



# A Proof of Concept Study to Assess the Imbalance of Self-Reported Wanting and Liking as a Predictor of Problematic Addictive Behaviors

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## Abstract

Tolerance, one of the key features of addiction, is a highly debated criterion for behaviors, considered controversial and difficult to assess. The Incentive-Sensitization Theory of Addiction (IST) provides a robust empirical background on the dynamics of the motivational and hedonic systems underlying addiction, reflecting tolerance. The aim of this proof-of-concept study was to introduce wanting and liking as an IST-based measure of tolerance. Survey data were analyzed on two potentially problematic substance use behaviors (alcohol and nicotine use) and seven potentially problematic behaviors (eating, gaming, pornography use, social media use, internet use, television series watching, and working) of 774 participants (517 women,  $M_{\text{age}} = 35.8$  years,  $SD = 11.84$ ), using linear regression models. The models describing the relationship between usage frequency and the difference between self-reported wanting and liking were significant for all of the investigated substance use and potential behavioral addictions. As a general pattern, the balance of wanting and liking was disrupted with increasing usage/behavior frequency, with a steady increment in wanting in all investigated cases. The findings indicate that the proposed approach holds promise as an empirically robust tool for addiction research, offering the potential to compare substance and behavioral addictions on a unified dimension.

**Keywords** Behavioral addictions · Substance addictions · Potentially addictive behaviors · Incentive sensitization theory · Tolerance · Criteria

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## Introduction

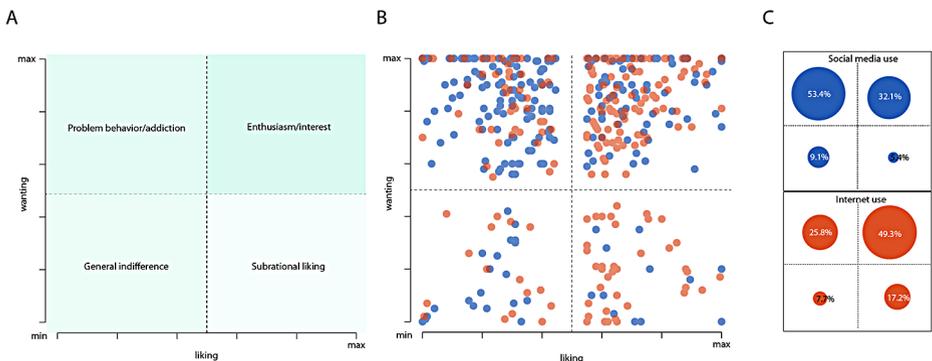
Several behaviors produce short-term rewards, similar to psychoactive substances, that may lead to persistent behavior despite knowledge of adverse effects (Grant et al., 2010). These adverse effects can include the core elements of addiction, such as craving prior to engagement, impaired control over the behavior, and continued behavioral engagement despite negative consequences (Potenza, 2006). A growing number of studies suggest that behavioral addictions share significant similarities with substance addictions in many domains, such as natural history, tolerance, comorbidity, and response to treatment (see Grant et al., 2010; Cuppone et al., 2021; Miranda-Olivos et al., 2022). These similarities have given rise to the concept of “behavioral addictions” which was added to the latest (fifth) edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) (American Psychiatric Association, 2013) and to the latest (eleventh) revision of the *International Classification of Diseases* (ICD-11; World Health Organization, 2019). At the time of writing, only gambling disorder and internet gaming disorder were included in the DSM-5, although it is possible that numerous other behaviors can lead to addiction (e.g. pornography use and compulsive sexual behavior (Duffy et al., 2016; Bóthe et al., 2020, 2022; Lew-Starowicz & Coleman, 2022), social media use (Hou et al., 2019; Luo et al., 2021), internet use (Shek et al., 2013), eating (Hebebrand et al., 2014; Miranda-Olivos et al., 2021), work (Andreassen et al., 2012) and exercise (Griffiths, 1997; Berczik et al., 2014) but more accurate diagnostic measures, criteria, and etiology are needed for inclusion (Potenza et al., 2018).

According to the ‘components’ model of addiction (Griffiths, 2005), all addictions comprise a number of distinct common components (i.e., salience, mood modification, tolerance, withdrawal, conflict, and relapse). The interpretation of these components is more straightforward in case of substance addictions, with limitations for behavioral addictions, potentially leading to false positive cases or the overpathologization of everyday activities (Billieux et al., 2015; Kardefelt-Winther et al., 2017). Tolerance, one of the key features of addiction, is a highly debated criterion, considered controversial, which some scholars claim is difficult to apply to behavioral addictions (e.g., Billieux et al., 2015; Kardefelt-Winther et al., 2017; Starcevic & Aboujaoude, 2017; Castro-Calvo et al., 2021). Tolerance, in the context of addiction, refers to the phenomenon where an individual’s response to a substance diminishes with repeated use, necessitating higher doses to achieve the same desired effect (Kalivas & Volkow, 2005). The increase in time spent on a particular behavior (the most commonly hypothesized phenomenon of tolerance) can be interpreted in different ways, many of which are not related to pharmacological tolerance (Starcevic & Aboujaoude, 2017). For example, as illustrated by Billieux et al. (2015), it’s generally agreed that as someone begins to play the guitar and invests more time in it, it doesn’t necessarily reflect the development of a tolerance for the behavior or a ‘music addiction’.

