that Positive Urgency also uniquely predicted future increases in illegal drug use. In contrast, Stojek and Fischer found that only (Lack of) Premeditation uniquely predicted the development of alcohol dependence symptoms over a (approximately) 4-month period. However, in those already exhibiting dependence symptoms at Time 1, both (Lack of) Premeditation and Negative Urgency predicted the exacerbation of alcohol dependence. Simons, Dvorak, Batien, and Wray (2010) conducted a daily diary study to track the drinking habits of 102 moderate/heavy drinking college students over 3 weeks. They found that (Lack of) Premeditation predicted greater intoxication over the 3-week period while, unexpectedly, Positive Urgency predicted less. When predicting symptoms of acute dependence, no UPPS+P trait was significant after controlling for intoxication. It should be noted that this study did not analyze data from the Sensation Seeking scale.

While limited to the findings of four studies, the evidence suggests that Negative Urgency may not play a key role in the prediction of early problems with alcohol. Indeed, Stojek and Fischer's (2013) results suggest that it plays a more prominent role in the escalation of

problem drinking after dependence symptoms have begun to emerge. That is, increases in negative affect stemming from the negative consequences of heavy drinking serve to further increase the risk of those who already display high Lack of Premeditation. Future longitudinal studies on at-risk drinkers are required to further test this 'escalation' hypothesis.

Among cross-sectional and longitudinal studies that have examined unique effects, the UPPS+P traits consistently associated with substance use appear to be (Lack of) Premeditation and Negative Urgency. The (Lack of) Premeditation trait is most similar to the (rash) impulsivity/disinhibition traits typically found in substance use studies. Negative Urgency is unique. It would appear that the core issue for this trait is whether the propensity to engage in rash action during heightened negative affect is meaningfully distinct from a general propensity to engage in rash action. Indeed, much of the association between Neuroticism and substance use disorders stems from its overlap with trait disinhibition (Chassin, Forst, & King, 2004). In a substantial meta-analysis of studies investigating personality traits and anxiety, depressive and substance use disorders, Kotov, Gamez, Schmidt and Watson (2010) found elevated levels of Neuroticism across all diagnostic groups; although less so for substance use disorders. Notably, there was a substantial association between trait disinhibition and substance use disorders even after controlling for Neuroticism. Thus, it is possible that Negative Urgency, a measure derived in part from the Impulsiveness subscale of Neuroticism (Whiteside & Lynam, 2001), provides an opportunity to test the combined risk of high Neuroticism and high disinhibition.

Another core issue for the UPPS+P model is the extent to which Sensation Seeking adequately taps reward sensitivity. Carlson et al. (2013) noted recently that the UPPS+P under-represents reward sensitivity in relation to externalizing behavior. They tested the unique contributions of reward (and punishment) sensitivity and UPPS+P to disinhibited behavior

(substance use and antisocial behavior) in 282 undergraduate students. Controlling for age and gender, the UPPS+P scales accounted for 21% of disinhibited behavior, with (Lack of) Premeditation and Sensation Seeking the only unique predictors. However, Reward Sensitivity accounted for significant additional variance over this (3%). Although this study did not separate substance use from other delinquent behavior, it gives some support to the notion that reward sensitivity may not be fully captured by the UPPS+P. The potential importance of reward sensitivity has been recently raised by Smith, Guller and Zapolski (2013) who stated:

...a crucial next challenge in this domain of clinical science is to identify what factors influence the tendency, by some, to engage primarily in externalizing behaviors while others engage primarily in internalizing behaviors. One possibility is that, separate from individual differences in the tendency to respond reflexively to emotion, there are individual differences in incentive or reward sensitivity. (p. 7)

Given the importance of reward sensitivity and incentive sensitization processes in the neurobiology of addictive behavior, this would seem particularly indicated (Dawe & Loxton, 2004; de Wit & Richards, 2004; Koob & Volkow, 2010; Robinson & Berridge, 2003).

