

**Desire thinking in addictive behaviors:
Empirical investigation, theoretical classification, and modification**

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Die Menschen leben von Vorstellungen.
Und damit kann man sie lenken.

MICHAEL ENDE

Declarations

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Hiermit versichere ich, dass die vorgelegte Dissertation gemäß §9 der Promotionsordnung der Fakultät für Ingenieurwissenschaften der Universität Duisburg-Essen vom 06. August 2015 eine selbstständig durchgeführte und eigenständig verfasste Forschungsleistung darstellt und ich keine anderen als die angegebenen Hilfsmittel und Quellen benutzt habe. Alle Stellen, die wörtlich oder sinngemäß aus anderen Schriften entnommen sind, habe ich als solche kenntlich gemacht. Die Arbeit lag weder in gleicher noch in ähnlicher Form einem anderen Prüfungsausschuss vor.

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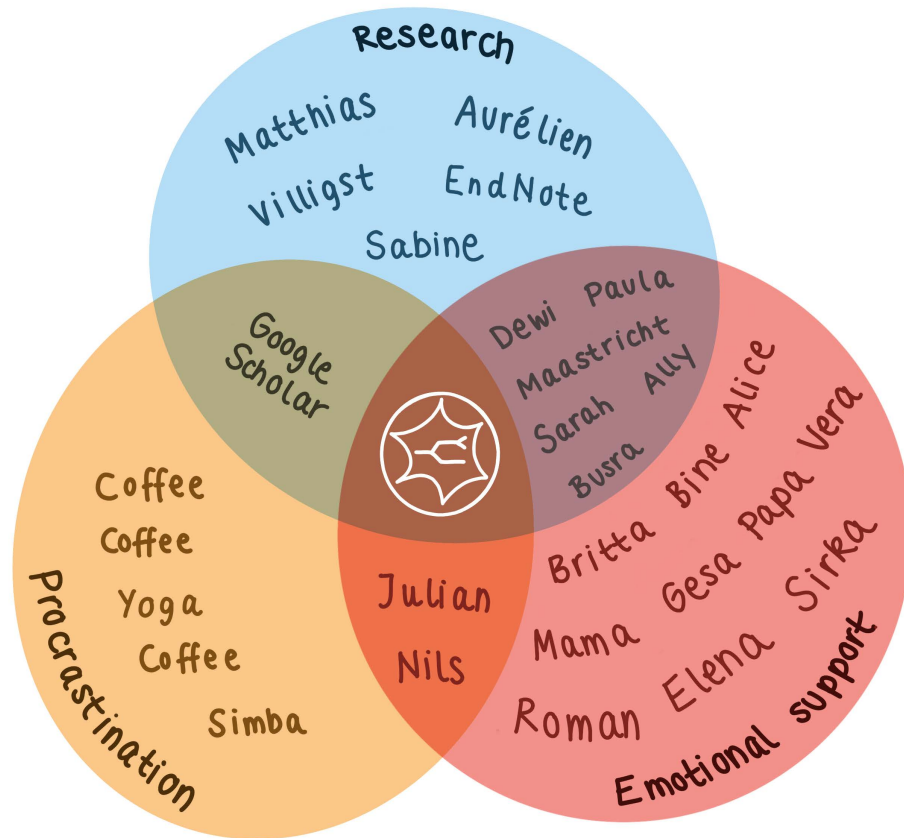
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THANK YOU!

Publication note

At the time of submission of this dissertation, Paper 1, 2, 3, and 4 have been published in peer-reviewed journals. The articles are cited as follows. The original versions of all manuscripts as published by the respective journals can be found in the Appendix.

Paper 1

Brandtner, A., Wegmann, E., & Brand, M. (2020). Desire Thinking promotes decisions to game: The mediating role between gaming urges and everyday decision-making in recreational gamers. *Addictive Behaviors Reports, 12*, 100295. <https://doi.org/10.1016/j.abrep.2020.100295>

Paper 2

Brandtner, A., & Brand, M. (2021). Fleeing through the mind's eye: Desire Thinking as a maladaptive coping mechanism among specific online activities. *Addictive Behaviors, 120*, 106957. <https://doi.org/10.1016/j.addbeh.2021.106957>

Paper 3

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Paper 4

Brandtner, A., Antons, S., King, D. L., Potenza, M. N., Tang, Y.-Y., Blycker, G. R., Brand, M., & Liebherr, M. (2022). A preregistered, systematic review considering mindfulness-based interventions and neurofeedback for targeting affective and cognitive processes in behavioral addictions. *Clinical Psychology: Science and Practice, 29*(4), 379-392. <https://doi.org/10.1037/cps0000075>

Abstract/Zusammenfassung

Abstract

Desire thinking is a voluntary and effortful process in which memories of a desired activity are recalled, but more importantly, a sensory prefiguration of that activity is elaborated and concrete actions to perform the activity are planned. This mechanism is an inherent human faculty and allows us to assess the consequences of our behavior based on what we have learned and the anticipation of what is to come, in order to make decisions based on it. However, within models around desire thinking and in related literature in the area of substance-use disorders, a dysfunctional character of desire thinking is described - namely, when it triggers an irresistible desire to pursue an activity that should actually be resisted or even shows addictive characteristics. In addition to substance-use disorders, problematic behaviors have also moved into the focus of addiction research and find a valid representative for the relevance of similar disorder patterns in the diagnosis of (Internet) Gaming Disorder, which has been in effect since January 2022. While desire thinking has already been identified as a relevant process among addictive behaviors, the exact modes of action are largely unresolved and have not yet been studied systematically. Therefore, the present work aims to test basic model assumptions within the commonly used desire thinking models, the Elaborated Intrusion Theory of Desire (EIT) and the Self-Regulatory Execution Function (S-REF) Model in the context of addictive behaviors (Paper 1 and Paper 2). The empirical findings of these papers, incorporating additional original literature, will be used to situate desire thinking in the Interaction of Person-Affect-Cognition-Execution (I-PACE) Model as a common model for describing affective and cognitive processes of behavioral addictions (Paper 3). Lastly, mindfulness techniques proposed as intervention methods for desire thinking are examined in terms of their effectiveness on the core processes postulated in the I-PACE Model (Paper 4). The results of this work suggest that the hypotheses made in the EIT and S-REF around desire thinking are also tractable in the context of behavioral addictions. The integration into the I-PACE model using theory and empirical literature particularly emphasize its proximity to craving while distinguishing the two processes. Mindfulness techniques show great efficacy on craving in the context of behavioral addictions, but due to the proposed differences between desire thinking and craving, probably require modification to address desire thinking as well.

Zusammenfassung

Desire Thinking ist ein freiwilliger und mühevoller Prozess, bei dem Erinnerungen an eine gewünschte Tätigkeit abgerufen, aber vor allem das zukünftige Beschäftigtsein mit der Tätigkeit sensorisch elaboriert und konkrete Handlungen zur Ausübung der Tätigkeit geplant werden. Dieser Mechanismus ist eine dem Menschen inhärente Eigenschaft und ermöglicht es uns, die Konsequenzen unseres Verhaltens aufgrund von Erlerntem und der Antizipation von Zukünftigem abzuschätzen, um darauf basierend Entscheidungen treffen zu können. Jedoch wird innerhalb von Modellen um *Desire Thinking* und in entsprechender Literatur im Bereich der Substanzabhängigkeit auch ein dysfunktionaler Charakter von *Desire Thinking* beschrieben – nämlich dann, wenn es das unwiderstehliche Verlangen auslöst, einer Tätigkeit nachzugehen, der eigentlich widerstanden werden soll oder die sogar suchtartige Charakteristika zeigt. Neben Substanzabhängigkeiten sind auch problematische Verhaltensweisen in den Fokus der Suchtforschung gerückt und finden mit der seit Januar 2022 geltenden Diagnose der (*Internet*) *Gaming Disorder* einen gültigen Vertreter für die Relevanz ähnlicher Störungsbilder. Während *Desire Thinking* bereits als wichtiger Prozess identifiziert wurde, sind die genauen Wirkmechanismen im Kontext von Verhaltenssüchten noch nicht systematisch geprüft worden. Die vorliegende Arbeit hat daher zum Ziel, grundlegende Modellannahmen innerhalb der geläufigen *Desire Thinking* Modelle, der *Elaborated Intrusion Theory of Desire (EIT)* und dem *Self-Regulatory Execution Function (S-REF) Model* im Kontext von suchtartigen Verhaltensweisen zu prüfen (Schrift 1 und Schrift 2). Die empirischen Befunde dieser Arbeiten werden unter Einbezug weiterer Originalliteratur dazu dienen, *Desire Thinking* im *Interaction of Person-Affect-Cognition-Execution (I-PACE)* Model als gängiges Modell zur Beschreibung affektiver und kognitiver Prozesse von Verhaltenssüchten zu verorten (Schrift 3). Zuletzt werden Achtsamkeitstechniken, die als Interventionsmethode für *Desire Thinking* vorgeschlagen werden, hinsichtlich deren Wirksamkeit auf die im I-PACE Modell postulierten Kernprozesse untersucht (Schrift 4). Die Ergebnisse dieser Arbeit deuten darauf hin, dass die in der EIT und S-REF gemachten Hypothesen um *Desire Thinking* auch im Kontext von Verhaltenssüchten tragbar sind. Die Integration in das I-PACE Modell mit Hilfe der Theorie und empirischer Literatur betont vor allem dessen Nähe zu *Craving* bei gleichzeitiger Unterscheidbarkeit der beiden Prozesse. Achtsamkeitstechniken zeigen große Wirksamkeit auf *Craving* im Kontext von Verhaltenssüchten, bedürfen aber aufgrund der Unterschiede zwischen *Desire Thinking* und *Craving* vermutlich einer Modifikation, um auch *Desire Thinking* adressieren zu können.

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Abbreviations

ACT	Acceptance and Commitment Therapy
CAS	Cognitive Attentional Syndrome
CSC-G	Conflicting Situations Catalogue for Gaming
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (5 th Revision)
DTQ	Desire Thinking Questionnaire
EIT	Elaborated Intrusion Theory (of Desire)
FA	Focused Attention
ICD-11	International Classification of Diseases (11 th Revision)
I-PACE	Interaction of Person-Affect-Cognition-Execution (Model)
MBCT	Mindfulness-Based Cognitive Therapy
MBRP	Mindfulness-Based Relapse Prevention
MORE	Mindfulness-Oriented Recovery Enhancement
OA	Open Awareness
S-REF	Self-Regulatory Execution Function (Model)

1 Introduction

"Happiness is just around the corner" is emblematic of the feeling we get when we think we just need that one more thing - and then we feel better. This is probably what each of us has thought when we imagine how good it would feel if we gained something, got more attention, bought something nice, or did something joyful. This imagination is extremely useful because it allows us to imagine situations, whether we have experienced them before or not. Thus, we can estimate the consequences of our actions even if we have never experienced a corresponding consequence. But this ability can also be our downfall if we can't let go of certain imaginations: More likes on social media, the next loot box in a computer game, infinite scrolling on pornography sites, imagining how happy buying that new watch would make us, or the titillating thought "next time I'll win at roulette!" - a number of tempting activities have one thing in particular in common: They create short-term rewards and a desire in us to do them again. While the vast majority of people can use the large offer of (technological) activities in a functional way, a vulnerable minority develops addiction-like problems with certain behaviors that increasingly also take place on the Internet (Meng et al., 2022). Substance addictions have been an issue of research and treatment approaches for decades, and since the early 1990s, addictive behaviors that are decidedly related to technology and the Internet have also come into focus (e.g., Young, 1996, 1998). In Germany, the prevalence of computer game and Internet-related disorders increased significantly between 2011 and 2019 - 5.5% of young adults in Germany are estimated to have a gaming or Internet-use disorder. Among 12- to 17-year-old adolescents, the figure claims 8.4%, while risky use is estimated among 21.9% of young adults and 30.8% of adolescents (Orth & Merkel, 2020). But it is not only the figures that illustrate the relevance of behavioral addictions. The suffering of those affected by the disease can also be considerable. With the semantic approximation to the meaning of the Latin *addicere* as to surrender to someone or to be slavishly devoted, the character of and the suffering pressure caused by addictive disorders can already be understood metaphorically. While symptoms allow the assessment of whether individuals are suffering from a behavioral addiction, it is primarily the affective and cognitive processes involved that lead into and maintain an addiction. These processes provide starting points for preventive and therapeutic procedures. This paper is primarily concerned with one of these processes that makes us feel that "Happiness is just around the corner": Desire thinking. Whether we are reminiscing about past experiences or dreaming about future situations, we are not in the here and now. One method that can achieve just the opposite is mindfulness. This collective term covers techniques that, in the broadest sense, are intended to ensure that we observe the present moment with full

attention and, above all, without judgment. This paper therefore further addresses the question of whether and how mindfulness techniques might have an effect on affective and cognitive processes, and desire thinking in particular. In the following, behavioral addictions will first be introduced with a focus on their hypothesized mechanisms of development and maintenance. Later, desire thinking and mindfulness in the context of addiction will be specifically addressed.