Given the lack of consensus on the criteria of tolerance, introducing and testing new measures is beneficial both for scientific purposes and clinical use in the long-term. Incentive-Sensitization Theory (IST) of addiction (Robinson & Berridge, 1993) provides a solid empirical background for both the motivational and hedonic aspects of addiction and tolerance. Although IST was originally developed to account for the neurobiological and psychological basis of substance craving (leading to substance misuse and relapse), there is growing evidence suggesting that IST might also be involved in the development and maintenance of potentially addictive behaviors (PABs), such as internet use disorder (Brand et

al., 2016), gambling disorder (Thomsen et al., 2014), overeating (Joyner et al., 2017), overworking (Wojdylo, 2019), gaming disorder, buying-shopping disorder, and compulsive sexual behavior disorder (Brand et al., 2019; Toates, 2022). Briefly, according to IST, pleasure activates mechanisms of associative learning that normally operate to assign motivational significance to reward cues, the process by which stimuli become “wanted.” In typical conditions, this mechanism serves an adaptive purpose, motivating behavior to acquire essential rewards like food or reproduction (Kringelbach & Berridge, 2010). However, research indicated (Robinson & Berridge, 1993) that repeated and intermittent engagement in drug-related activities can result in persistent neuroadaptive alterations, which renders the brain system hypersensitive to both the drug itself and the cues associated with it, leading to an escalating sense of “wanting” towards the abused substance. Crucially, distinct neural systems are assumed to be responsible for the hedonic impact (i.e., “liking”) of the behavior, which is not subject to sensitization, but to tolerance (Berridge et al., 2009). Since “liking” is subject to tolerance and “wanting” is to sensitization, repeated substance use can upset the balance of the two systems, resulting in increased “wanting” with constant or reduced “liking”. This imbalance between the motivational and affective system is assumed to be responsible for the paradoxical situation when individuals with substance use disorder crave for a substance from which they do not expect to experience pleasant feelings (Robinson & Berridge, 2001).

Drawing from both the theoretical framework of IST and empirical data, we can extract pertinent states for addiction research by examining the interplay between wanting and liking (Fig. 1A). Based on the work of Litman (2005), instances characterized by a strong desire but a comparatively low expectation of enjoyment have been labeled as “irrational.” These experiences can drive impulsive, approach-oriented behavior, despite the anticipation of limited positive emotional response (Berridge, 2004). Based on the assumptions of IST, the current authors posit that this state bears resemblance to addiction or problematic behavior. On the contrary, in case of high wanting accompanied with high liking, the two systems are in balance, thus they reflect high interest but not addiction. In this interpretation, the aforementioned “music addiction” is the phenomenon, in which the motivation for playing increases over time, accompanied by constant or even reduced enjoyment of the



**Fig. 1** A: Classification of hypothesized experiences linked with varying degrees of wanting and liking. B: Distribution of wanting and liking scores for social media use (depicted in blue,  $N = 221$ ) and internet use (depicted in orange,  $N = 209$ ) within the present sample. Scores falling within the 45 to 55 range for both wanting and liking were omitted from the plot to enhance the differentiation between the four quadrants. C: An aggregated illustration of point B

activity (given the absence of external incentives). Yet, if wanting rises alongside liking, there isn't a development of tolerance, but rather a heightened level of enthusiasm/interest. Conditions characterized by high liking but a relatively low level of wanting have been termed "subrational" (Litman, 2005). These states are elicited by the pleasurable emotional experiences linked with a stimulus that is appreciated but not strongly desired (Berridge & Winkielman, 2003). Finally, a convergence of diminished activation in both the wanting and liking systems would likely indicate an overall dearth of motivation, presenting itself as a sense of indifference (Litman, 2005).

Based on the above reasoning, the present authors argue that the relative value of wanting and liking could potentially serve as a meaningful indicator of tolerance. Using the difference between liking and wanting as a measure is in line with most requirements expressed towards addictions. A key factor of addiction is that it has adverse effects on the user (Griffiths, 2019) leading to significant harm or distress (Kardefelt-Winther et al., 2017), which might be expressed in liking (i.e., the subjective evaluation of pleasant and unpleasant effects associated with an activity). Also, in the working definition of problem behaviors proposed by Kardefelt-Winther et al. (2017), it is included that the behavior is not reduced by the person and persists over a significant period of time. The present authors argue that the wanting of an activity may carry supplementary information in addition to the time actually spent on the activity, because it reflects a core affect without the distortion of internal factors (e.g., an attempt to quit) and external factors (e.g., lack of resources). For example, a cigarette-smoking individual attempting to quit might reduce/stop the behavior – although still wanting it – which does not mean that the addiction has terminated. Also, Griffiths (2017) argued that the working definition of addiction should focus on the common factors and similarities of addictions, rather than on the behavior-specific factors. Since the tendency to the loss of balance between the motivational and hedonic systems is a universal neural mechanism (Berridge, 2000), its interindividual variability is assumably low, and potentially present in any reward-related activities, making the proposed measure a possibly suitable tool to compare different addictions. Lastly, the rich neuroscientific evidence (e.g., Heinze et al., 2009; Ihssen et al., 2017; Robinson & Berridge, 2000) on IST meets Van Rooij and Prause's (2014) recommendations on the use of criteria based on neuroimaging models.