3. Neurocognitive pathways linking impulsivity facets to addictive behavior

Neurobiological models of addiction vulnerability highlight the importance of two interrelated neural processes: heightened incentive salience arising from the limbic “impulsive” system and impaired response inhibition arising from the prefrontal “executive” system (see Table 1). All drugs of abuse (directly or indirectly) activate the mesolimbic dopamine system, with the nucleus accumbens playing a critical role in their acute reinforcing effects (Koob & Volkow, 2010). Repeated self-administration results in sensitization of these mesolimbic

dopamine neurons, which further increases the salience of the drug and drug-associated stimuli, producing a heightened sense of “wanting” and appetitive motivation (Robinson & Berridge, 2003). Whether or not this impulse leads to approach behavior depends, in part, on prefrontal inhibitory control mechanisms that include the orbitofrontal cortex (OFC), anterior cingulate cortex (ACC), insula, and inferior frontal cortex (Goldstein & Volkow, 2002; Jentsch & Taylor, 1999; Koob & Volkow, 2010; Swick, Ashley, & Turken, 2011; Whelan et al., 2012).

While both of these core vulnerabilities were once thought to result exclusively from repeated drug use, growing evidence of pre-existing individual differences has suggested otherwise (Dawe, Gullo, & Loxton, 2004). Biologically-based models of personality emphasize the importance of natural variation in the functioning of both the mesolimbic dopamine system (reward sensitivity) and prefrontal cortex (inhibitory control) in “trait” impulsivity (Barratt, 1972; Cloninger, 1987; Depue & Collins, 1999; Eysenck, 1993; Gray, 1970; Zuckerman, 1991). Such differences, considered to be largely genetic in origin, were theorized to place individuals at heightened risk for externalizing problems, including substance abuse (Cloninger, 1987; Gray, 1994; Zuckerman, 1991). Indeed, self-report measures of Reward Sensitivity traits have been shown to predict reward-related activity in the mesolimbic system and stronger craving for alcohol (Beaver et al., 2006; Costumero et al., in press; Franken, 2002; Hahn et al., 2009; Kambouropoulos & Staiger, 2001). Self-report measures of Rash Impulsiveness traits have been shown to predict lower grey matter volume in the OFC and ACC (Matsuo et al., 2009), as well as lower ventral prefrontal cortex (PFC) activity during response inhibition (Brown, Manuck, Flory, & Hariri, 2006). These findings provide evidence linking biologically-based impulsivity traits to the predicted variations in core addictive processes.

High Rash Impulsiveness and poor inhibitory control are familial vulnerability traits that predate drug abuse (Ersche et al., 2012; Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010; Ridenour et al., 2009; Tarter, Kirisci, Habeych, Reynolds, & Vanyukov, 2004). Stop-Signal Reaction Time (SSRT) scores derived from performance on the Stop-Signal Task (Logan, Schachar, & Tannock, 1997) are one of the most commonly used indices to assess response inhibition. Ersche et al. (2012) found that white matter connectivity in the inferior PFC was related to SSRT and risk for stimulant dependence, suggesting it may serve as a neurocognitive endophenotype for addiction. These findings are consistent with early reports from the longitudinal IMAGEN project, in which 1,896 14-year olds completed the Stop-Signal Task (and others) during functional magnetic resonance imaging (fMRI; Whelan et al., 2012). Whelan et al. (2012) identified a right-hemisphere PFC network comprising the inferior frontal gyrus, insula, and ACC that was significantly associated with both successful response inhibition and adolescent substance use. Reduced inhibition-related OFC activation was also a key predictor of substance misuse in the sample. This is consistent with Ersche et al. (2012), who found reduced grey matter in the OFC and increased grey matter in the striatum differentiated stimulant-dependent individuals from non-dependent siblings (Volkow & Baler, 2012).