1.1 Addictive behaviors and Internet-use disorders

Behavioral addictions are behaviors that can take on addictive proportions without the ingestion or delivery of substances, but through the repeated performance of rewarding activities (World Health Organization, 2022). According to the International Classification of Diseases 11th Revision (ICD-11), disorders due to addictive behaviors can be assessed by three diagnostic criteria: (1) Impaired control over the onset, frequency, intensity, duration, cessation, and context of the behavior, (2) increasing priority of the behavior to the extent that the behavior takes precedence over other interests, and (3) continuation or escalation of the behavior despite the occurrence of negative consequences that have to persist for a period of 12 months. However, the ICD-11 allows for a reduction in the required duration if the symptoms are severe and the diagnostic requirements are met. In addition to gambling disorder, the diagnosis of gaming disorder was added to the 11th revision of the ICD in May 2019. Both gambling disorder and gaming disorder can be differentiated into predominantly offline (i.e., in a casino, gambling without Internet access) and predominantly online (i.e., on the Internet), depending on the predominant location of the behavior. The validity of other proposed disorders that are attributable to addictive behaviors, such as compulsive sexual behavior (Mauer-Vakil & Bahji, 2020; Potenza et al., 2017) and the use of specific Internet applications, which are referred to as specific Internet-use disorders (Brand, Wegmann, et al., 2019; Brand et al., 2016), are currently discussed (Brand et al., 2020; Rumpf et al., 2021). In the context of the latter, social network use disorder (Wegmann et al., 2018), shopping disorder (Müller et al., 2019), and pornography use disorder (Antons et al., 2019) have increasingly been discussed as potential candidates for ICD-11 category 6C5Y "*other specified disorders due to addictive behaviors*".

While most individuals are able to use applications (e.g., social networks) in an enriching way, for example, in a helpful way as a tool, a vulnerable portion of users experience limitations and negative consequences from their use (Kuss et al., 2014). These experienced negative consequences may include loss of relationships, neglect of previously enjoyed activities, and an overall decrease in psychological well-being, in addition to a decrease in academic and career performance (e.g., Kuss, 2013; World Health Organization, 2022). The clinically relevant cases still depict the minority, that nevertheless experiences a considerable

suffering. The prevalence rate of gaming disorder is estimated to be as high as 3.05% worldwide (Stevens et al., 2020) while ranging around 0.1 und 5.8% for gambling disorder (Calado & Griffiths, 2016). Prevalence rates for other candidate phenomena (i.e., social network use disorder, pornography use disorder, and shopping disorder) seem to have higher variance depending on the disorder, population, region, culture, and measurement instrument (e.g., Cheng et al., 2021; Maraz et al., 2016; Wartberg et al., 2020). In addition to Internet-use disorders with a clear outline and object of the addictive behavior (e.g., shopping disorder), there also exists the nonspecific Internet-use disorder, which generally describes the addictive use of the Internet without defining which specific Internet behavior results in repetitive reward as defined in the ICD-11. For this non-specific Internet use, a meta-analysis by Pan et al. (2020) estimates a prevalence of 7.02%, which is significantly higher than for specific Internet-use disorders. Due to a less narrowly defined disorder pattern and an associated multitude of different screening and diagnostic instruments, nonspecific Internet-use disorder could therefore be systematically overestimated.

Even in field-specific research circles, there is still disagreement about whether "the Internet" or a specific device can cause addiction and whether there is such a thing as a general Internet addiction or smartphone addiction. Griffiths (2014) postulates an addiction through the Internet, where the Internet is understood as a gateway to the addictive substance, and an addiction to the Internet, where all activities on the Internet are considered the same. Referring to Wegmann and Brand (2019), behavioral addictions are used in this work as a term for phenomena where the emphasis is on the rewarding activity within an application (e.g., leveling up within a computer game, getting likes on a social media application) rather than the fact that the computer game or post was made possible via the Internet or computer-machine interaction in the first place. Like a patient with pathological alcohol use is diagnosed with an alcohol addiction rather than a "bottle addiction," a behavioral addiction in this work is always understood to be specified by the addictive content (e.g., rewarding features of social media).

One of the main lines of argumentation that led to the inclusion of computer gaming disorder into the ICD-11 and by means of which the above-mentioned behaviors are also discussed as potentially addictive is the similar presence and functioning of underlying core psychological mechanisms that can be identified in both addictive behaviors and substance-use disorders. The premise here is that a similarity of underlying mechanisms of action indicates a similarity of disorders. This premise is one of three metalevel criteria proposed by Brand et al. (2020) to justify that certain behaviors are potential addictive disorders rather than, for example, obsessive-compulsive disorders. Foremost among these metalevel criteria is the clinical relevance of the behavior, which is manifested primarily by the negative consequences

experienced by the affected individuals. Importantly, the theoretical embedding of the disorders plays a role insofar as addiction models should be those models that can best explain the phenomenon. Therefore, three models are presented below, with a focus on the Interaction of Person-Affect-Cognition-Execution Model (Brand, Wegmann, et al., 2019; Brand et al., 2016) as a common framework of behavioral addictions.

1.2 Models of addictive behaviors

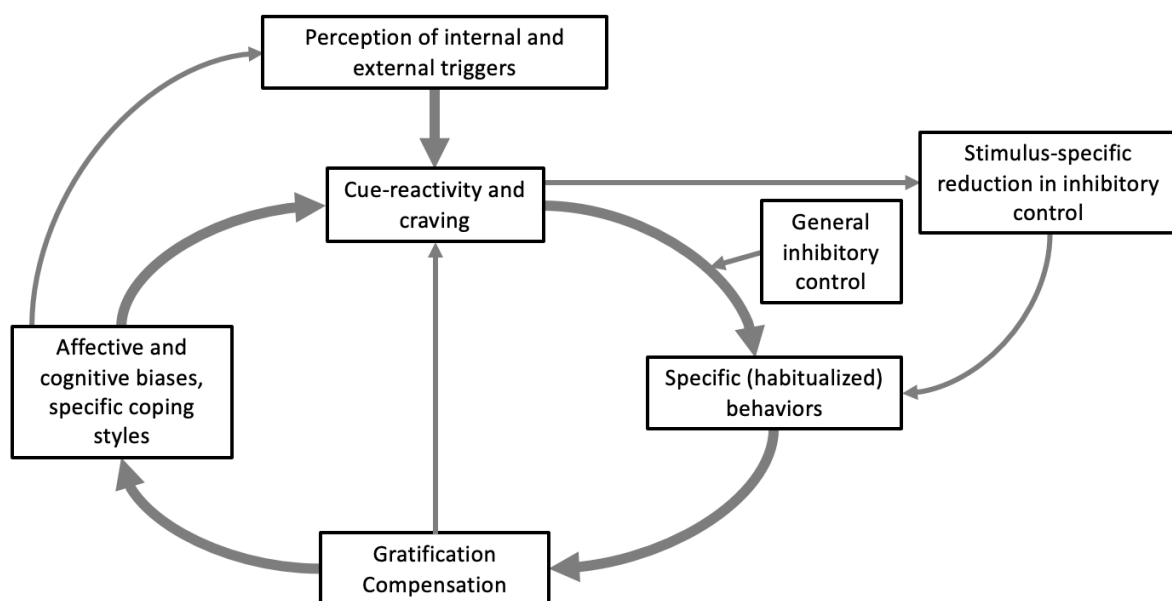
Several models of behavioral addictions accumulated in the literature over the past 20 years that focus on different aspects of addictive disorders. The Pathway Model of Problematic Gambling (Blaszczynski & Nower, 2002), which has recently also been adapted for social network use disorder (Canale et al., 2021) or the Pathways Model (Billieux, 2012) address developmental histories of an addictive disorder. The Tripartite Model of Internet Gaming Disorder (Wei et al., 2017) mainly explains the response to addiction-associated stimuli with a (1) reflective, (2) impulsive, and (3) interoceptive system. In the context of problematic Internet use, Davis (2001) postulates a cognitive-behavioral model that focuses on the emergence and maintenance of maladaptive cognitions, which, according to Davis (2001), primarily involve pathological rumination about the self and about the world. These cognitions generate unpleasant experiential states that may ultimately give rise to behavioral symptoms via coping attempts through use. A model that additionally integrates therapeutic approaches is the cognitive-behavioral model of Internet gaming disorder (Dong & Potenza, 2014). This model offers an expanded view of how to address the addiction-specific mechanisms of Internet gaming, but it does not offer integration of predisposing psychopathologies as does the model by Davis (2001) or specific personality facets as do the pathway models of Billieux (2012) and Canale et al. (2021). Thus, the models each have their own strengths, but at the same time are limited to specific foci.

The Interaction of Person-Affect-Cognition-Execution Model, or I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016), is a model that integrates the individual strengths of the previously mentioned models. Initially, it served to describe the development and maintenance of specific Internet-use disorders (Brand et al., 2016), and since 2019, a revised version can also be applied more generally to describe relevant psychological processes of addictive disorders (Brand, Wegmann, et al., 2019). In its four subdivided components, the I-PACE model describes personality-constituting, psychopathological, and biopsychological factors that may promote and predispose the development of an addictive behavior (P component), as well as relevant affective and cognitive responses to internal and external stimuli (A and C components), and processes directly involved in the performance of the

behavior (E component). In doing so, the I-PACE model integrates several theoretical approaches from substance addiction research and transfers their underlying assumptions into the context of behavioral addictions. Thus, the basic ideas of the Incentive Sensitization Theory (Berridge & Robinson, 2016; Robinson & Berridge, 1993), the Impaired Response Inhibition and Salience Attribution Model (Goldstein & Volkow, 2011; Zilverstand et al., 2018), the Reward Deficiency Syndrome (Blum et al., 1996; Blum et al., 2015), conditioned and operant learning (Everitt & Robbins, 2005, 2016), and dual-process approaches (Bechara, 2005) are also reflected in the assumptions of the I-PACE model. Furthermore, the I-PACE model also incorporates previous theoretical models that address the identification, classification, and mode of action of underlying psychological mechanisms in behavioral addictions (e.g., Blaszczynski & Nower, 2002; Dong & Potenza, 2014; Wei et al., 2017).

Figure 1

The inner circuit of the I-PACE model



Note. Figure modified according to Brand et al. (2016) and Brand, Wegmann, et al. (2019).

Looking specifically at the A, C, and E components, it is assumed that more (proximal) or less (distal) addiction-associated internal (within the person) or external (environmental) stimuli trigger a response in the individual, often measured in terms of cue reactivity and craving. Increasing craving for an activity makes it more and more likely to actually perform the behavior. In addition, when frontal brain-associated top-down processes are unable to inhibit the bottom-up impulses of the limbic reward system, diminished executive performance, such

as reduced inhibitory control, may favor a decision to engage in a behavior (Bechara, 2005). Engaging in the activity can feel both rewarding (gratification aspect) and relieving (compensation aspect) to the individual. In both cases, the behavior is reinforced in terms of operant conditioning, making it more likely to engage in it again. Specifically, this occurs because the individual can learn to be able to get a good mood or avoid a negative mood with the behavior. Expectations of the behavior can thus be formed, which can manifest in the form of a specific coping mechanism. The establishment of the (coping) expectations could favor that triggers might be reacted to with a strengthened desire in the future (see Figure 1). Thus, the I-PACE model describes a circuit of core mechanisms associated with addictive behaviors that have also been identified as relevant to Internet-use disorders (e.g., Golec et al., 2021; Schmitgen et al., 2020; Trotzke et al., 2019; Trotzke et al., 2021; Wegmann et al., 2021). The revised version of the I-PACE model also allows the distinction of the cycle described above into early and later stages of the addiction process, which differ in terms of the strength of the conditioning processes and the intensity of the affective and cognitive reactions experienced. One process that seems to be growing in importance for addiction research, but is not specifically included in the I-PACE model, is desire thinking. Desire thinking is therefore presented and discussed in more detail in the following Chapter.

2 Desire thinking

There you are, unsuspectingly reading a dissertation and suddenly it is mentioned in a chapter that someone orders a freshly baked croissant in a cozy street café on a Saturday morning. It's quite possible that you start imagining what it would be like to eat a croissant yourself right now. You may imagine how crispy the croissant may feel, that it is still warm, and that the aroma hits your nose as you break it open. If you don't like croissants, or if you've just eaten one, then this idea won't be an extraordinarily great temptation for you. But if you have developed a desire for a croissant, then this idea can trigger a pleasant activation, which, however - if there is no prospect of this desire being fulfilled - can turn into an agonizing dissatisfaction.