Given this contextual background, the aim of the present study was to test whether wanting-minus-liking (WmL) measured with survey method is a suitable indicator of tolerance, presented through preliminary data on the imbalance of the motivational and hedonic systems in case of different potentially addictive behaviors (internet use, social media use, pornography use, eating, work, gaming, and series watching) and potentially addictive substance use behaviors (alcohol drinking and tobacco smoking). Since "wanting" and "liking" are assumed to depend on mechanisms operating below the threshold of consciousness (Berridge et al., 2009; Anselme & Robinson, 2016), it is imperative to address the feasibility of assessing them through self-report methods. Addressing this inquiry presents a formidable challenge, as obtaining a direct measure of both explicit and implicit facets of "wanting" and "liking" proves unattainable, as the original research paradigm employed in animal studies is not suitable to investigate these processes in the context of human subjects (Tibboel et al., 2011). It is crucial to emphasize that while the Incentive Saliency Theory (IST) posits that the motivational and hedonic systems operate independently of conscious cognition, meaning that "wanting" and "liking" are not products of conscious processes, it does not assert that these states cannot be consciously experienced after their expres-

sion (Anselme & Robinson, 2016). Instead, cognitive self-control frequently wrestles with “wanting” (Anselme & Robinson, 2016), implying that “wanting” should be—at least partly—susceptible to conscious cognitive processes. Hence, it would be unwise to disregard the use of self-report methods in this initial stage of human research, as developing and evaluating new measures could prove valuable. File et al. (2022) introduced the Imaginative Wanting and Liking Questionnaire (IWLQ), designed to gauge levels of wanting and liking evoked through imaginative micro-scenarios associated with problematic behaviors. The choice of employing this imaginative technique is grounded in the belief that vivid mental imagery of reward cues can activate quantifiable “wanting” attributes, as proposed by Berridge et al. (2009). Since its inception, the questionnaire has undergone testing in both substance-related contexts (tobacco use; File, Bóthe & Demetrovics, 2023) and behavior-related contexts (social media use; manuscript in preparation). These studies have unveiled correlations between wanting-minus-liking and dependence. More importantly, an investigation was conducted among smokers ( $n = 123$ ), examining the correlation between wanting-minus-liking (assessed with IWLQ) and attentional bias (measured using a flicker paradigm). The results revealed a notable correlation ( $0.32, p = .001$ ) between wanting-minus-liking and the speed at which smoking-related alterations were detected (File et al., 2023, in press). Notably, no significant correlation was observed between nicotine dependence (evaluated using the Fagerström Test for Nicotine Dependence) and the speed of detecting smoking-related changes. This indicates that the IWLQ’s evaluation of wanting and liking may possess a heightened sensitivity to incentive sensitization in contrast to dependence per se. This suggests that additional exploration of the imaginative approach may be warranted.

In the IST nomenclature, it is important to emphasize that “wanting” and “liking” denotes the distinct neuropsychological mechanisms associated with the motivational and hedonic dimensions of reward-seeking behavior. Given the current state of research, the precise association between implicit assessments of “wanting” and “liking,” as well as their correspondence with self-reported measures, remains an open question. Therefore, in this present study, explicit measures of wanting and liking (without quotation marks) are employed to indicate assessments directly reported by participants.

According to the assumptions of IST, a behavior can be considered problematic, if the balance of the hedonic and motivational systems are disrupted. Building upon this premise, the following hypothesis was formulated: the difference of wanting-minus-liking will increase as a function of usage frequency of the potentially problematic behaviors. A secondary goal of the study was to present data on the wanting and liking properties of the investigated behaviors, in order to illustrate the potential of this approach in assessing the addictive potential of various behaviors. It is crucial to emphasize that the goal of the present paper was not to define exact thresholds for inclusion of behavioral additions, but rather to introduce a well-established theoretical framework (i.e., IST) as a possible measure of tolerance for future investigation.

## Method

### Procedure and Participants

The data presented here originated from another study (File et al., 2022), in which IST was studied as a function of usage frequency, intensity, and subjective severity in relation to psychological constructs, such as impulsivity, reward deficiency, and well-being. Although the initial goal of the data collection was to investigate incentive sensitization more generally without investigating behavior/substance-specific differences, the sample is appropriate for an explanatory approach.

Participation in the online survey was advertised by a popular news portal. The research project was advertised as an investigation into the psychological factors influencing intense involvement in various behaviors. Survey completion took approximately 20–25 min. Missing values were replaced by a semi-random value drawn from a set of numbers reflecting the distribution of the respective variable. The research adhered to the principles outlined in the Declaration of Helsinki. The research protocol and procedures were reviewed and approved by the institutional ethical review board of the Eötvös Loránd University, with approval granted under reference number 2020/258. This approval ensured that the study design, data collection, and participant interactions adhered to the ethical standards. Participants provided informed consent prior to data collection, and participants were ensured of their anonymity. No personal information that may allow identification was asked, and a secure online platform (*Qualtrics Research Suite*; *Qualtrics*, Provo, UT) was used for data collection.

### Measures

*Screeners for Substance and Behavioral Addictions (SSBA)*. One item from the SSBA (“*I did it too much in the past 12 months*”) was used to assess potentially addictive behaviors. Participants were requested to specify if they engaged excessively in any of the substances or behaviors under investigation (alcohol, nicotine, cannabis, other drugs, gambling, eating, gaming, pornography use, sex, social media use, internet use, watching television series, shopping, work) over the preceding 12 months, choosing from four response options: ‘Totally disagree’, ‘Partly disagree’, ‘Partly agree’, ‘Totally agree’. The SSBA measure has demonstrated strong psychometric properties (Schulter et al., 2020) and allowed for the assessment of potentially addictive behaviors in a short time. Hereafter only substances/behaviors were assessed for wanting, liking and frequency of use/behavior, for which “Partly agree” or “Totally agree” responses were indicated on that item. The substances and behaviors of interest were based on Schulter et al.’s study (2020), with the modification that cocaine was replaced with “other drugs” and four additional behaviors were investigated (pornography use, social media use, television series watching, and internet use), given recent calls for further investigations on these potentially addictive behaviors (e.g., Brand et al., 2019; Grubbs & Kraus, 2021; Tóth-Király et al., 2018).