However, it is important not to oversimplify the distinction made between the neurophysiological and behavioral components of Reward Sensitivity and Rash Impulsiveness. Neurological and behavioral processes underlying each trait do not operate in isolation and, as with self-report measures of the traits, would be expected to overlap and show some correlation (Gullo & Dawe, 2008). The OFC and striatum are densely interconnected and previous studies have linked OFC activity with the functioning of striatal areas (Lehéricy et al., 2004). Specifically, reduced OFC activity is associated with fewer dopamine D₂ receptors in the

striatum (Volkow et al., 2006). Given the robust association between reduced striatal D₂ receptor availability and substance dependence, this OFC-striatum link may reflect an important neural mechanism for the top-down regulation of limbic reward processing and approach motivation (Koob & Volkow, 2010). In support of this hypothesis, Volkow et al. (2006) reported higher-than-normal striatal D₂ receptor availability in non-dependent members of alcohol-dependent families, which was correlated with greater OFC metabolism.

The interconnectedness between components has also been observed at the behavioral level. Padmala and Pessoa (2010) experimentally “impaired” Stop-Signal response inhibition in otherwise healthy adults simply by rewarding correct “go” approach responses on the task. Not only was inhibition impaired, but participants displayed a similar pattern of reduced activity in the inferior frontal gyrus and other regions previously observed in addicted populations. Therefore, functional deficits in “top-down” cognitive control regions can be produced solely by increasing the incentive value of approach stimuli and “bottom-up” dysregulation. There are two important implications here: 1) abnormalities in one domain of impulsivity could manifest in processes considered to “belong” to another domain, and 2) given this, no domain of impulsivity should be studied in isolation without controlling for the other (at any level of analysis). This underscores the importance of examining the unique contributions of impulsivity facets to addictive behavior.

It is clear from the above discussion that the neurobehavioral processes underlying Reward Sensitivity and Rash Impulsiveness play important and distinct roles in the vulnerability to addiction (see also Dawe et al., 2004; Gullo & Dawe, 2008). Furthermore, such findings might apply equally to UPPS Sensation Seeking and (Lack of) Premeditation, respectively, given their overlap with Reward Sensitivity and Rash Impulsiveness traits. With that in mind, what unique

contributions do the other UPPS+P traits make to neurobehavioral processes underlying addictive behavior?

Clark et al. (2012) reported lower D₂/D₃ receptor binding in the striatum of pathological gamblers high in Negative or Positive Urgency. This suggests a potential role in incentive sensitization and appetitive motivational processes, similar to Reward Sensitivity. However, no relationship between Urgency traits and D₂/D₃ receptor binding was found in healthy controls, nor was there an overall group difference between gamblers and controls in receptor binding. Analyses also did not control for the 57% shared variance between the Urgency traits (or the overlap with Reward Sensitivity, which was not measured). Therefore, it is not clear whether this association is specific to either trait, or reflects a non-specific marker of vulnerability.

Moreno-Lopez et al. (2012) investigated the relationship between UPPS+P traits and brain volume in 38 cocaine-dependent individuals and 38 matched controls. Cocaine users were found to have significantly lower grey matter volume in areas that included the OFC, right inferior frontal gyrus, right insula, left amygdala, and caudate. Higher Lack of Premeditation scores were associated with less grey matter in the right insula and left putamen in cocaine users, but not in controls. Unexpectedly, greater Lack of Premeditation was associated with more grey matter in the left inferior frontal gyrus in cocaine users, but less grey matter in controls. Also unexpected was the correlation between higher Negative Urgency and more grey matter in left middle frontal gyrus and right sub-gyral region in cocaine users. However, Negative Urgency did correlate with grey matter volume in the expected direction in these regions amongst controls. No significant associations emerged between the UPPS+P traits and white matter volume.

Boy et al. (2011) found that only Negative Urgency correlated with lower GABA concentrations in the dorsolateral PFC, an inhibitory neurotransmitter. This could represent a

unique mechanism of risk for the trait. However, it is also possible that this association reflects the negative affect component of the trait, independent of one's general propensity to engage in rash action. Indeed, Bielau et al. (2007) reported a higher concentration of dorsolateral PFC GABA neurons in patients with major depression, compared to healthy controls and those with bipolar disorder. It should also be noted that neither Negative Urgency nor dorsolateral PFC GABA levels were related to response inhibition as indexed by SSRT. While this suggests the association may be more related to negative affectivity than impulsivity *per se*, the association is worthy of further study.