Modified from Kavanagh et al. (2005, p. 446)

The ability to mentally travel into the future and imagine a future experience with all its accompanying sensory components is discussed in the psychological literature under several names. *Future-oriented mental time travel*, *episodic foresight*, or *future thinking* (Atance & O'Neill, 2001; Noël et al., 2017; Suddendorf, 2010) are only a few terms that all refer to the human ability to mentally simulate and elaborate an action in the future, such that, for example, future decisions can be weighed up and stored in prospective memory in the form of a plan of action (Atance & O'Neill, 2001; Kliegel et al., 2000). It is therefore not surprising that this ability especially plays a role when it comes to imagining and planning the fulfillment of a desire. In this context, the cognitive process of mentally elaborating a wish is called desire thinking (Caselli & Spada, 2011, 2015). Specifically, desire thinking is understood as a voluntary, conscious cognitive elaboration process by means of which the formation of emotively charged and multi-sensory future-oriented ideas, the retrieval of positive memories related to a pleasurable target, as well as the finding of good reasons to achieve this target and the planning to pursue it comes about (Caselli & Spada, 2011, 2015; Kavanagh et al., 2005). The target of desire thinking can take the form of an activity, an object, or a state (Kavanagh et al., 2004, 2005). To specify the context of this work, the desire to pursue a desire shall be understood specifically as the pursuit of an (online) activity, but not as the consumption of substances. Desire thinking is understood to be multi-dimensional and can be conceptually divided into two distinct sub-processes. Imaginal prefiguration refers to the sensory elaboration of multisensory representations that are formed around an activity (Andrade et al., 2012; Caselli & Spada, 2011). Thus, a mental image formed around the use of a shopping website arguably

includes the pictorial visualization of the browser, the device, and possibly the typical corporate identity of the favorite store, but also emotive and sensory features such as the idea of excitement when making a purchase, or the feeling of clicking the mouse. The role of these mental images or visual representations is given particular importance in this context (see Chapter 2.1). Verbal perseveration describes a linguistic occupation with the desired activity and has as its content the conceptualization of plans for achieving the activity or goal (Caselli & Spada, 2011). In this process, concrete verbal thoughts are captured, which might be "After work, I have time to play computer games" or "I could check my messenger before the bus comes."

At this stage, desire thinking is theoretically embedded in two model descriptions, one explaining the emergence and maintenance of desires (Elaborated Intrusion Theory of Desire; see Chapter 2.1) and one explaining the development of problematic alcohol consumption (Self-Regulatory Execution Function Model; see Chapter 2.2). In the following, these two models and the role of desire thinking within these models will be explained in more detail. The importance of desire thinking in addictive behaviors will be highlighted in Chapter 2.3 with relevant literature.

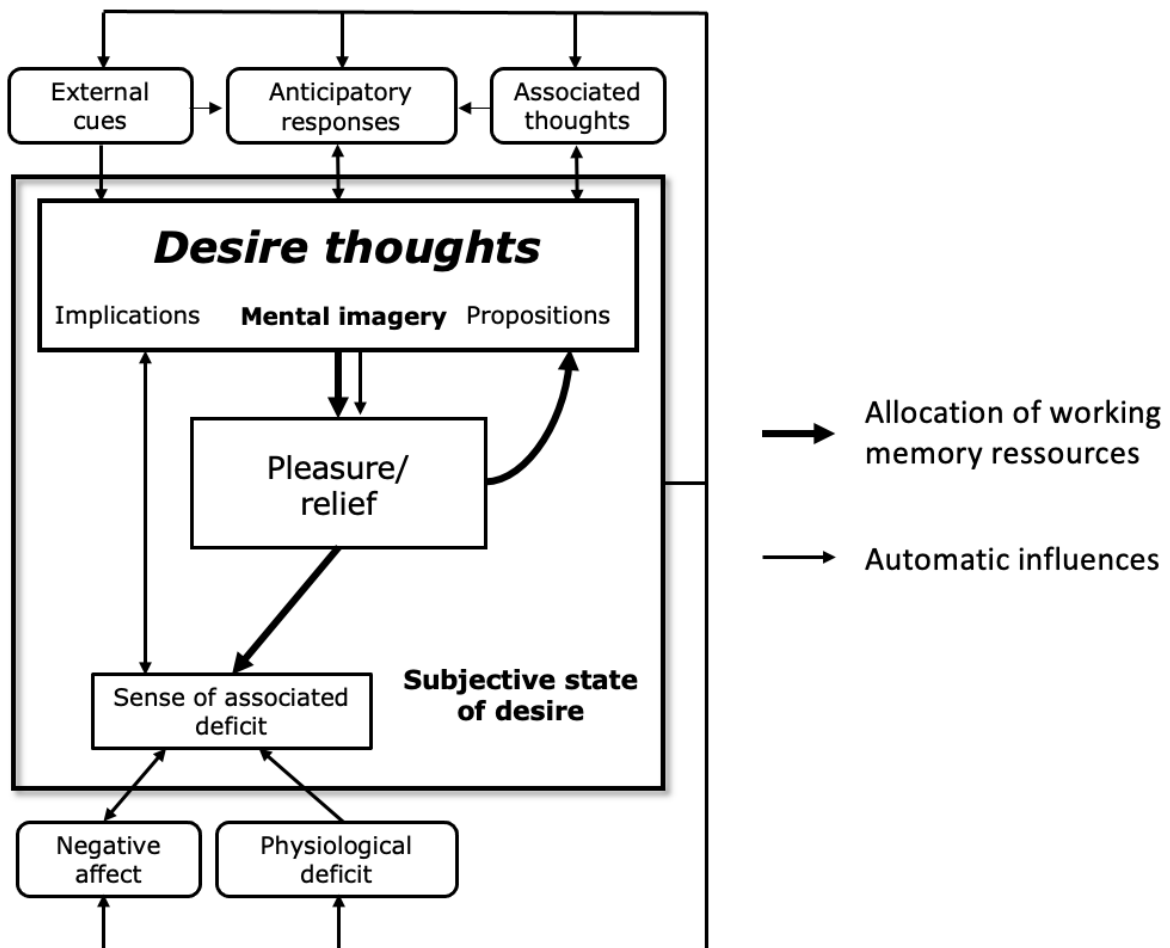
2.1 Elaborated Intrusion Theory of Desire

The Elaborated Intrusion Theory of Desire (hereafter EIT) already makes clear by its very name that it is a model description of the formation of desires that distinguishes between automatic-associative (i.e., intrusive) and higher-order (i.e., elaborated) processes (Kavanagh et al., 2005). While the automatic-associative processes are more spontaneous in nature and can thus be experienced as intrusive, the higher-order elaboration of these initial intrusive associations involves the controlled search for related content, which is referred to as desire thinking (Caselli & Spada, 2015; Kavanagh et al., 2005). In Figure 2, the processes describing the (consequences of the) elaboration of a desire – constituting the subjective state of desire or craving – are depicted within the central box. The sources of desire-associated information (i.e., trigger) are placed in the five outer rounded boxes. According to the EIT, the five triggers (external stimuli, anticipatory reactions, associated thoughts, negative affect, and physiological deficit) can lead to spontaneous intrusions directly or indirectly mediated by automatic associations. These initial intrusions may already contain fragmentary spontaneous thoughts and flash-like mental images (Kavanagh et al., 2005). The incoming or interacting arrows mark the transition to the conscious perception of spontaneous associations. Desire thinking (represented by the thick arrows within the central box) allocates attention and working memory to these initial associations. Desire thinking is thus a deeper elaboration of the desired activity. This

elaboration includes the partial fulfillment of the actual wish or desire, because the experience of pleasure or relief can be simulated and planned. Especially the mental images are assumed to be accompanied with emotionality which assigns a strong motivational power to them (Andrade et al., 2012; May et al., 2004). Even better than linguistic thoughts, mental images are able to mimic actual activity with all its experiential components (i.e., visual, auditory, olfactory, gustatory, and senso-motor), thus generating a readiness to act that has already been able to promote actual behavior in several contexts (Libby et al., 2007; Renner et al., 2016; Renner et al., 2019).

Figure 2

The Elaborated Intrusion Theory of Desire



Note. The figure was modified according to Kavanagh et al. (2005). In the model language of EIT, the arrows shown correspond to cognitive activity (e.g., desire thinking), whereas the boxes within the central box correspond to the outcome of cognitive activity (e.g., desire thoughts).

The EIT posits two self-reinforcing loops by means of which the desire or craving experience may be fostered. Firstly, the verbal and imaginal elaboration of an activity is associated with pleasure or relief, causing a drive to achieve the simulated reward. This constitutes the motivational component of desire, also referred to as urge (Canale et al., 2019). It resembles, albeit to a much lesser extent, the actual gratification and compensation experienced by the behavior itself. Experiencing this reinforcement (i.e., pleasure/relief) can lead to further elaborations of the desire or activity and thus stronger desire thoughts, which can favor pursuing the desired activity. Secondly, generating and experiencing desire thoughts can provoke an experienced deficit, as the actual state is compared with a desired state (via desire thinking) and can lead to the conclusion that "something is missing". Since the mental images can only partially satisfy the actual desire, being merely constituted by its simulation, there may thus be a sense of associated deficit, which may further lead to negative affect. If the fulfillment of the desire is beyond the individual's capabilities, it may be an attempt to compensate for the experienced deficit through the further elaboration of the desire. As stated in the EIT, a possible escape of this loop may be the pursuit of the activity (Kavanagh et al., 2005) that may have, as can be the case for addictive behaviors, also adverse consequences for the individual.

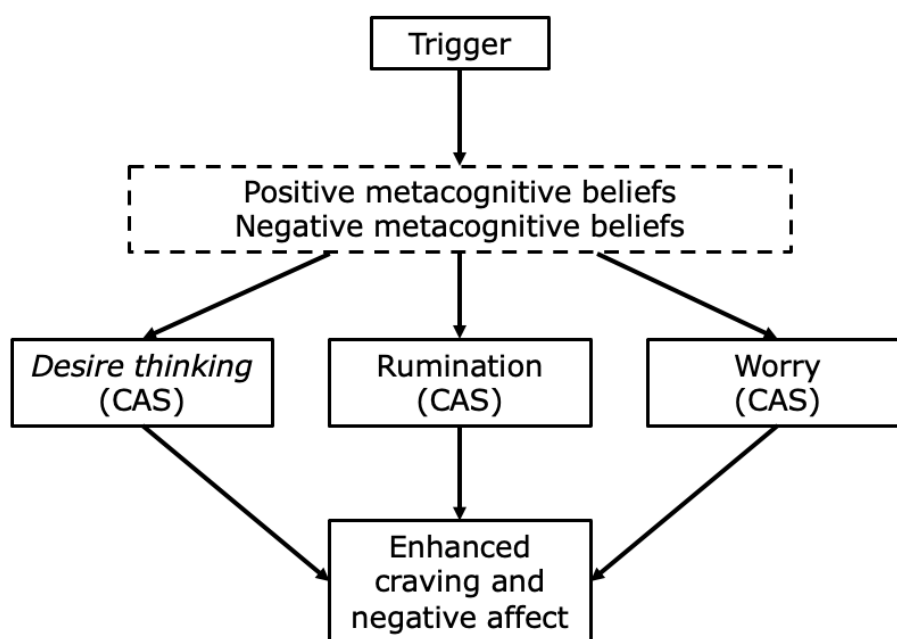
2.2 Self-Regulatory Execution Function Model

Desire thinking is understood within the EIT as one of several processes involved in the development of desire. According to the EIT, what desire aims at can theoretically be all behaviors, objects, or states - regardless of whether they could harm the individual or not. This also means that desire thinking is not assumed to be a fundamentally dysfunctional process. Contrary, the Self-Regulatory Execution Function Model (hereafter S-REF; Spada et al., 2013; Wells & Matthews, 1994; Wells & Matthews, 1996) offers an approach to explaining the concrete problematic character of desire thinking. In its original version, the S-REF is a model for explaining disorders of emotion, focusing primarily on a dysfunctional style of processing cognitions and emotions, as well as an unfavorable guidance of attentional processes (Wells & Matthews, 1994; Wells & Matthews, 1996). Through an adaptation of the S-REF model by Spada et al. (2013), it first found application in the specific context of alcohol dependence and later in the more generic context of addictive behaviors (Spada, Caselli, Nikčević, et al., 2015). The basic idea of the S-REF model is that unpleasant states are tried to be regulated by means of certain thinking patterns. However, metacognitive assumptions about these thinking patterns ensure that the thoughts persist and can take on a brooding character rather than being reduced by metacognitive attempts to regulate them. That is, it is assumed that metacognitive beliefs activate a certain cognitive style, the Cognitive Attentional Syndrome (hereafter CAS). The

CAS includes several cognitive strategies that are perceived as (alleged) coping strategies to reduce negative thoughts or unpleasant emotional states and are used in this sense. These strategies include threat monitoring, thought suppression, avoidance, and so-called extended thinking styles, which include desire thinking in addition to pathological worry and rumination. Exemplarily, metacognitive beliefs about the usefulness of CAS strategies could be “Desire thinking will help me cope” or “It will be over soon if I just suppress my thoughts”. Such positive metacognitive beliefs about the usefulness of the CAS strategies might lead to their activation, whereas negative metacognitive beliefs (e.g., “I shouldn’t be having these thoughts!”) additionally lead to their prolongation.

Figure 3

The Self-Regulatory Execution Function Modell



Note. The figure shows extended thinking styles of the pre-engagement phase, which is one of three phases describing the processes before the actual behavior.