*Imaginative Wanting and Liking Questionnaire*. According to Berridge et al. (2009), vivid imagery of reward cues may be sufficient to trigger measurable “wanting” properties, without the presence of the actual stimuli. Based on this, wanting and liking were assessed in micro-scenarios in which participants were asked to imagine themselves in specific sub-

stance-related or behavior-related situations. Following an imagery prompt (e.g., “Envision yourself in a setting where you have your preferred alcoholic beverage before you at a time and location of your choosing”), participants were instructed to provide responses on liking and wanting in relation to the scenario. Expected affective states (i.e. liking) were assessed on a continuum from  $-100$  (indicating very negative) to  $100$  (indicating very positive) before, during, and after engagement in the behavior (e.g., “Anticipate your emotional state prior to your first sip of the beverage,” “Report your emotional state during the consumption session,” and “Describe your emotional state post-effects of consumption”). Expected levels of self-regulatory effort required to resist or terminate participation in the behavior (i.e. wanting) were rated on a scale ranging from  $0$  (denoting no effort) to  $100$  (indicating substantial effort) before, during, and after engagement (e.g., “Quantify the amount of willpower you believe you would need to refrain from consuming the beverage,” “Quantify the amount of willpower you believe you would need to halt consumption after the initial sips,” and “Quantify the amount of willpower you believe you would need to abstain for the subsequent 24 hours following desired consumption”). Further, frequency of engagement on a weekly basis (e.g., “How often do you engage in alcohol consumption?” with response options: ‘Weekly or less’, ‘2–3 times a week’, ‘4–5 times a week’, ‘Every day, or nearly every day’) was assessed. Finally, frequency of engagement on a daily basis was assessed, with specific queries tailored to the nature of the behavior (e.g., for substances: “On days you consume alcohol, how many drinks do you typically have?” with response options: ‘1’, ‘2–3’, ‘3–4’, ‘5–6’, ‘7 or more’; for behaviors: “On days you engage in work activities, how many extra hours do you generally work?” with response options: ‘1 h or less’, ‘2–3 hours’, ‘4–5 hours’, ‘6 h or more’). The measure for wanting (before, during and after) showed acceptable internal consistency of the data in the present sample ( $\alpha = 0.787$ , 95%CI = [0.779, 0.795]). The measure for liking (before, during and after) showed poor internal consistency of the data in the present sample ( $\alpha = 0.548$ , 95%CI = [0.528, 0.569]).

## Statistical Analyses

Multiple linear regression models were computed in order to analyze the relationship between the frequency of the substance use or behavior and (1) wanting-minus-liking (WmL) and (2) liking and wanting before, during, and after the activity. Frequency of use was calculated by multiplying reported weekly frequency and daily frequency (frequency weekly  $\times$  frequency daily) for each substance use and behavior. Importantly, the measure of daily frequency was not standardized across substances and behaviors (e.g., for tobacco it was the number of cigarettes smoked, while for internet use it was the time spent in general) thus direct comparisons would be misleading. Multi-collinearity was examined for all variables by calculating the variance inflation factor. Multivariate normality tests were conducted for each model and normality were found to be violated in case of alcohol use (skewness = 2.35, kurtosis = 16.10), social media use (skewness = 0.75, kurtosis = 16.33), internet use (skewness = 0.85, kurtosis = 17.76) and series watching (skewness = 1.36, kurtosis = 17.61). Consequently, robust regression models (iterated re-weighted least squares) were employed to ensure the validity and reliability of the results. To determine if robust regression models offered a better fit to the data compared to the ordinary least square model, residual standard errors of each model were calculated. The robust models did not yield better model fit, therefore findings are reported from the ordinary least square models.

**Table 1** Overview of the demographic characteristics of the sample

	%	Mean	SD
Age		35.8	11.84
Gender (female)	66.7		
<b>Completed education</b>			
Primary education	2.1		
Vocational degree	5.9		
High-school degree	13.8		
College or university degree	73.9		
<b>Relationship Status</b>			
Single	30.7%		
In romantic relationship	61.0		
Other	3.2		

**Table 2** The number of responses for each substance use behavior and potentially addictive behaviors examined

Alcohol drinking	195
Tobacco smoking	235
Eating	297
Pornography use	150
Gaming	108
Work	301
Social media use	437
Internet use	477
Television series watching	251

Analyses were carried out using R (4.0.2), packages stats (R Core Team, 2020), statmodels (Seabold & Perktold, 2010), MASS (Venables & Ripley, 2002) and QuantiPsyc (Fletcher & Fletcher, 2010). Figures were plotted with ggplot2 (Wickham, 2016).

## Results

### Sample Characteristics

Sample characteristics are reported in Table 1. After deletion of incomplete data, the final sample consisted of 774 participants (517 women, 66.7%) aged between 18 and 74 years ( $M_{age} = 35.8$  years,  $SD = 11.84$ ).

A total of 774 participants reported no substance use behaviors (SUBs) or potentially addictive behaviors (PABs), and the remaining 704 participants indicated a total of 2859 SUBs and/or PABs (see Table 2), averaging 4 SUBs/PABs per person ( $SD = 1.99$ ). As the number of responses for marijuana ( $n = 56$ ), other substances ( $n = 24$ ) and gambling ( $n = 19$ ) were low, they were excluded from further analyses. Problematic sexual behaviors and problematic shopping were also excluded from the analyses, because there were no high activity users in the sample. In the case of problematic sexual behavior, the median weekly frequency was option 2 (2–3 times a week) (mean = 2.59,  $SD = 0.99$ ), while the median daily frequency was 1 (1 time a day) (mean = 1.40,  $SD = 0.51$ ). Regarding problematic shopping, both the median weekly and daily frequency were option 1 (once or less, both

weekly and daily) (weekly: mean = 1.21, SD = 0.47; daily: mean = 1.50, SD = 0.61). The final sample consisted of 2402 SUBS/PABs (see Table 2).