Xue, Lu, Levin, and Bechara (2010) experimentally manipulated prior risk experiences to increase risky decision-making on a gambling task. They found that the increase in risky decision-making was positively correlated with insular activation. Furthermore, Negative Urgency scores were positively related to insular activity, although not risky decision-making itself.

Joseph, Liu, Jiang, Lynam, and Kelly (2009) examined the unique contribution of UPPS traits to neural processes underlying autonomic arousal and emotion regulation. They presented emotionally arousing stimuli to high ($n = 20$) and low ($n = 20$) sensation seekers whilst undergoing fMRI in order to investigate neural correlates of autonomic arousal and emotional regulation. They also tested the additive value of UPPS traits in predicting signal differences detected between the groups. As expected, high sensation seekers showed stronger activation in regions associated with autonomic arousal (right insula), whereas regions associated with emotional regulation (anterior medial OFC and left ACC) were more strongly activated in low sensation seekers. Over-and-above the Sensation Seeking effects, high Negative Urgency was associated with lower activation in emotion regulation regions among low sensation seekers, as

expected. However, this was not specific to negative stimuli, but applied equally to arousing stimuli of positive and negative valence. High Negative Urgency was also associated with lower activation in arousal regions among high sensation seekers, contrary to expectation. That is, while controlling for Sensation Seeking, Negative Urgency predicted less activation in emotional control regions, but also less activation in arousal regions. No other UPPS traits contributed significantly to the prediction of neural activity over Sensation Seeking.

In summary, there are inconsistent relationships between UPPS+P traits and neurophysiological processes involved in addiction and impulsivity. However, it is important to note that few neuroimaging studies have been conducted using the UPPS+P scales and most that have done so did not examine unique associations. Thus, the inconsistency in findings may be the result of a poor signal-to-noise ratio when examining individual scales in isolation. Closer examination of unique relationships in future studies is therefore recommended. Future research would also be assisted by further theoretical development of the underlying mechanisms of UPPS+P traits. In particular, predictions that specify the neurophysiological processes unique to each trait. Cyders and Smith (2008) have proposed that variations in an amygdala-OFC circuit underlie individual differences in Urgency traits. However, they make no predictions concerning how the neurobiological basis of Positive Urgency differs from that of Negative Urgency, which it must if they are separate, normally-distributed personality traits uniquely involved in addictive behavior.

4. The relative merit of ‘top-down’ versus ‘bottom-up’ approaches to understanding impulsivity.

“In the long run, any account of behaviour which does not agree with the knowledge of the nervous and endocrine system which has been gained through the direct study of physiology *must be wrong*” - Jeffrey A. Gray (from *The psychology of fear and stress* [1987; 2nd ed.], p. 241).

It is clear from the above discussion that the lack of theoretical integration with other lines of research is a major obstacle for UPPS+P going forward. Whilst research to-date has failed to support unique contributions of the five traits to substance use, it is not entirely clear what contributions were expected in the first place. For instance, what aspect of substance use should be predicted by (Lack of) Perseverance but not (Lack of) Premeditation? Stronger theory and closer integration with existing models could assist here. Much is already known about the neurobiology of addiction and impulsive behavior, and this can both inform and constrain theorizing at ‘higher’ trait levels.