Desire thinking, according to the assumptions of the S-REF model (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013), is therefore activated in response to aversive triggers to regulate unpleasant cognitions and emotional states. In the context of addictive behaviors, the pre-engagement phase of the S-REF posits that desire thinking may be dysfunctional because (1) it does not regulate negative states through metacognitive loopbacks, but instead recruits even more attentional resources, causing the individual to remain entrenched in this thinking style

and due to the (2) subsequent experience of increased craving and increased negative affect (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013; see Figure 3). This dysfunctional meaning of desire thinking in the context of addictive behaviors is more clearly illustrated in the next Chapter.

2.3 Desire thinking in addictive behaviors

First mentions of desire thinking can be found in the context of studies of appetitive substances such as alcohol, food, soft drinks, and tobacco, among others (May et al., 2004). Subjective reports collected by May et al. (2004) suggest that craving experiences are similar among these different behaviors. Based on the assumption that craving is a cognitive phenomenon, the researchers criticize that some researchers (e.g., Tiffany, 1990) understand craving as an epiphenomenon and the subjective aspects as secondary, thus neglecting what happens cognitively during a craving episode. In all collected reports, both thoughts about the substance and the generation of sensory images were reported, which seem to precede craving but accompany it nonetheless. The authors therefore conclude that desire thinking seems to be a transdiagnostic phenomenon in the context of addictive disorders (May et al., 2004). Further exploration of desire thinking in a sample of clients with craving-associated disorders, such as alcohol abuse, pathological gambling, or nicotine dependence, suggested that desire thinking across these different disorders shows qualitative similarities in its presence during a craving episode, its purpose, metacognitions about desire thinking, and its effects on craving (Caselli & Spada, 2010). With initial clues to differentiate desire thinking and craving in terms of content, a measurement instrument was then developed. The introduction of the Desire Thinking Questionnaire (hereafter DTQ; Caselli & Spada, 2011) ensured the isolated measurability of desire thinking, which until then had only been studied approximately as a facet of craving (e.g., Harvey et al., 2005; May et al., 2008; Steel et al., 2006). Because of the close relationship between desire thinking and craving in the area of addictive behaviors, which is mirrored in qualitative reports and theoretically supported in the EIT (Kavanagh et al., 2005) and S-REF (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013), some of the first empirical quantitative studies investigating desire thinking were devoted to its association with craving (e.g., Caselli, Manfredi, et al., 2015; Caselli et al., 2013; Caselli & Spada, 2015). Caselli et al. (2013) found that desire thinking could produce short-term craving increases compared to two control conditions. Of the behaviors that subjects reported imagining during the induction phase, 26.7% accounted for snacking, 22.2% for sexual activity, 20% for physical activity, and 20% for practicing hobbies. 11.1% reported imagining Internet use, and 0% reported shopping. Using a convenience sample, the findings of Caselli et al. (2013) suggest that desire thinking

seems to play a role in everyday behaviors. Furthermore, it could be shown that desire thinking might distinguish between problematic and unproblematic levels of consumption or behaviors (Caselli, Ferla, et al., 2012), thus also emphasizing its clinical relevance in the context of alcohol consumption.

At the time of the start of this doctoral project in January 2020, desire thinking was most intensively studied in the context of alcohol consumption (Caselli, Canfora, et al., 2015; Caselli, Ferla, et al., 2012; Caselli et al., 2020; Caselli et al., 2017; Martino et al., 2017; Martino et al., 2019), followed by some studies in the area of nicotine dependence (Caselli, Nikcevic, et al., 2012; Caselli & Spada, 2015) and food consumption (Frings et al., 2019; Nikčević et al., 2017; Spada, Caselli, Fernie, et al., 2015; Spada et al., 2016). In the context of substance-independent behaviors, desire thinking had been mainly investigated in the context of gambling (Caselli & Spada, 2015; Fernie et al., 2014). For the area of Internet-based behaviors, publications prior to this doctoral project counted a few studies in the context of general Internet use (Caselli & Spada, 2015; Spada et al., 2014), Facebook use (Marino et al., 2019), and Internet pornography use (Allen et al., 2017). Thus, work that systematically examines desire thinking in the context of gaming, social networks use, and online shopping was absent until the start of this doctoral project, although there was some support for the relevance of examining these contexts. Thus, empirical works were not numerous, mainly served the purpose to disentangle effects of desire thinking and craving, and no study existed in these contexts that systematically addressed the hypotheses of the EIT and the S-REF model.

Therefore, a concrete theoretical embedding of desire thinking into a common model describing behavioral addictions was needed. Systematically embedding desire thinking into a common theoretical framework for behavioral addictions, the I-PACE model, through existing empirical literature and the writings of this Cumulus would thus allow for the systematic testing of model assumptions and would pave the way for future research in this area. In addition to inspiring further empirical research, theoretical models may additionally facilitate the derivation of preventive implications and therapeutic interventions (Brand, 2021). Thus, the positioning of desire thinking into the I-PACE model could clarify therapeutic implications for desire thinking in the context of behavioral addictions. Possible interventions specifically listed for addressing desire thinking include mindfulness techniques (Caselli & Spada, 2015, 2016; Spada et al., 2013). These techniques mainly train to focus attention into the here and now and could be effective especially for desire thinking, whose temporal orientation is mainly in the future. In the following, the concept of mindfulness will therefore be explained and further placed in the context of addictive behaviors

3 Mindfulness

The concept of mindfulness originated in the Buddhist tradition, where it is also called "insight meditation" (Nyanaponika, 1962). The goal of this type of meditation is to gain insight into the truthfulness of things, which is to be achieved by practicing "bare attention" or "detached observation". The concept of this form of meditation was secularized in the early 1980s, and mindfulness meditation has since been understood in Western cultures to mean cultivating attention (1) intentionally and (2) nonjudgmentally (3) in the present moment (Kabat-Zinn, 1994). Away from this generic understanding, there are inconsistencies in the literature as to what exactly the term mindfulness should be used for. Garland and Howard (2018) suggest distinguishing between (1) a mindful state (i.e., a state of metacognitive awareness of internal processes), (2) mindfulness practice (i.e., practicing mindfulness techniques such as breath counting), and (3) a mindful mindset (i.e., a trait-like tendency to be mindful even when mindfulness is not currently being practiced). Mindfulness practice is basically done by means of two heuristic styles of mindfulness, focused attention (FA) and open awareness (OA) (Lutz et al., 2008). While FA meditation focuses on a particular object (e.g., one's own breath) and, upon a perceived distraction, attention is directed back to the initial object, OA meditation has no particular focus of attention. Instead, it attempts to adopt a non-reactive observational stance that should result only in the perception of external and internal stimuli (e.g., "There is a thought"), but not in the evaluation of them (e.g., "I don't want to have this thought"). According to Wielgosz et al. (2019), these forms of mindfulness meditation have a number of positive consequences for various psychopathologies: Mindfulness meditation might help with depressive rumination because it is practiced bringing attention back to the present moment. At the same time, it might help with anxiety disorders, because through de-reification it is learned that thoughts are not part of reality and thus it is possible to get out of negative thought patterns more effectively. Another major branch of research is also devoted to the effectiveness of mindfulness meditation and mindfulness-based techniques in addictive disorders. This will be discussed in more detail in the following Chapter.

3.1 Mindfulness in the context of addictive behaviors

As the I-PACE model suggests, stress responses are crucial triggers for the development of craving and cue reactivity (Brand, Wegmann, et al., 2019; Brand et al., 2016). Standardized mindfulness programs such as the Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn et al., 1985; Kabat-Zinn et al., 1984) aim to reduce individual stress reactions and sensitize for own thought processes with the help of mindfulness techniques. The effectiveness of these

programs (Goldberg et al., 2018; Wielgosz et al., 2019) motivated the design of intervention programs specifically tailored to the treatment of addictive disorders, such as the Mindfulness-Based Relapse Prevention (MBRP; Bowen et al., 2009) or Mindfulness-Oriented Recovery Enhancement (MORE; Garland, 2016); or adapted for these purposes, such as Mindfulness-Based Cognitive Therapy (MBCT; Segal et al., 2018), or Acceptance and Commitment Therapy (ACT; Hayes et al., 1999). In these approaches, mindfulness exercises such as body scans, mindful breathing, and de-reification of craving are used to modify addiction-specific processes such as restructuring of reward processing, reducing cue reactivity, and strengthening of executive functions (Garland & Howard, 2018; Rosenthal et al., 2021; Schwebel et al., 2020; Tapper, 2018; Witkiewitz et al., 2013). Nonetheless, review studies show that mindfulness interventions also have a positive effect on emotion regulation (Sancho et al., 2018), thought suppression (Skanavi et al., 2011), and stress reactivity (Li et al., 2017). These processes are transdiagnostic for a variety of mental disorders, but are also among the maintaining mechanisms of addictive disorders (e.g., Velotti et al., 2021), which is why they are often included as secondary outcome variables in studies on mindfulness effectiveness.

The success of mindfulness techniques in the context of addiction could lie, above all, in interrupting the automatism of a variety of reactions (Witkiewitz et al., 2013). Mindfulness techniques might counteract the automatic reactions resulting from learning processes by learning to accept unpleasant states (e.g., craving) instead of "automatically" reaching for the addictive content. Furthermore, automated attentional processes (e.g., attentional biases) could be more easily noticed. According to Malinowski (2013), the underlying core neuropsychological processes that facilitate learning nonjudgmental mindfulness are primarily emotional and cognitive flexibility and attention. In their model, Hölzel et al. (2011) add the components of body awareness and a change of perspective on the self. The reason why these mechanisms might be effective in the context of addictive disorders is seen by Tang, Posner, et al. (2015) in the close linkage of these mechanisms to self-regulatory capacity. Neural networks associated with this mechanism show reduced activity in addicted individuals (Tang, Hölzel, et al., 2015). This suggests that targeted training of attentional control, emotion regulation, and self-awareness could increase self-regulatory capacity in addicted individuals, and thus reduce addiction-associated symptoms. To date, a number of reviews exist that discuss the effectiveness of mindfulness methods in the area of substance addictions. With regard to efficacy in behavioral addictions with a specific focus on the underlying affective and cognitive processes, no review existed at the time of this doctoral project, although the core processes involved in behavioral addictions such as executive control, cue reactivity, craving, and attentional biases (Brand, Wegmann, et al., 2019; Brand et al., 2016) suggest a potential efficacy

of mindfulness according to the postulated mechanisms of action (Posner et al., 2007; Tang, Hölzel, et al., 2015; Tang, Posner, et al., 2015; Tang et al., 2016).

With the above outlined potential that mindfulness techniques seem to have on several addiction-specific mechanisms, the question arises whether and how mindfulness techniques could also have a positive influence on desire thinking in behavioral addictions. At the time of writing, no experimental study existed to examine this possible influence. Therefore, by looking into existing research on the effectiveness of mindfulness techniques on the core processes postulated in the I-PACE model, a potential effect for desire thinking could be inferred. This preparatory work can help identify mindfulness techniques specific to the process of desire thinking.

4 Research objectives and summaries of the writings of the Cumulus

The purpose of this work is to explore the relevance of desire thinking in the context of gaming and gambling behaviors, the use of social networks and pornography, as well as shopping behavior, and to empirically sort the construct into the existing model assumptions of the I-PACE model. This basis will help to transfer and evaluate the effects that mindfulness techniques have on the core processes of the I-PACE model and might further have on desire thinking. For this purpose, four papers have been published, whose research objectives are briefly presented below and visualized in a summarizing figure (see Figure 4). Subsequently, the writings of the Cumulus are described separately.

As described in Chapter 2.1, the EIT (Kavanagh et al., 2005) assumes two self-reinforcing cognitive loops that might become behaviorally effective through their pathway via desire thinking. One of the two loops assumes that desire thinking can lead to an experience of and drive for pleasure and relief (i.e., urge), and that this urge is likely to induce more desire thoughts. According to the EIT, the potential consequence of this loop is the actual performance of the behavior (e.g., gaming). This assumption of the EIT, that increasing urge leads to increased desire thinking, and that this interaction ultimately makes behavioral engagement more likely, was empirically tested in the first empirical study and in the context of gaming (Paper 1).

The second study is dedicated to an assumption of the S-REF model. The S-REF assumes, as explained in Chapter 2.2, that desire thinking occurs as a sub-process of the CAS, which may be initiated as a coping mechanism in response to aversive triggers (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013). According to the S-REF model, desire thinking may only be a putative coping mechanism since it can lead to increased craving, thus providing increased intrapsychic attention rather than functionally coping with the aversive states. Testing the assumption derived from the S-REF model that desire thinking might be a dysfunctional coping mechanism in response to emotion regulation difficulties that induces craving was therefore empirically tested in the context of different online activities (Paper 2).