The coefficients of linear regressions for WmL are shown in Table 3A. Models on alcohol and tobacco use, eating, and television series watching showed higher explained variance ( $R^2 = 0.16\text{--}0.20$ ) relative to models on gaming, pornography use, working, social media use, and internet use ( $R^2 = 0.09\text{--}0.11$ ). WmL-after positively predicted the frequency of use/behavior in case of every investigated substance use/behavior, indicating that with an increase in the frequency of the behavior, the increase in wanting appears to show a greater rise in comparison to liking (i.e. the imbalance between wanting and liking increases). Also, for tobacco use, eating, pornography use, and television series watching, WmL-before also positively predicted frequency. In the case of tobacco use, WmL-during positively predicted usage frequency.

Coefficients of linear regressions for liking and wanting are shown in Table 3B. According to the predictions of IST, there was a positive correlation between wanting (after) and usage frequency for all investigated SUBs and PABs. Liking was independent of frequency in most cases, except for tobacco use, eating, and working. In the case of eating and working, liking negatively predicted usage frequency. Contrary to the predictions of IST, in the case of tobacco use, liking positively predicted smoking frequency.

## Discussion

The goal of the present study was to introduce a new measure of tolerance to address concerns (Billieux et al., 2015; Starcevic & Aboujaoude, 2017) about the current approach used mostly in the field of behavioral addictions. To test this idea, data were analyzed from a previous study, (File et al., 2022) in which wanting and liking patterns were presented for two substances (i.e., alcohol and tobacco) and seven behaviors (i.e., eating, gaming, pornography use, social media use, internet use, television series watching, and working) as a function of usage/behavior frequency.

As a general pattern – consistent with the predictions of Incentive-Sensitization Theory (IST; Robinson & Berridge, 1993) – the balance of wanting and liking was disrupted with increasing usage/behavior frequency, that is, wanting-minus-liking (WmL) – reflecting the balance between the motivational and hedonic systems – decreased as a function of SUBs/PABs frequency. Importantly, all of the investigated SUBs/PABs showed similar WmL patterns, providing additional evidence for the universality of the underlying processes (Berridge & Robinson, 2016), and supporting the eligibility of the proposed measure. Although the sensitization of the motivation system was relatively uniform between substances/behaviors (see Table 3, and Fig. 2), significant differences emerged in the adaptation of the hedonic system.

This is consistent with previous results, by which the transition from causal use to compulsive use is the consequence of the sensitization of the motivational system, while changes in the hedonic system are less pronounced and are considered as a side-effect (Berridge et al., 2009). In the case of eating, a decrement of liking and an increment of wanting was observable with increasing intensity, consistent with the model of the “food addiction cycle” (Adams et al., 2019) stating that tolerance and craving (increased wanting) parallel to social, emotional, and behavioral difficulties (decreased liking) can lead to the overconsumption

**Table 3** A.: Relationship between wanting-minus-liking (WmL) and frequency of the behavior/use. B.: Relationship between wanting, liking and intensity of the behavior/use

	Alcohol use	Tobacco use	Eating	Gaming	Pornography use	Working	Social media use	Internet use	Series watching
No. observations	195	235	297	108	150	301	437	477	251
Adjusted R <sup>2</sup>	0.16	0.19	0.20	0.10	0.11	0.10	0.09	0.09	0.18
F-value	F(3, 191) = 13.13	F(3, 231) = 19.19	F(3, 293) = 25.56	F(3, 104) = 5.22	F(3, 146) = 6.99	F(3, 297) = 12.35	F(3, 433) = 14.62	F(3, 473) = 16.47	F(3, 247) = 19.82
p-value	$p < .001$	$p < .001$	$p < .001$	$p = .002$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
WmL before (β)	-	-0.29 ( $p < .001$ )	-0.23 ( $p < .001$ )	-	-0.29 ( $p = .001$ )	-	-	-	0.28 [0.13, 0.43] ( $p < .001$ )
WmL during (β)	-	0.24 ( $p < .001$ )	-	-	-	-	-	-	-
WmL after (β)	0.36 [0.19, 0.48] ( $p < .001$ )	0.32 [0.19, 0.45] ( $p < .001$ )	0.31 [0.19, 0.43] ( $p < .001$ )	0.27 [0.05, 0.50] ( $p = .02$ )	0.18 [0.01, 0.35] ( $p = .04$ )	0.29 [0.17, 0.41] ( $p < .001$ )	0.18 [0.06, 0.29] ( $p = .002$ )	0.26 [0.15, 0.37] ( $p < .001$ )	0.14 [0.01, 0.27] ( $p = .04$ )
<b>B.</b>									
Adjusted R <sup>2</sup>	0.23	0.29	0.21	0.24	0.25	0.11	0.10	0.12	0.22
F-value	F(6, 188) = 10.42	F(6, 228) = 16.79	F(6, 290) = 13.83	F(6, 101) = 6.63	F(6, 143) = 9.32	F(6, 294)	F(6, 430) = 9.17	F(6, 470) = 11.81	F(6, 244) = 12.59
p-value	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Wanting before (β)	-	-	-	-	-	-	-	-	0.37 ( $p < .001$ )
Wanting during (β)	-	-	-	-	-	-	-	-	-
Wanting after (β)	0.45 [0.31, 0.59] ( $p < .001$ )	0.49 [0.36, 0.63] ( $p < .001$ )	0.28 [16, 0.40] ( $p < .001$ )	0.44 [0.21, 0.67] ( $p < .001$ )	0.40 [0.24, 0.57] ( $p < .001$ )	0.29 [0.16, 0.43] ( $p < .001$ )	0.24 [0.13, 0.35] ( $p < .001$ )	0.33 [0.22, 0.44] ( $p < .001$ )	0.20 [0.06, 0.33] ( $p = .004$ )
Liking before (β)	-	-	-0.13 [-0.24, 0.03] ( $p = .014$ )	-	-	-	-	-	-
Liking during (β)	-	0.15 [0.03, 0.28] ( $p = .017$ )	-	-	-	-	-	-	-
Liking after (β)	-	-	-0.12 [-0.23, 0.01] ( $p = .028$ )	-	-	-0.13 [-0.25, 0.01] ( $p = .036$ )	-	-	-