For instance, Koob and Volkow (2010) identify a Withdrawal/Negative Affect stage in the addiction cycle. During this stage, withdrawal-related negative affect engages the extended amygdala and negative reinforcement-related drug-seeking. This can begin prior to the development of substance dependence. Recent evidence from rodent studies suggests that increased binge drinking causes dysregulation of GABA interneurons in the medial PFC and reduces the brain region’s functional connectivity with the amygdala, leading to deficits in executive control over behavior (O. George et al., 2012). Given that individual differences in Negative Urgency have been theorized to reflect variations in an OFC-amygdala circuit (Cyders & Smith, 2008) and have been empirically linked to prefrontal GABA levels (Boy et al., 2011), it is possible that individuals high in Negative Urgency may be uniquely vulnerable to

neuroadaptations during the Withdrawal/Negative Affect stage. This prediction would not only be in keeping with Stojek and Fischer's (2013) 'escalation' findings, but also suggest an alternative mechanism underlying it: that the unique role of Negative Urgency in substance abuse is vulnerability to more significant neuroadaptations subsequent to binge drinking. Interestingly, George et al. did not observe a general increase in anxiety-like behavior, suggesting that these neuroadaptations did not increase general negative affectivity (i.e., Neuroticism). Of course, the amygdala is involved in more than just negative affect and the critical question is whether Negative Urgency uniquely predicts vulnerability to these neuroadaptations and negative reinforcement processes over-and-above general disinhibition, reward sensitivity, and Neuroticism in human beings. Regardless, this demonstrates the potential of a 'bottom-up' integration of findings to enrich the theory underlying UPPS+P.

The divergence of the UPPS+P from existing models of impulsivity speaks to the relative merit of 'top-down' theory construction that is based on self-report data and factor analysis, as opposed to a 'bottom-up' approach based on neurophysiological and behavioral data. Eysenck, Barratt, Cloninger, Gray, and Zuckerman all developed their theories (and self-report scales) with a close eye on biological data. Their 'impulsivity' traits focus primarily on reward sensitivity and general (dis)inhibitory processes, which align well with core dysfunctions observed in addiction. How might such models, and those summarized in Table 1, more parsimoniously account for the role of negative affect and urgency? That is, without the addition of a new trait? Basically, by arguing that impulsive behavior in times of high negative affect still operates via these same two processes (Gullo & Dawe, 2008). Negative affect sensitizes mesolimbic reward pathways and active avoidance behavior, which is still approach behavior mediated by the reward system, not the avoidance/anxiety system (Gray & McNaughton, 2000;

Koob & Le Moal, 2001; Zuckerman & Kuhlman, 2000). Zuckerman and Kuhlman (2000) further argued that elevated levels of anxiety and Neuroticism observed in substance abusers can be accounted for by the consequences of drug-taking, and are not causes of it. This is a more parsimonious explanation for the findings presented in Table 2 concerning Negative Urgency, as well as other longitudinal findings from different scales (Chassin et al., 2004; Sher, Grekin, & Williams, 2005).

In summary, impulsivity is a core vulnerability to addictive behavior. However, five factors are not basic for addiction. There is broad agreement across different levels of analysis that traits related to reward sensitivity and disinhibition play an important and unique role in addictive behavior. These processes are reflected, to varying degrees, in the UPPS+P traits of Sensation Seeking and (Lack of) Premeditation. However, it is likely that UPPS+P Sensation Seeking does not fully capture individual differences in reward sensitivity. Regardless, these traits are not unique to UPPS+P and appear in many models of impulsivity and addiction. Negative Urgency, on the other hand, is not well-represented in alternative models of impulsivity, despite consistently emerging as a unique predictor of substance use. Tighter integration with other lines of research may lead to important theoretical innovations concerning this trait. However, even it may not escape Ockham's razor, given that the Negative Urgency findings can still be accounted for in more parsimonious models. These two-factor models, anchored in biological processes, show remarkable consistency across domains and provide an optimal balance of explanatory power, parsimony, and integration of evidence.

5. References

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Conflict of Interest

No conflict declared.