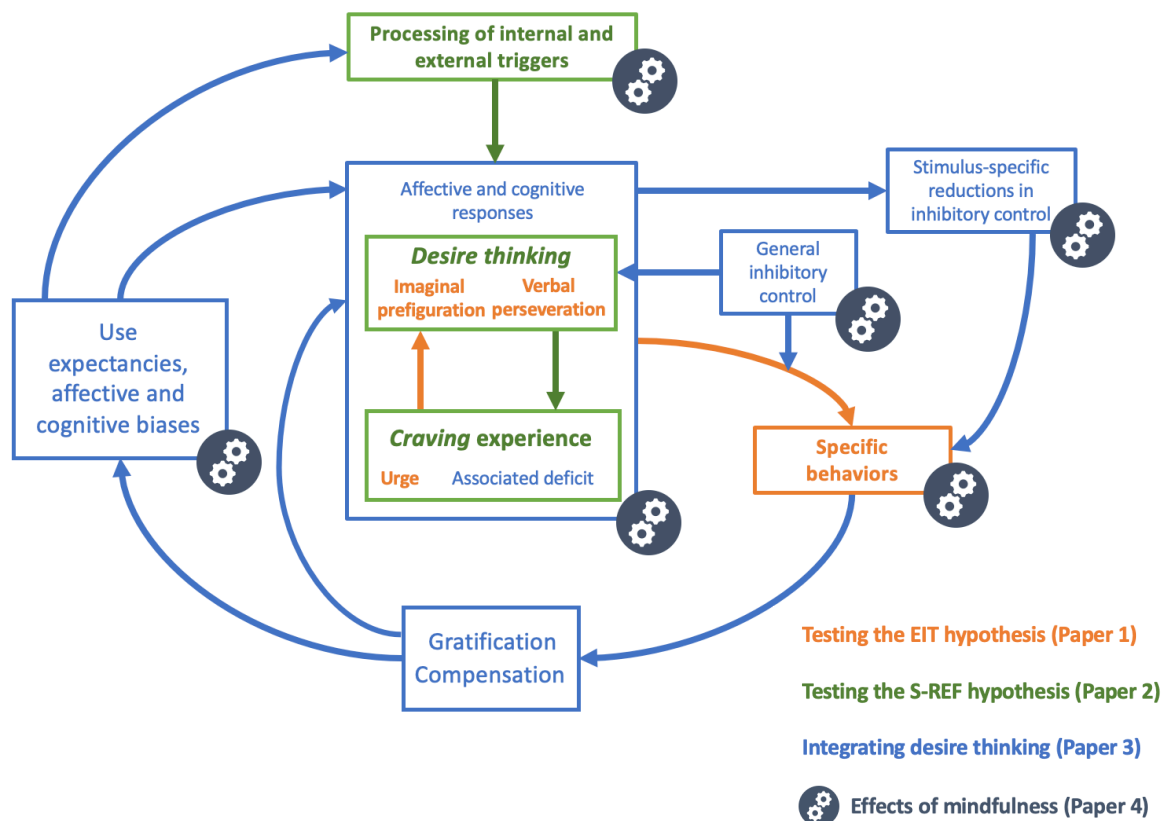
The I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016) provides a theoretical basis and thus the possibility to derive hypotheses regarding the interaction of the core psychological mechanisms considered relevant in the development and maintenance of behavioral addictions. As a superordinate model description, it does not decisively list all potentially involved processes, but allows for their classification by means of generic super-

categories. Desire thinking was put in relation to the core mechanisms summarized in the I-PACE model based on empirical work around Internet-use disorders (Paper 3).

The core mechanisms of the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016) can be understood as leverage points for various preventive and therapeutic procedures. In addition to established first-line procedures (e.g., cognitive behavioral therapy for pathological gaming; Stevens et al., 2019), there are complementary approaches, such as mindfulness-based techniques, that could influence addiction-associated processes. A systematic review examined the extent to which mindfulness techniques can influence the core mechanisms of behavioral addictions as outlined in the I-PACE model (Paper 4). Although there has been no experimental work specifically addressing the influence of mindfulness techniques on desire thinking, the results are nevertheless discussed in this light.

Figure 4

Visualized subprojects of this work (Papers 1, 2, 3 and 4)



Note. Shown is the inner circuit of the I-PACE model with partially visualized model integrations from Paper 3.

In summary, the aim of this thesis is to examine, by means of empirical work, whether the hypotheses postulated within models around desire thinking can also be validated in the context

of potentially addictive behaviors (Paper 1 and Paper 2). Using these two studies and adding further empirical literature on desire thinking, a position for desire thinking within the I-PACE model will then be proposed (Paper 3). With the help of this positioning, connections between desire thinking and other relevant core mechanisms of addictive behaviors will help to better understand the triggers and effects of desire thinking. Finally, a systematic review will show whether mindfulness techniques can affect the core mechanisms of behavioral addictions (Paper 4) in order to conclude on their effectiveness on desire thinking (see Figure 4).

4.1 Paper 1: Testing the desire thinking hypothesis from EIT

Original title: *Desire Thinking promotes decisions to game: The mediating role between gaming urges and everyday decision-making in recreational gamers*

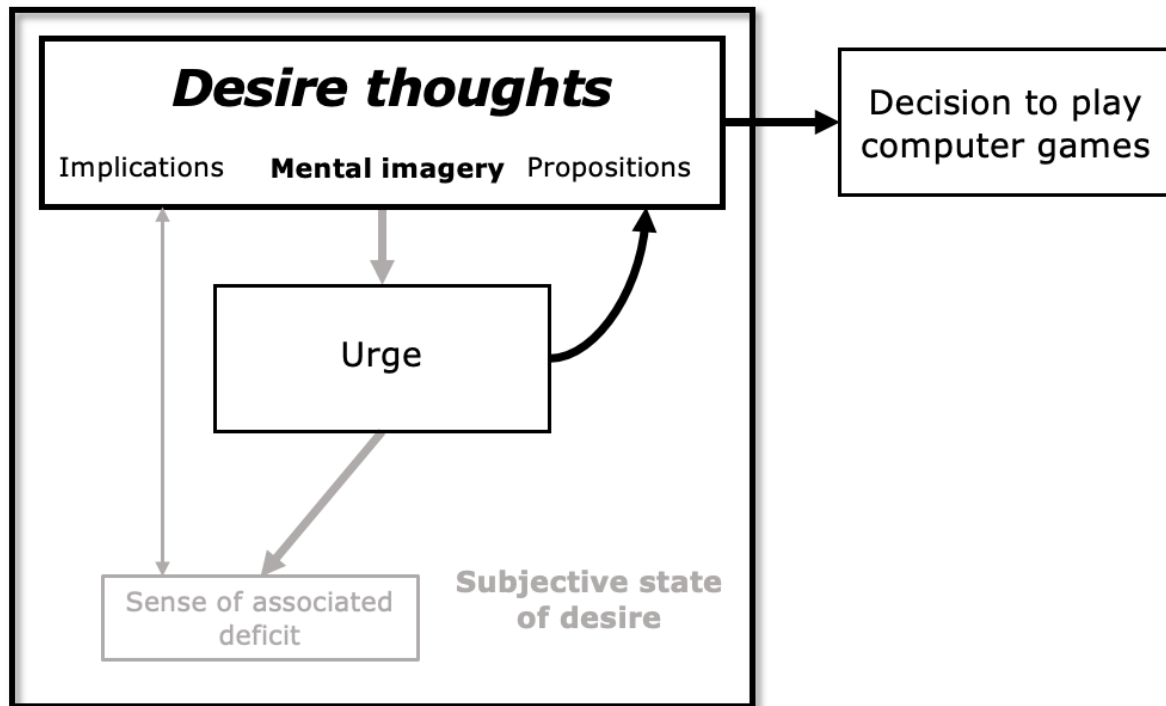
The first study is devoted to testing the validity of an assumption of the EIT in the context of computer gaming that tends to be risky. As described in Chapter 2.1, the EIT posits two self-reinforcing loops to explain how desire thinking can make engaging in a behavior more likely. One loop assumes that desire thinking produces a drive for pleasure or relief - a motivational state that can be described as urge (c.f., Canale et al., 2019). Experiencing this urge can induce even more desire thinking until the urge becomes irresistibly strong and may result in the decision to play computer games (see Figure 5). Assuming that this sequence of events may apply similarly to multiple behaviors, the focus of this paper is on the behavior-provoking property of desire thinking in the context of computer gaming. It was hypothesized that desire thinking would mediate the relationship between an urge and the decision to play computer games (see Figure 5).

For this study, a preliminary study containing a focus group setting was first used to develop an instrument that would make the dependent variable, deciding to play computer games, ecologically measurable. Accordingly, the goal was to operationalize decision behavior not with computerized reaction-time- or profit-maximization-measures (for review, see Schiebener & Brand, 2017), but to approximate the actual situations in everyday life in which people must decide for or against computer gaming. In the qualitative part of the preliminary study, a 6-member focus group, consisting of three female and three male gamers, collected and discussed possible everyday decision-making situations and rated them according to frequency of occurrence in everyday life. This resulted in 36 hypothetical scenarios in which the option of playing computer games is always confronted with a conflicting alternative (e.g., "You come home and realize that you should tidy up your apartment. Tidying up the most

important things will take some time. However, you actually wanted to play. What are you doing?"). This scenario catalog has been summarized under the name Conflicting Situations Catalogue for Gaming (hereafter CSC-G; Paper 1; Brandtner, Wegmann, et al., 2020).

Figure 5

Hypothesis on the mediating role of desire thinking according to EIT



Note. According to the EIT, pleasure and relief associated with desire thinking are summarized as a motivational state of urge.

The CSC-G was presented in the subsequent online questionnaire of the main study with the instruction to read through the scenarios and then decide for or against playing computer games. Furthermore, the online survey also included the question about the urge to play computer games in form of a visual analogue scale and the DTQ (Caselli & Spada, 2011) with its two subfacets imaginal prefiguration und verbal perseveration. A total of 118 people were recruited for the survey with the help of the German panel provider Respondi GmbH. The respondents were considered suitable for participation if they stated that they played computer games for at least 14 hours per week. In the quantitative evaluation, the decision scenarios of the CSC-G were reduced by means of statistics of classical test theory (i.e., item difficulty, discriminatory power) and based on ratings of how often such a situation occurs at all (specific statistical methods are explained in Brandtner, Wegmann, et al., 2020). After statistical adjustment, the instrument comprised a total of 18 items. Decisions to play computer games were coded as 1,

decisions for the alternative activity as 0, such that the range of the questionnaire spans values from 0 to 18. Higher values thus indicate more decisions for computer gaming. The mediation analysis was addressed using a sequential path model in MPlus 8 (Muthén & Muthén, 2011). The urge to play computer games was included as an independent variable, the decision to play computer games as a dependent variable, and the desire thinking subfacets sequentially as mediators.

The results of the mediation analysis show a complete mediation effect through the mediation variables imaginal prefiguration and verbal perseveration ($\beta = 0.16$, $SE = 0.06$, $p = .007$). Neither another indirect path nor the direct path between the urge and the decision to play computer games became significant. The model could explain 28.3% of the variance within the dependent variable ($p < .001$).

The full mediation of the relationship between an initial urge to play computer games and the decision to do so by the desire thinking facets indicates the behavioral relevance of desire thinking. Apparently, an initial urge or associative association with computer games is not sufficient to trigger an actual decision to play computer games, but it might be the elaboration of the desire that seems to create an irresistible pressure to act. The results are further explored in the general discussion in Chapter 5.

4.2 Paper 2: Testing the desire thinking hypothesis from S-REF

Original title: *Fleeing through the mind's eye: Desire thinking as a maladaptive coping mechanism among specific online activities*

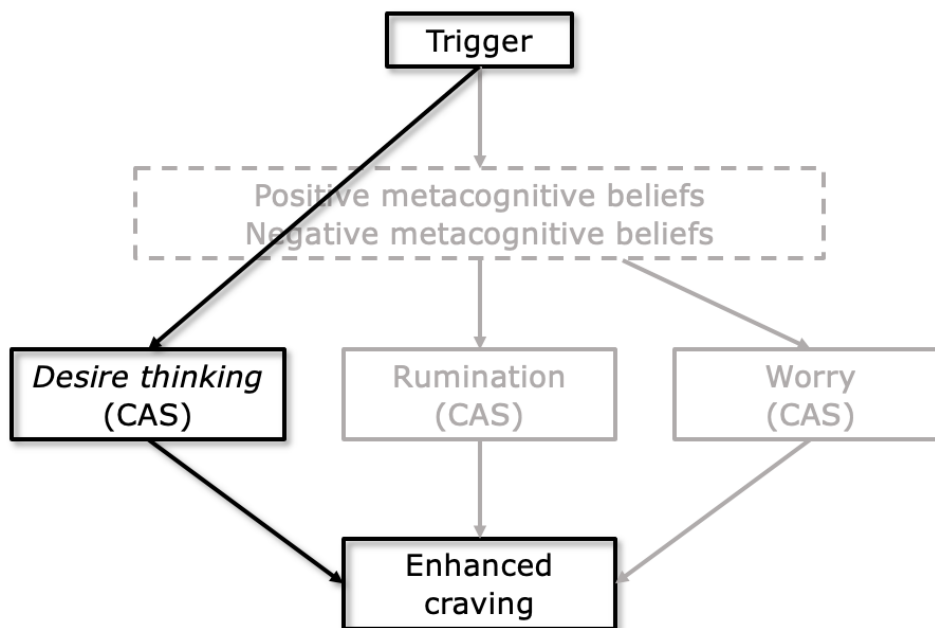
The second study is devoted to testing a hypothesis around desire thinking from the S-REF model as described in Spada et al. (2013). Specifically, it shall be examined to what extent desire thinking may lead to increased craving as a reaction to negative emotional reactivity. The observation that craving may be initiated in response to aversive triggers in the context of substance-related addictive disorders is interpreted as an attempt to regulate negative emotional states (e.g., Childs & de Wit, 2010). However, the concrete mechanisms underlying the emergence of craving remain unclear for the context of behavioral addictions.