Notes: WmL = wanting-minus-liking. Relationships that did not achieve statistical significance (at the  $p = .05$  level) are not presented

of food. For alcohol use, gaming, series watching, and social media use, liking was steady, and the observed imbalance was attributed to the sensitization of the motivational system.

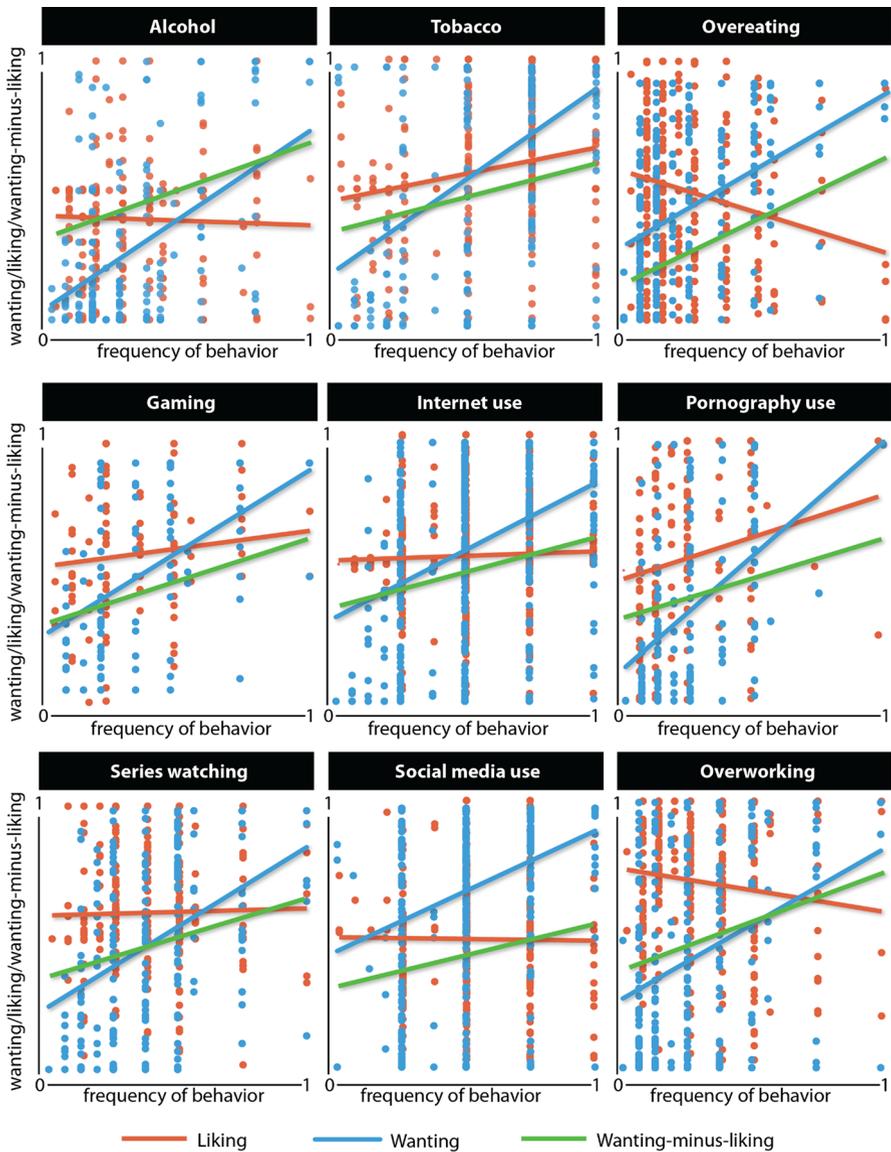
For social media use, prior studies (e.g., Ihssen & Wadsley, 2021) reported similar patterns, as wanting was correlated with excessive and problematic use, while liking was not. The results concerning alcohol use were supported by prior findings (e.g., Hobbs et al., 2005), reporting that wanting was increased by the alcohol priming dose, whereas liking was not. For pornography and tobacco use, both liking and wanting increased, with a higher rate for wanting. The present authors argue (see below) that this pattern might contribute to high addictive potential. In the case of tobacco use, it is evidenced by its prevalence (e.g., 25% of the adult population in the USA smoke cigarettes) (King et al., 2012), despite its well-known adverse effects (e.g., Milcarz et al., 2018). For pornography use, it is less obvious, since although 70% of males and 20% of females aged 18–30 years use pornography weekly (Hald, 2006), the prevalence of problematic use is around 5% for men (Kuzma & Black, 2008) and 3% for women (Baranowski et al., 2019).

Although the regression models describing the relationship between usage frequency and WmL were significant for all the examined SUBs/PABs, the explained variance differed. In the case of alcohol use, tobacco use, eating, and series watching, the explained variance of the model was higher than for gaming, pornography use, working, and social media, and internet use (see Table 3A). If overeating is classified as a substance addiction (e.g., Wooley & Wooley, 1981), these results might suggest that the sensitization process is more pronounced for substance-related behaviors. However, as in the case of series watching, explained variance was also relatively high, therefore further investigations are necessary.