Table 1. *Distinct components of impulsive substance use.*

Domain	↑ Approach Impulse	↓ Inhibitory Control
<i>Personality</i>		
Dawe & Loxton (2004)	Reward Sensitivity/Drive	Rash Impulsiveness
Steinberg (2008)	Sensation Seeking	Impulsivity
Woicik, Stewart, Pihl, & Conrod (2009)	Sensation Seeking	Impulsivity
Depue & Collins (1999)	(Agentic) Extraversion	(Low) Constraint
<i>Behavior</i>		
Wiers et al. (2007)	Appetitive Motivation	(Poor) Self-regulation
de Wit & Richards (2004)	Delay Discounting	Motor (Dis)inhibition
Bari & Robbins (in press)	Impulsive Choice	Impulsive Action
Swann, Bjork, Moeller, & Dougherty (2002)	Reward-delay Impulsivity	Rapid-response Impulsivity
Goldstein & Volkow (2002)	(Impaired) Salience Attribution	(Impaired) Response Inhibition
Potenza & Taylor (2009)	Choice Impulsivity	Response Impulsivity

Neurophysiology

Bechara (2005)	Impulsive System (striatum, amygdala)	Reflective Prefrontal Cortex System (VMPFC, DLPFC, ACC, insula)
Jentsch & Taylor (1999)	Limbic System (NAcc, VTA, amygdala)	Frontal Cortical System
Bickel et al. (2007)	Impulsive System (NAcc, ventral pallidum, amygdala)	Executive System (PFC, VMPFC)

Note. VMPFC = ventromedial prefrontal cortex, DLPFC = dorsolateral prefrontal cortex, ACC – anterior cingulate cortex, NAcc = nucleus accumbens, VTA = ventral tegmental area, PFC = prefrontal cortex.

Table 2. Summary of studies investigating unique relations between UPPS+P traits and substance use.

Study	Sample	UPPS Measure	Substance Use Measure	Summary of Findings
<i>Prospective Studies</i>				
Cyders et al. (2009)	418 undergraduate students (75% female; mean age = 18.2, SD = 0.76, 70% retention at Time 2)	UPPS+P	Drinking Styles Questionnaire (G. T. Smith, McCarthy, & Goldman, 1995)	- SS prospectively predicted drinking frequency (approx. 8 months later) - PU prospectively predicted drinking quantity and problems (approx. 8 months later)
Zapolski et al. (2009)	407 undergraduate students (73% female; mean age = 18.5, SD = 8.1) 71% retention at Time 2	UPPS+P	Risky Behaviors Scale (Fischer & Smith, 2004)	- PU prospectively predicted illegal drug use (approx. 9 months later)

Stojek & Fischer (2013)	319 female undergraduate students (modal age = 18)	UPPS+P	Short Michigan Alcoholism Screening Test (SMAST; Selzer, Vinokur, & Rooijen, 1975)	<p>-Premeditation prospectively predicted the emergence of alcohol dependence symptoms (approx. 4 months later)</p> <p>-Premeditation and NU prospectively predicted the progression of alcohol dependence severity among those reporting at least one symptoms at Time 1 (approx. 4 months later)</p>
Simons et al. (2010)	<p>102 moderate-to-heavy drinking college students (52% female; mean age = 20.3, SD = 1.5)</p> <p>Women: >11 drinks/week; Men: >15 drinks/week</p>	UPPS (SS scale not administered/analyzed)	<p>Modified daily Drinking Questionnaire (DDQ-M; Dimeff, Baer, Kivlahan, & Marlatt, 1999)</p> <p>Young Adult Alcohol Consequences Questionnaire (Read, Kahler, Strong, & Colder, 2006)</p>	<p>-Premeditation prospectively predicted greater intoxication over following 21 days, PU predicted less</p> <p>-While controlling for intoxication, no UPPS scale prospectively predicted alcohol dependence symptoms</p>