With the understanding of desire thinking as a conscious elaboration process, the question arises whether desire thinking mediates the connection between aversive emotional states and craving and thus could be one responsible process for the emergence of craving in the context of (potentially) addictive activities (see Figure 6). In this model, the activation, intensity, and duration of negative emotional reactions served as operationalization for the

response to aversive triggers in the pre-engagement phase of the S-REF model. Thus, a mediation hypothesis was posited in which desire thinking mediates the relationship between heightened negative emotional reactivity and craving. The context in this paper is expanded to include several online activities that tend to be problematic, and thus includes not only gaming but also social network use, online shopping, online pornography use, and online gambling.

Figure 6

Hypothesis on the mediating role of desire thinking according to S-REF



Note. Experiencing triggers as aversive was operationalized in this mediation model as the general negative emotional reactivity.

The mediation hypothesis was tested using a structural equation model that latently modeled negative emotional reactivity (Becerra et al., 2017; Preece et al., 2019), desire thinking (Caselli & Spada, 2011), and craving (May et al., 2014) based on the subfacets of the questionnaires used (detailed descriptions of the questionnaires can be found in Brandtner & Brand, 2021). A total of 925 respondents were recruited with the help of the German panel provider GapFish GmbH to answer the questionnaires on negative emotional reactivity, desire thinking, and craving. As preferred online activity, 45.6% reported social networking, 36.1% shopping, 14.1% gaming, 2.7% pornography, and 1.5% gambling. The analyses were calculated with MPlus 8 (Muthén & Muthén, 2011).

All model fits of the structural equation model except for the χ^2/df ratio with 3.9 showed acceptable to good values (complete listings of model fit indices can be found in Brandtner & Brand, 2021). The model set up is therefore well able to represent reality in the sample surveyed. While the indirect path from negative emotional reactivity via desire thinking to craving became significant ($\beta = 0.23$, $SE = 0.03$, $p < .001$), the direct positive association between negative emotional reactivity and craving in the overall model lost its significance ($\beta = .04$, $SE = 0.03$, $p = .199$).

The results of this study show that a tendency to experience negative emotions quickly, intensely, and for a long period of time (Becerra et al., 2017; Preece et al., 2019), increases the likelihood for the occurrence of desire thinking and a subsequent craving experience. In addition to a deficit or difficulty in emotion regulation (Caselli, Canfora, et al., 2015; Faghani et al., 2020), general emotional reactivity also seems to be associated with desire thinking. Critical to this form of emotion regulation could be, however, that the use of desire thinking can lead to the development of craving for an activity as the results of this study show. This does not imply that desire thinking is a fundamentally dysfunctional process. Rather, it suggests that it can become dysfunctional when it leads to an experience of craving in the sense of an emotion regulation attempt. This finding is further explored in the general discussion in Chapter 5.

4.3 Paper 3: Integrating desire thinking into the I-PACE model

Original title: *Integrating desire thinking into the I-PACE Model: A special Focus on Internet-use disorders*

The purpose of the third work is to propose a position for desire thinking in the I-PACE model by means of theoretical derivations and subsequent validation of this position by empirical studies, considering the findings in Papers 1 and 2. Consequently, the third paper is a narrative literature review that results in theoretical model assumptions.

For the theoretical positioning, the EIT described in Chapter 2.1 (Kavanagh et al., 2005) and the S-REF model described in Chapter 2.2 (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013) were used. The derivation of the position of desire thinking is based primarily on the greatest commonality of the two models with regard to desire thinking - namely, the connection between desire thinking and craving. Although the understanding of this connection differs slightly between the two models (the EIT understands desire thinking as a sub-process of craving, the S-REF model understands desire thinking as the most proximal antecedent of

craving), they have in common that they attribute distinct properties to the two processes and postulate an interwoven interaction of both. This distinction at the construct level is therefore also evident in the revised I-PACE model, in which desire thinking and craving are sorted together into the category of affective and cognitive reactions, but are still to be understood as distinct entities. Thus, the integrative I-PACE model postulates that desire thinking is a process of voluntary cognitive elaboration of an activity with its two subfacets imaginal prefiguration and verbal perseveration. Desire thinking itself, also according to the EIT, can be experienced as gratifying and/or compensating, which is translated by looping back through the gratification/compensation category within the integrative I-PACE model (see Figure 7). Craving is understood as a consequential and accompanying phenomenon that is subdivided according to the EIT into its subfacets urge (i.e., the drive for pleasure/relief) and associated deficit (i.e., the feeling that something is missing).

According to the adapted I-PACE model, desire thinking is more likely to be understood as a voluntary cognitive response to triggers that may lead to further accompanying affective processes, whereas craving is more likely to be understood as an affective experience that may, however, have cognitive antecedents (e.g., desire thinking). In particular, the adapted I-PACE model integrates, in addition to theoretical assumptions and existing empirical work, the hypotheses on desire thinking examined in Paper 1 and Paper 2, which were derived from the EIT and the S-REF model. Both the results on the self-reinforcing loop according to the EIT (*urge* → *imaginal prefiguration* → *verbal perseveration* → *specific behavior*), as well as the results on desire thinking as a (dysfunctional) coping mechanism according to the S-REF model (*processing of internal and external triggers* → *desire thinking* → *craving*) can be found in the adapted I-PACE model and can be derived as hypotheses for future (replication) studies. Furthermore, the integrative I-PACE model also postulates relationships between desire thinking and the existing categories of the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016). The hypothesized relationships can be seen in Figure 7, can further be found in Paper 3 (Brandtner et al., 2021) and are discussed in more detail in Chapter 5.1.1.

4.4 Paper 4: The effect of mindfulness techniques on the components of the I-PACE model

Original title: *A preregistered, systematic review considering mindfulness-based interventions and neurofeedback for targeting affective and cognitive processes in behavioral addictions*

The fourth paper is a narrative review that aimed to compare the application of two techniques (neurofeedback and mindfulness techniques) in terms of their effectiveness on affective and cognitive processes in behavioral addictions. These two techniques are particularly interesting to compare because they have in common that both primarily work with the client's focused attention. That is, neurofeedback is decidedly designed to change affective and cognitive responses (i.e., the down-regulation of reactions to addiction-associated stimuli and the up-regulation of reactions to neutral stimuli, c.f., Dickerson, 2018; Volkow et al., 2011) whereas mindfulness teaches people to accept their affective and cognitive responses without judgment (see Chapter 3). Both techniques show efficacy for substance addictions (e.g., Hartwell et al., 2016; Kirsch et al., 2016; Rosenthal et al., 2021) and should be contrasted in their effect on core mechanisms postulated in the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016) namely, perceived stress, cue reactivity and craving, maladaptive decision-making behavior, decreased inhibitory control, and attentional biases.

For the search strategy, the type of intervention (e.g., neurofeedback, mindfulness) was combined with the extent of pathological behavior (e.g., pathologic*, addict*) and the behavior itself (e.g., porn*, videogam*) using a boolean AND. Within the brackets, entities were combined with the boolean OR (e.g., mindfulness AND pathologic* AND porn*). Furthermore, the MeSH term "behavioral addiction" was used. PubMed, Scopus, and Web of Knowledge databases were searched. The exact search and selection procedure can be found in Paper 4 (Brandtner et al., 2022).

Because no study was identified during the review process that used neurofeedback as an intervention technique for behavioral addictions, this work focuses primarily on findings related to mindfulness techniques. A total of 15 appropriate studies were identified. These show positive effects of mindfulness techniques in the context of behavioral addictions, especially regarding perceived stress levels (i.e., five studies postulate a significant decrease) and craving (i.e., four studies postulate a significant decrease). The findings on the influence on inhibitory control, maladaptive decision-making behavior, and attentional biases are heterogeneous and thus less clear. Overall, there is a high diversity in the mindfulness techniques and protocols

used, of which mindfulness-based cognitive behavior therapies emerged as particularly successful (Melero Ventola et al., 2020; Toneatto et al., 2014).

The effects that mindfulness techniques show on craving and stress in this review are consistent with findings from research on substance-use disorders (Khanna & Greeson, 2013; Witkiewitz et al., 2005). The findings on craving are particularly relevant to this work because of its close link to desire thinking. The success that mindfulness techniques have in addressing craving experiences could be explained primarily by three modes of action: First, mindfulness techniques provide a shift of attention on the here and now, and thus away from the content of craving (e.g., wanting to play computer games). Second, cognitive working memory resources occupied by mindfulness practices could also ensure that there is simply not enough capacity available for cognitive processing of the craving (e.g., Baddeley, 2003; Baddeley & Hitch, 1974), resulting in a correspondingly lower craving response. However, this explanation could only account for short-term effects of working memory and does not help to elucidate long-term effects of mindfulness techniques. Third, it is learned that thoughts (and thus craving-associated sensations) come and go. For this, craving is often metaphorically compared to a wave motion that comes up and subsides on its own. "Surfing the urge" is a visualization technique that helps clients to accept the craving reaction and let it pass (Baer, 2003; Bowen & Marlatt, 2009). These assumptions are discussed in more depth in Chapter 5.2.1.

5 Discussion

5.1 Theoretical implications

By conducting two empirical studies and adding existing literature, a proposed position for desire thinking within the I-PACE model could be made in Paper 3. Desire thinking is consequently located close to the very related concept of craving and thus within the category of affective and cognitive responses to internal and external triggers, as proposed in the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016). With this sorting, associations to related constructs within the model are also postulated. These associations are intended to demonstrate how desire thinking is linked and functions at the process level in the context of addictive behaviors. Using these assumptions about process linkages, sequences of affective and cognitive responses with respect to desire thinking can be hypothesized and empirically tested. In the following, the assumptions about associations of desire thinking to these constructs are first theoretically argued and then underpinned with empirical literature (including the writings of Cumulus) in the context of addictive behaviors.

5.1.1 Associations with core mechanisms of the I-PACE model

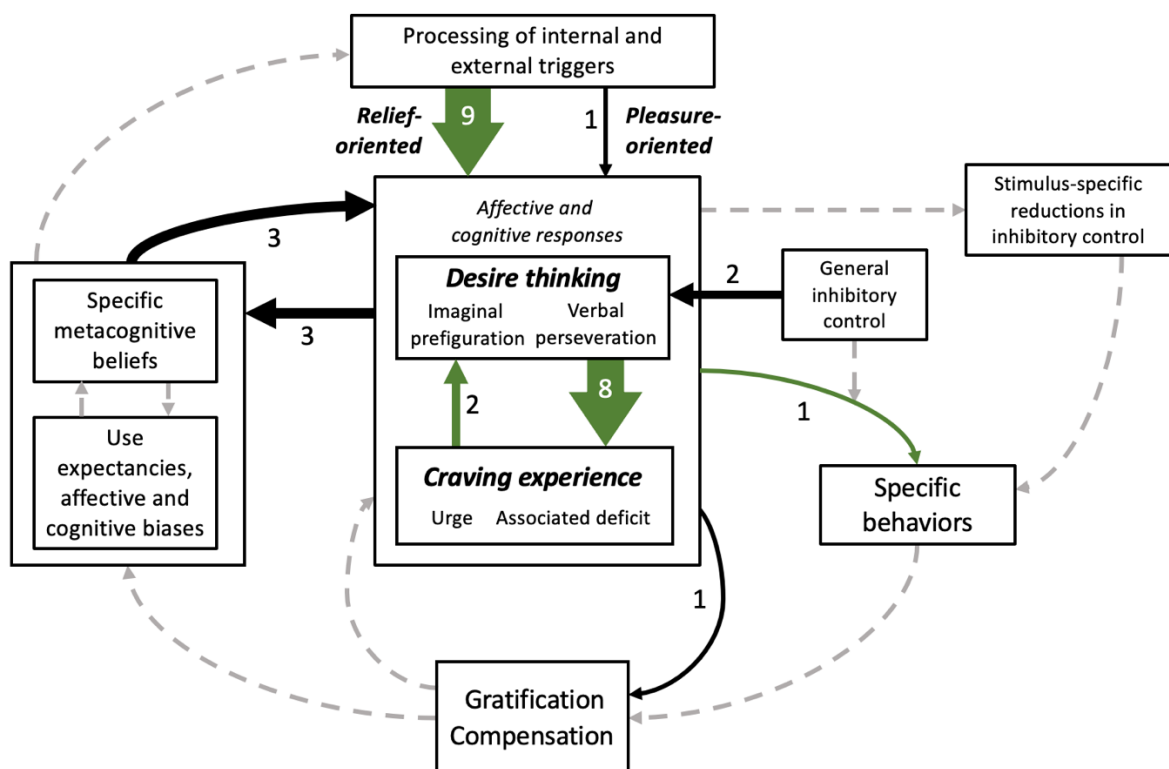
Desire thinking and trigger processing

As Figure 7 shows, a relief-oriented and pleasure-oriented pathway can now be found in the modified inner circuit of the I-PACE model. The relief-oriented processing pathway is based on the S-REF model assumptions (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013), the empirical verification within a writing of the Cumulus (Paper 2; Brandtner & Brand, 2021), and other empirical studies in the context of addictive behaviors (Aydm et al., 2022; Dragan et al., 2021; Fernie et al., 2014; Khosravani et al., 2022; Sharifi et al., 2022; Solem et al., 2020; Thomas et al., 2020) indicative of a linkage between desire thinking and the experience of psychological distress. So far, this linkage was falsified by one study that did not find significant correlations between desire thinking and anxiety/depression in the context of sexual behavior (Efrati et al., 2020). Still, evidence accumulates that desire thinking may be activated in response to aversive emotional states in the sense of a coping mechanism to regulate these emotional states towards a relief experience. The pleasure-oriented processing pathway is based on an initial exploratory study of desire thinking, which used qualitative interviews to record that 37.5% of respondents reported using desire thinking to generate a sense of pleasure (Caselli & Spada, 2010). Further, findings by Caselli, Manfredi, et al. (2015) suggest that desire thinking may function as a mediator between novelty seeking and craving. Novelty seeking is understood