The results of the present study suggest, that individuals are able to differentiate between their liking and wanting estimations on before, during, and after the use/behavior. If so, the proposed measure might carry potentially valuable information concerning the dynamics of the contributing factors to addiction. For example, craving (“wanting” in IST [Robinson & Berridge, 1993]) is usually assessed with single items embedded in large-scale surveys (Tiffany & Wray, 2012), therefore little is known about its temporal dynamics. Also, liking linked to different time points (before, during, and after) might confound with other, higher-level processes. For example, in the case of eating, liking-before negatively predicted eating frequency (see Table 3B), which might indicate maladaptive coping motivations, as reported in previous studies (e.g., Solomon, 2001; Lee et al., 2022).

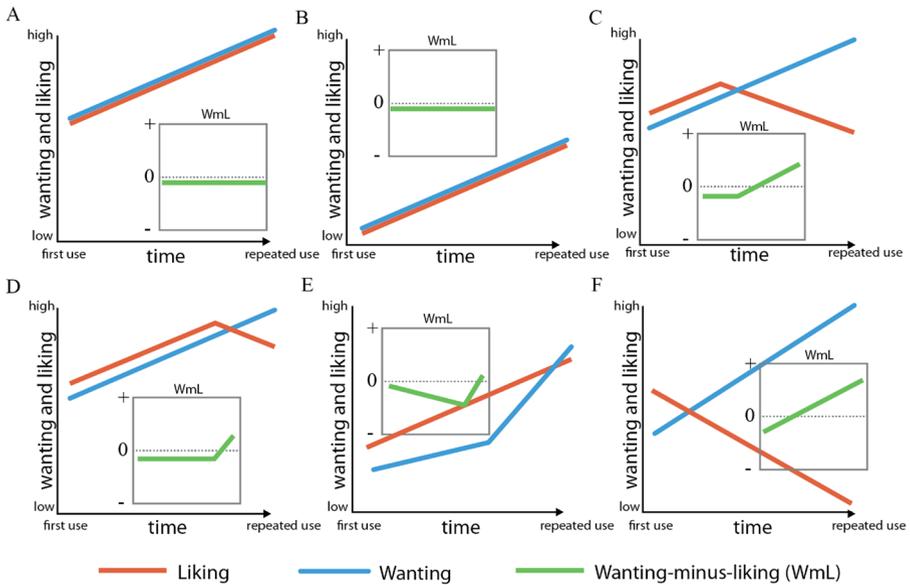
Also, liking-after showed the same pattern, which is somewhat consistent with Solomon’s (2001) findings because eating itself became the stressor. However, motivation to cope with negative emotions has been described for various other substance uses and behaviors (such as in the cases of alcohol use [Merrill & Read, 2010], gaming [Melodia et al., 2022] and series watching [Starosta et al., 2019]), but no similar associations were found in the present study. One possible explanation could be that negative (coping, conformity) and positive (enhancement and social) emotion-based motivations (e.g., Merrill & Read, 2010) were equally present in the current sample for most investigated behaviors. Since motivation was not assessed, further studies are necessary to test this assumption.

The present authors are aware that this is a very simplistic approach, as a variety of negative consequences specific to the behavior might emerge with repeated behavior, contributing to liking. For example, increased level of psychological distress, or body image dissatisfaction can be consequences of excessive social media use (Sadagheyani & Tatari, 2020). Moreover, frequent pornography consumption might lead to lower level of partner



**Fig. 2** Scatter plots along with linear regression lines depicting the normalized levels of wanting, liking, and their difference (WmL) following engagement in the investigated behaviors and substance uses. These measures are plotted against the normalized frequency of use of the investigated behaviors and substance uses

commitment (Lambert et al., 2012), and overeating can lead to obesity, a serious health concern (GBD 2015 Obesity Collaborators, 2017). It is possible that these specific negative consequences are included in liking, which reflects the cumulative degree of positive consequences (e.g., relaxation: Brown & Munson, 1987; Sinha & Jastreboff, 2013; Park et al., 2011) and negative consequences (e.g., guilt: Dearing et al., 2005; Vaghefi et al., 2020).



**Fig. 3** Hypothetical wanting and liking dynamics (on the y-axis) as a function of duration of use (on the x-axis)

If this is the case, then liking should be considered a low-resolution generic measure that cannot provide a detailed picture, but this is what makes it suitable for comparing different behaviors and substance uses. However, before reaching this conclusion, further studies are needed to examine the relationship between “liking” and specific consequences and motivations.

Although the measure of balance (i.e., difference) of the hedonic and motivational systems are informative by itself regarding addictiveness, examining WmL separately can elucidate the situation. For example, the WmL dynamics of the hypothetical behavior presented in Fig. 3A and B are the same with markedly different liking and wanting levels. Because wanting and liking are in balance in both cases (Fig. 3A and B) – according to IST – they are not considered behavioral addictions, but viewed as enthusiasm/interest. The present authors assume that behaviors with high wanting (compared to ones with low) at baseline (i.e., at low frequency or at the beginning of use) are probably more addictive, as control loss might happen with higher likelihood and with shorter latency. Therefore, activity A might be potentially riskier than activity B, although both behaviors show the same WmL pattern. Furthermore, assessing the relative levels of wanting and liking for behaviors with equivalent usage frequencies may yield insights into their respective addictive potentials. In the present investigation, both social media use ( $N = 437$ ) and internet use ( $N = 477$ ) were equally represented, demonstrating prevalent high-frequency engagement (96.1% and 89.51% daily users for social media and internet use, respectively). This justifies their comparison for illustrative purposes. As depicted in Fig. 1B and C, a greater proportion of users (53.4%) engaging in social media use fell into the high wanting-low liking quadrant, in contrast to internet use (25.8%). This suggests that, for a majority of individuals, social media use may exhibit a higher addictive potential.