Clinical Studies

Verdejo-Garcia et al.	36 substance-dependent	UPPS	Addiction Severity	-NU predicted drug use
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(2007)	individuals (58.3% female, mean age = 36.1, SD = 10.7). Drug of choice: 5 alcohol, 14 methamphetamine, 7 cocaine		Index (McLellan et al., 1992)	severity	-No scale predicted alcohol use severity
	36 gender and age-matched controls (61% female; mean age = 38.1, SD = 15.8)				
Whiteside et al. (2005)	122 adults recruited from Alcoholics Anonymous (AA) groups, Gamblers Anonymous, and various hospital/community treatment centres (66.4% female; mean age = 40.2, SD = 11.6)	UPPS	AUDIT		-No scale predicted unique variance in alcohol problems. However, as a set, they account for 8% shared variance in alcohol problems
<i>Developmental Studies</i>					
Settles et al. (2012, Study 2)	-905 5th grade girls -908 5th grade boys	UPPS (SS scale not administered/analyzed)	Drinking Styles Questionnaire (dichotomized: presence vs absence of 1+ drinking problems)		-While controlling for pubertal status and negative affect, only NU predicted problem drinking in boys and girls
<i>College Studies</i>					
Adams et al. (2012)	432 undergraduate students (46.9% male; Mean age = 19.0, SD = 0.8)	UPPS+P	Latent factor comprising 2 items from AUDIT + highest amount consumed in		SS, Premeditation, and NU predicted problem drinking

Murphy & MacKillop (2012)	116 college students (80.5% female; mean age = 20.3, range 18-23)	UPPS+P	past year Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993)	-After controlling for delay discounting & mindfulness, only NU predicted alcohol consumption
			-Items 1-3 comprised a <i>consumption</i> measure -Items 4-10 comprised <i>alcohol problems</i> measure	-After controlling for delay discounting & mindfulness, only NU and Premeditation predicted alcohol problems
Fischer & Smith (2008)	246 undergraduate students (50% male; modal age = 19)	UPPS	Drinking Styles Questionnaire (G T Smith et al., 1995)	- SS and Premeditation predicted alcohol use - NU and Premeditation predicted problem drinking
Fischer, Smith, Annus, & Hendricks (2007)	66 female undergraduates (32 with bulimic symptoms). Mean age = 19.5, SD = 2.1	UPPS	Structured Clinical Interview I for DSM-IV (SCID-I)	- NU predicted frequency of alcohol problems
Gonzalez, Reynolds, & Skewes (2011)	143 college students (69.9% female; mean age = 21.3, SD = 2.0)	UPPS	Brief Young Adult Alcohol Consequences Questionnaire (B-YAACQ; Kahler, Strong, & Read, 2005)	-When controlling for depression, delay discounting, and drinking to cope motives, only NU predicted alcohol

				problems
Magid & Colder (2007)	267 undergraduate students (53% female; mean age = 19, range: 18-26)	UPPS	Alcohol Use: product of single items measuring past-month quantity and frequency Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989)	- Premeditation and SS predicted alcohol use -After controlling for alcohol use, NU and Perseverance predicted alcohol problems
Curcio & George (2011)	317 undergraduate students reporting past-year alcohol use (aged 18-25 years, 75% female)	Sensation Seeking (Steinberg et al., 2008) UPPS-P: NU and PU scales only	College Alcohol Problems Scale-Revised (Maddock, Laforge, Rossi, & O'Hare, 2001)	-Only SS predicted problem drinking
Settles et al. (2012, Study 3)	418 undergraduates (75% female; mean age = 18.2, SD = 0.76)	UPPS (SS scale not administered/analyzed)	Drinking Styles Questionnaire Illegal drugs items on Risky Behavior Scale (Fischer & Smith, 2004)	-While controlling for negative affect, NU & Premeditation predicted problem drinking and illegal drug use
A. E. Smith et al. (2010)	255 undergraduate students who reported past month alcohol use (73.3% female; mean age = 20.6, SD = 4.3)	UPPS (only SS & NU were analyzed)	Modified daily Drinking Questionnaire (DDQ-M) Young Adult Alcohol	-After controlling for sex, race, parental income, & reinforcing efficacy, NU & SS predicted alcohol

Consequences Questionnaire	problems and no. of drinks per week
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Note. NU = Negative urgency; PU = Positive Urgency; Premeditation = (Lack of) Premeditation; Perseverance = (Lack of) Perseverance; SS = Sensation Seeking.