as a developmentally and situationally stable trait that manifests in character as, among other things, an exploratory, excitable, and curious tendency (Cloninger, 1987). Individuals who exhibit higher expressions of this character trait may therefore also be more inclined to achieve new and exciting experiences - not only in reality and through physical experience, but also within their thought and affect worlds (Berpohl et al., 2008) and thus possibly also through desire thinking. The adapted I-PACE model posits that both the relief-oriented and pleasure-oriented pathway may become equally dysfunctional since increased desire thoughts may be associated with increased craving experiences (Paper 2; Brandtner & Brand, 2021) or directly with (possibly undesirable) behavior (Paper 1; Brandtner, Wegmann, et al., 2020). The specific association between desire thinking and craving in the context of addictive behaviors will be discussed in the next chapter.

Figure 7

Desire thinking integrated into the modified I-PACE model



Note. The figure is taken from the original manuscript by Brandtner et al. (2021) and adjusted based on an updated literature search (July 2022). Thicker arrows indicate a higher publication density. Numbers indicate the number of published articles on respective linkages. Green color indicates the contribution of the writings of the Cumulus. Gray-dashed arrows indicate that there is no empiricism yet including these pathways in the context of desire thinking in addictive behaviors.

Desire thinking and craving

On a theoretical level, the EIT and the S-REF model imply the differentiability of desire thinking and craving. Both share the assumption about the sequence of (aversive) triggers that can trigger desire thinking and that desire thinking can be involved in the emergence and escalation of craving (Kavanagh et al., 2005; Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013), which should make both constructs definitionally different. At the same time, the EIT argues for a certain closeness of the two constructs by describing craving as an affective response in which the mental images and verbal thoughts (i.e., desire thoughts) are accompanied by a motivational drive for pleasure or relief and a sense of associated deficit (Kavanagh et al., 2005; Spada, Caselli, Nikčević, et al., 2015). A conceptual sub-division of craving facets (i.e., drive for pleasure/relief, associated deficit) coincides with assumptions in other models, such as the Psychobiological Three-Way Model of Alcohol Craving according to Verheul et al. (1999), which, in addition to the facet of obsessive craving, also postulates a reward craving (primarily evoked by pleasant affect situations) and a relief craving (as a reaction to negative affect situations) and thus distinguishes different subfacets of craving. Contrary to what can be read in associated psychological literature, the term urge is, according to some authors and in the sense of the EIT, not a synonym for craving, but describes only a partial experience or facet of it (Canale et al., 2019; Cornil et al., 2021). The findings made in Paper 1 suggest that an urge alone may not be sufficient to determine the decision to game. Although existing literature illustrates a close linkage between craving and future behavioral enactment or relapse (for meta-analysis, see Vafaie & Kober, 2022), there are still controversial opinions and results on how reliably craving can predict addictive behaviors (e.g., Gass et al., 2014). In the light of Paper 1 of this Cumulus, it might be especially the accompaniment of desire thoughts that could eventually lead to a decision (Brandtner, Wegmann, et al., 2020). This idea is further evaluated among “*Desire thinking and decision making*”.

Figure 7 illustrates that the relationship between desire thinking and craving in the context of addictive behaviors is studied intensively. The influence that desire thinking seems to have on the development and maintenance of craving has so far been studied in the context of pornography consumption (Allen et al., 2017; Paper 2: Brandtner & Brand, 2021), sexual behaviors (Caselli et al., 2013), gaming (Paper 2: Brandtner & Brand, 2021; Dragan et al., 2020), gambling (Caselli & Spada, 2015), shopping (Paper 2: Brandtner & Brand, 2021), social networks use (Paper 2: Brandtner & Brand, 2021; Marino et al., 2019; Sharifi et al., 2022), and in the context of unspecified Internet use (Caselli, Manfredi, et al., 2015; Caselli et al., 2013; Caselli & Spada, 2015); and the studies seem to confirm the strong association between both constructs. Empirically, the correlations for the subfacets of desire thinking (imaginal

prefiguration and verbal perseveration) with craving across different behavioral and substance addictions average .46 (e.g., Allen et al., 2017; Paper 2: Brandtner & Brand, 2021; Paper 1: Brandtner, Wegmann, et al., 2020; Caselli, Manfredi, et al., 2015; Martino et al., 2017). Overall, this indicates moderate to strong effect sizes, suggesting that the constructs appear to share approximately 20% of their variance. This indicates their closeness in terms of content, yet highlights that the constructs may be different enough to have their own informative value, which might also be the case in the context of addictive behaviors.

Desire thinking und gratification/compensation

Another extension in the modified inner loop of the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016) is the circular loop between affective and cognitive responses and the experience of gratification and compensation. This arises primarily from the EIT-compliant conceptualization of craving (Kavanagh et al., 2005; May et al., 2004), which posits that craving can be generated due to desire thoughts being experienced as rewarding or relieving. The duality of some experiences thus stands out from processing internal and external triggers (pleasure-oriented vs. relief-oriented), through experiencing an urge (drive for reward vs. drive for relief), to experiences associated with the behavior (gratification vs. compensation). Furthermore, desire thoughts may simulate "real" gratification or compensation. That is, just thinking about how pleasurable or relieving it can feel to open the laptop and scroll through online shops after work may simulate the actual experience and induce corresponding expectancies that might in turn contribute to the actual experience while acting out the behavior. Consistent with the assumption of earlier and later phases of addiction development and maintenance (Brand, Wegmann, et al., 2019), it is conceivable that corresponding to a shift from experiencing gratification to experiencing compensation during the performance of the behavior, a shift within the quality of desire thoughts might also be experienced: While the rewarding component of the experienced desire thoughts may predominate in the earlier phases, there may be increased relief-oriented desire thinking episodes in later phases of addiction. In the context of behavioral addictions, one study has been devoted to the affective properties of desire thoughts (Brandtner, Pekal, et al., 2020). After an experimental cue induction, a quadratic tendency was shown in experiencing positive accompanying emotions during mental imagery of computer games: Up to a medium symptom severity, the positive emotion experienced together with the mental imagination increases. From a medium to high symptom severity, the positive emotion decreases again. The results were slightly below the significance level of $p = .05$, and yet dot plots were able to show an approximate relationship. Systematic studies on this relation are currently pending. Notably, the mentioned study did not investigate the contribution

of craving and desire thinking on the rewarding or relieving experience during behavior engagement, but provides initial insight into how a shift from simulated gratification to simulated compensation might develop in the course of addiction.

Desire thinking and decision making

Since the work of Bechara (2003, 2005), dual-process models have become an increasing focus of addiction research as basis for explaining reduced self-control (e.g., Hofmann et al., 2009). These models hypothesize an imbalance between impaired prefrontal control mechanisms (reflective system) and an overactivated limbic reward system (impulsive system) that may lead to decreased self-control over health-related behaviors (e.g., Friese et al., 2008) and could also provide an explanation for impaired decision-making behavior in the context of behavioral addictions (e.g., Dong et al., 2017; Dong, Lin, Hu, et al., 2015; Dong, Lin, & Potenza, 2015). In the specific context of problematic computer gaming, some cognitive mechanisms are known to have a detrimental effect on decision-making behavior of gamers, such as reduced inhibitory control (Argyriou et al., 2017; Kräplin et al., 2021), impaired emotion regulation (Wu et al., 2020), heightened cue reactivity and craving (Brand, Rumpf, et al., 2019; Dong et al., 2020), psychological distress and according coping mechanisms (Bányai et al., 2019; Schneider et al., 2018), use expectancies (Laier et al., 2018), dysfunctional (meta-) cognitions (Marino & Spada, 2017; Moudiab & Spada, 2019), and also for the research field comparatively newer concepts like a dysfunctional time perspective and perception (Lukavská, 2018; Nuyens et al., 2019). With Paper 1 of this thesis, it appears that also desire thinking may be a factor which can promote an impaired decision behavior in the context of computer games (Paper 1; Brandtner, Wegmann, et al., 2020). Thus, desire thinking might be a proximal precursor of decision making in the computer game context; in other words, it might be a predictor for actual behavior, which shifts its relevance in the seriality of affective and cognitive processes towards a behavioral efficacy. With this finding, desire thinking and its modification could thus also be discussed as a leverage point for interventions and prevention measures (see Chapter 5.2).

Referring to dual-process models of decision making (Bechara, 2003, 2005) it is conceivable that desire thinking might weaken inhibitory control performance of the reflective system during a craving episode. The reflective system, in contrast to its counterpart, the impulsive system, is characterized by a slower, conscious, and serial mode of operation aimed at exercising self-control and weighing the consequences of one's behavior in a goal-oriented manner (Bechara, 2003, 2005; Kahneman, 2003) – a conceptualization that is also applies in the context of behavioral addictions (Brand, Wegmann, et al., 2019; Brand et al., 2016). Similarly, also desire thinking is defined by a laborious, deliberate mode of working and

includes a verbal component aimed at elaborating the goal-oriented achievement of the desired target (Caselli & Spada, 2015). That is, desire thinking could be understood as approximately "reflective" since it effortfully recruits top-down cognitive resources to elaborate on a certain desire. Thus, beyond weakening inhibitory control, it is possible that desire thinking may even hijack the capacities of the reflective system and uses them for producing desire thoughts. Thus, desire thinking could, besides provoking craving responses, additionally take over executive resources, which could be the reason why existing literature often refers to an "escalation of craving" through desire thinking (Caselli et al., 2020; Caselli et al., 2017; Caselli & Spada, 2015; Martino et al., 2019; Spada et al., 2013). This mutual influence between desire thinking and craving is also depicted in Figure 7 with interacting arrows. Since impulsive and reflective activities are focused on the desired target - if the above made assumptions prove true - the decision to engage in the desired activity may become more likely, as the results of Paper 1 already show (Brandtner, Wegmann, et al., 2020). Further, the recruitment of top-down reflective resources could be an alternative explanation as to why some studies using brain imaging techniques find increased activation patterns in prefrontal areas during drug cue exposure (c.f., Zilverstand et al., 2018). Instead of interpreting these results as being efforts for self-regulation, these activity patterns in prefrontal areas could relate to effortful desire thinking processes. In this light, brain imaging studies are needed that systematically examine the modification of desire thinking and evaluate its effect on specific decision-making behavior in the context of behavioral addictions.

Desire thinking and metacognition

The S-REF model (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013) decidedly postulates the involvement of metacognition in the development of craving. The term metacognition consists of the root word "meta" which means "about" or "on" (Metcalf & Shimamura, 1994), and the specification "cognition" (lat. *cognoscere* = to recognize, experience) which is commonly translated as "to think". Metacognitions are colloquially understood as "thinking about thinking" or "knowledge about one's knowledge", and thus the reflection of one's own thinking processes. They are generally divided into (1) knowledge about one's own thinking processes and (2) the regulation of one's own thinking processes (Schraw, 1998) – a definition that also finds application in the field of addictive behaviors and corresponding metacognitive processes (Casale et al., 2021; Hamonniere & Varescon, 2018). Metacognitions were not yet specifically mentioned in the I-PACE model (Brand, Wegmann, et al., 2019; Brand et al., 2016), but have been included in the modified model (Paper 3; Brandtner et al., 2021) due to their theoretical and empirical association with desire thinking

(e.g., Allen et al., 2017; Spada et al., 2016; Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013; Thomas et al., 2020). Metacognitions appear to interact with desire thinking in that both positive (e.g., "Desire thinking will help me take my mind off things") and negative metacognitive beliefs (e.g., "Once I start desire thinking, I cannot stop") exist about desire thinking that promote the initiation and maintenance of desire thinking. Consistent with the two metacognition facets, these metacognitive beliefs include both knowledge about desire thinking and assumptions about its emotion-regulation properties. Especially the emotion-regulation facet emphasizes that desire thinking could be metacognitively understood as a (putative) coping mechanism, which also aligns with the findings from Paper 2 of the Cumulus (Brandtner & Brand, 2021).