Assuming that “wanting” and “liking” are largely the result of unconscious processes (Berridge et al., 2009), a key question is whether disruption of the hedonic and motivational systems can be associated with measurable changes in attitudes towards the behavior, such as the willingness to reduce the frequency of the behavior. Based on this, self-reflection (alcohol: Yang & Kim, 2021) and perceived self-control (social media use: Masood et al., 2021) are significant predictors of intention to quit, it is possible that conscious level projections of those processes have behavior modulatory effects. If so, then the temporal dynamics of the two systems may explain some degree of dependence; for example, activity C (Fig. 3C) may be less risky than D and E (Fig. 3D and E) because the balance of wanting and liking is later distorted, when wanting is still relatively low, so that any attempt of quitting is more likely to be successful. Based on such reasoning, activity C (which represents a prototypical progress of addiction) can be considered a low-risk behavior, with a rapid decrease in liking parallel with a steep increment of wanting. However, in the present study, eating showed a very similar WmL pattern to activity C, from which a rich literature is available stating the opposite (e.g., Hardman et al., 2015; Meadows & Higgs, 2013), therefore further studies are needed.

The present study was not explicitly designed to explore differences between enthusiasm/interest and addiction, therefore no behaviors that are explicitly considered passionate were investigated. As a result, there is currently no evidence that the proposed measure has a discriminative value between passionate behaviors (positive consequences outweighing negatives [Griffiths, 2019]) and problem behaviors. Considering that the distinction between the two phenomena is not clear (Szabo, 2018), and largely explained with the loss of control and negative consequences associated with the behavior (Wang & Chu, 2007), WmL might contribute to a better understanding. Moreover, the temporal dynamics of positive and negative consequences associated with intensive involvement in behaviors is not yet well-understood (Wu et al., 2013). Therefore, investigating the WmL dynamics of passionate behaviors might provide some novel insights regarding the transition from recreational to maladaptive behaviors. Considering Burke and Fiksenbaum’s (2008) findings that passion is associated with less obsessive job behaviors and higher levels of work satisfaction and psychological wellbeing, the polarity of WmL might reflect the passion-addiction transition, assuming that WmL is negative in case of passionate behaviors.

## Limitations

The issues raised in this discussion suggest a need to examine many aspects of the measure that have not been addressed in this preliminary study. In addition, a number of limitations warrant consideration. Since no substance/behavior specific scales were used to assess the respective behaviors, the extent to which the sample is genuinely affected by each of the substances/behaviors examined was not known. Since the reported prevalence of problems was much higher for most behaviors compared to that reported in other studies (e.g., for social media 56.5% reported in the present study, while based on moderate classifications it is estimated to be around 25% [Cheng et al., 2021]), it can be assumed that the current sample largely comprises problematic uses/behaviors. This assumption may be further supported by the fact that the current sample exhibits a low percentage of high-frequency users. However, to identify clinically relevant consequences, inclusion of high severity users would be crucial. Further, while the suggested measure demonstrated an associa-

tion with behaviorally assessed attentional bias (File et al., 2023), the connection between IWLQ scores and neurobiological markers (e.g., EEG) indicative of incentive sensitization remains unexplored. Hence, it is imperative to conduct additional examinations to ascertain the validity of the proposed scale. Moreover, the assessment exclusively focused on the frequency of behaviors, without accounting for their duration, which could have offered a more nuanced and comprehensive understanding of the phenomenon (e.g. see Smith & Pearce-Dunbar, 2023; Smith, 2022). Finally, the cross-sectional design was not capable of determining causal relationships, therefore applying longitudinal approaches are necessary to verify the suspected link between usage frequency and wanting/liking.

## Conclusion

The present study's preliminary findings suggest that the proposed measure is promising, and worthy of further investigation. It has the potential to contribute to both scientific purposes and clinical use. The discussion and limitations raised a number of issues that should be the subject of future research. If these questions are answered, the measure reflecting the imbalance of the motivational and hedonic systems is likely to provide an empirically robust tool for addiction research, with the potential to compare substance and behavioral addictions along one unified dimension.

**Author Contributions** DF: conceptualization, methodology, visualization, writing and analysis. BF: conceptualization, methodology, writing and analysis. BB: conceptualization, review and editing. MG: review and editing. ZD: conceptualization, supervision, review and editing. All authors contributed to the article and approved the submitted version.

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**Data Availability** Data and scripts are available by requesting them at [file.domonkos@ppk.elte.hu](mailto:file.domonkos@ppk.elte.hu).

## Declarations

**Conflict of Interest** ELTE Eötvös Loránd University receives funding from the Szerencsejáték Ltd. to maintain a telephone helpline service for problematic gambling. ZD has also been involved in research on responsible gambling funded by Szerencsejáték Ltd. and the Gambling Supervision Board and provided educational materials for the Szerencsejáték Ltd's responsible gambling program. The University of Gibraltar receives funding from the Gibraltar Gambling Care Foundation. MDG's university has received research funding from *Norsk Tipping* (the gambling operator owned by the Norwegian Government). MDG has also received funding for a number of research projects in the area of gambling education for young people, social responsibility in gambling and gambling treatment from Gamble Aware (formerly the Responsible Gambling Trust), a charitable body which funds its research program based on donations from the gambling industry. MDG regularly undertakes consultancy for various gaming companies in the area of social responsibility in gambling. However, these funding sources are not related to the present study and the funding institution had no role in the study design or the collection, analysis, and interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

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