Metacognitions about desire thinking could further shed light on the "voluntariness" of desire thinking. In its basic definitional understanding as a human trait, desire thinking is described as a voluntary process (Caselli & Spada, 2015). However, reports of desire thinking, reflecting metacognitive knowledge about desire thinking, suggest that desire thoughts might also be experienced as intrusive and uncontrollable in the psychopathological process (Caselli & Spada, 2013). Especially the desire thinking component "verbal perseveration" already indicates by its name that the linguistic desire thinking content is perseverative (lat. *perseverare* = to persist), that is, the constant adherence to a thought. Stark (2007) defines perseveration as a "phenomenon in which the subject unintentionally produces or becomes attached to a unit of information, a particular linguistic form or unit of action, that he or she has previously produced or heard at some level, i.e., processed auditorily, or seen, i.e., processed visually" (p. 932). However, if perseveration would be understood as a fundamental quality of the verbal component of desire thinking., this understanding would stand in contrast with the assumption that desire thinking is basically voluntary. There might be a chance that the intrusiveness of desire thinking changes in the course of addiction, which should be a focus for future research. Metacognitions could be a key element in understanding the perseveration or voluntariness of desire thinking, by means of which desire thinking could be specified among different severity levels of addictive behaviors (see also explanations on the therapeutic relevance of desire thinking in Chapter 5.2).

5.1.2 Proximity to conceptually related constructs

Desire thinking is a comparatively young construct with its first mentions in 2010 (Caselli & Spada, 2010) and with the development of a questionnaire (Caselli & Spada, 2011), that made desire thinking measurable for the first time in 2011 (see Chapter 5.2.2). The challenge in postulating and integrating new constructs into the research context is to demonstrate their

added value compared to existing constructs that may be equally or better able to describe the observed phenomenon. Thus, a newly postulated construct must be able to describe a phenomenon more validly and reliably than existing constructs already do. Thus, the introduction of the construct desire thinking also faces the challenge of withstanding critical reflection on its justification. In the case of desire thinking, the theoretical and practical relevance in the context of addictive disorders has been approached mainly through qualitative studies (Caselli & Spada, 2010; May et al., 2004), and, after the development of a questionnaire (Caselli & Spada, 2011) also empirically through predictive models and experimental designs (e.g., Caselli et al., 2017; Faghani et al., 2020). These were primarily concerned with the distinction from craving, which is arguably similar to desire thinking due to its assumed imagery component (Kavanagh et al., 2005). Nevertheless, the above-mentioned empirical work was able to establish an incremental value of desire thinking in predicting addictive behaviors over and above craving. Accordingly, it has been clarified within this thesis where the assumed definitional difference between desire thinking and craving may lie (see Chapter 2.3) and that they could be conceptually different constructs.

Besides craving, there are other constructs that show a conceptual proximity to desire thinking. As such, Koob and Volkow (2010) postulate a third phase of addiction development that they name "preoccupation/anticipation". Here, the preoccupation component comes very close to what is meant by verbal perseveration, and the anticipation component comes very close to imaginal prefiguration, which are the two subprocesses of desire thinking. Although limbically initiated, a certain executive control in the representation of behavioral consequences and the anticipation of effects of the drug is assumed (Koob & Volkow, 2010), as is done for desire thinking. The subjective effect of this process is declared by the authors as the experience of craving, describing a similar sequence of cognitive and affective events as within the EIT or the S-REF model, in which the subjective effect of desire thinking may also often be craving (Kavanagh et al., 2005).

Although the mechanisms described show crucial similarities, preoccupation/anticipation and desire thinking can nevertheless be attributed different characteristics. Preoccupation/anticipation is postulated to be the third phase of addiction development. That is, unlike desire thinking, which is defined as a basic human (unproblematic) ability (Caselli & Spada, 2015), the preoccupation/anticipation phase is understood as a consequence of prior addiction-specific reinforcement learning and corresponding neurological sensitization (Berridge & Robinson, 2016; Koob & Volkow, 2010; Robinson & Berridge, 1993). Desire thinking might therefore be differentiable from Koob & Volkow's craving phase in the early phases: Koob & Volkow (2010) assume preoccupation/anticipation to arise from

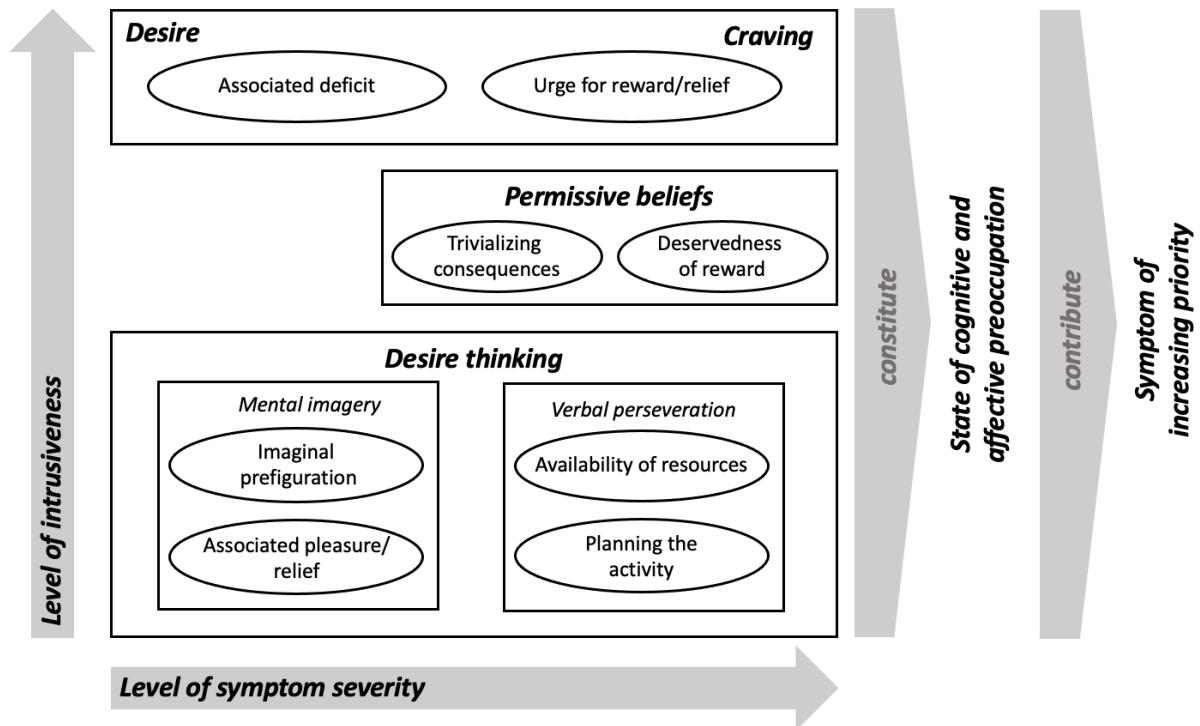
prior intoxication (or prior engagement in a certain behavior, respectively) which desire thinking does not necessarily need as a precursor. However, it is conceivable that desire thinking resembles the third phase of the addiction cycle in the later course of addiction, where desire thinking may become – as is assumed for preoccupation/anticipation (Koob & Volkow, 2010) – more a processing of conditioned reinforcement and requires less effortful elaboration since elaboration processes could have been habitualized (see Figure 8). Therefore, studies that systematically investigate the effortfulness of desire thinking in the course of addiction would be a reasonable next research goal (see also discussion on “*Desire thinking and metacognition*”).

Furthermore, there are inconsistencies in the use of the term preoccupation. Preoccupation, as a proposed diagnostic criterion for gaming disorder in Section 3 within the Diagnostic and Statistical Manual of Mental Disorders 5th Revision (DSM-5; American Psychiatric Association, 2013), depicts a symptom expression and thus an already observable characteristic of a disorder. In the context of pathological gaming, Weinstein et al. (2017) state that the symptom of preoccupation is characterized by the person recalling past computer gaming episodes or anticipating future sessions. In addition, gaming becomes a dominant activity in everyday life. According to this definition, the symptom of preoccupation includes both a cognitive and a behavioral component on a phenomenological level. Thus, depending on the authorship, preoccupation is referred to definitionally as a mere cognitive or as a cognitive and behavioral symptom (Koob & Volkow, 2010; Weinstein et al., 2017). Desire thinking, on the other hand, means the purely cognitive process, the momentary activity of incessant mental activity (Caselli & Spada, 2011, 2015), in which, despite the possible activation of memories of past activities, there is an emphasis on mental future orientation. To clarify terminologies, this work posits in Figure 8 and Table 1 that there may be several cognitive and affective processes that may constitute a subjective state of preoccupation. That is, a person could be similarly preoccupied with desire thoughts, craving, certain beliefs, and certain expectancies. This preoccupation may ultimately result in the symptom expression of increased priority as listed in the ICD-11; which is preferred over the DSM-5-derived symptom terminology of preoccupation here to avoid the above mentioned inconsistencies. Nevertheless, despite the here presented possible conceptual separation, the phenomenological boundaries may not be very clear-cut. Especially when trying to measure these phenomena, researchers need to specify the process they want to address - when is it about the process itself (i.e., desire thinking), when is it about the subjective effect of this process (i.e., craving), when is it about a mental occupation of several thoughts (i.e., preoccupation), and when is it about an increased

emotional/cognitive/behavioral value in everyday life caused by these process (i.e., increased priority)?

Figure 8

Assumed relationship between related affective and cognitive concepts



Note. The level of intrusiveness is assumed to increase from bottom to top as indicated by an arrow. Symptom severity of the addictive behavior increases from left to right.

As a last example, there might be a conceptual proximity to permissive beliefs, which are often mentioned in the literature under the terms self-licensing, self-justification, or facilitative beliefs (e.g., Beck et al., 1993; Burton & Abbott, 2018; de Witt Huberts et al., 2012; Prinsen et al., 2016). Permissive beliefs are positioned in the Cognitive Model of Addiction as a reaction to craving (Beck et al., 1993). It is hypothesized that experiencing craving while simultaneously experiencing conflict related to the addictive disorder (e.g., medical, financial, social, legal consequences of use) creates cognitive dissonance and associated psychological tension. This tension is aimed to be reduced with the help of permissive beliefs that could involve thoughts about the deservedness of reward or the trivialization of negative consequences (Beck et al., 1993). The activated beliefs could thus provide a justification for the behavior and an experienced relief - despite the knowledge of experiencing a lack of sleep due to the nightly gaming session, the computer may now be turned on with a "good" excuse. Such thoughts are also often described as the content of the verbal component of desire thinking, which is

supposed to include the evaluation of good reasons to pursue the activity (Caselli, Canfora, et al., 2015; Caselli et al., 2017; Frings et al., 2019; Marino et al., 2019; Martino et al., 2017). Caselli et al. (2020) showed that the experimental manipulation of desire thinking caused an increase in permissive beliefs, suggesting a close connection between the two processes. For permissive beliefs to emerge, it is assumed that the individual must be in conflict with an activity and then finds justifications for the behavior (Beck et al., 1993). However, this is not necessarily the case with desire thinking - desire thinking can also involve the use of social networks when it is not in conflict with other activities (c.f., Kavanagh et al., 2005). However, since the serial order of desire thinking components is still under research (c.f., Marino et al., 2019 vs. Caselli et al., 2015), there is a possibility that the sub-facet verbal perseveration follows a craving episode (i.e., imaginal prefiguration → craving → verbal perseveration). This opens the discussion for future research that needs to investigate if (1) permissive beliefs could indeed fall, among others, under the content of verbal perseveration, if (2) the concept of verbal perseveration shows such big similarities with an already existing concept that its *raison d'être* is questionable, or if (3) clear definitions and empirical studies help to argue that verbal perseveration and permissive beliefs are not the same and should be treated as separate constructs.

It becomes clear that the related constructs presented here share some similarities with desire thinking while definitions and models argue that some core characteristics are different. Since desire thinking has already entered the field of behavioral addictions (e.g., Frings et al., 2019; Marino et al., 2019; Spada et al., 2014), and not least with Paper 1 and Paper 2 of this Cumulus, it is particularly important to establish a common basis of understanding about related constructs. Therefore, Figure 8 attempts to map a possible distinguishability at the concept level as a conclusion of this section, although the causality between processes is not yet clearly understood. It is suggested that permissive beliefs shall be distinguished from desire thinking since this conceptualization follows a clear definition and permissive beliefs are a direct successor of cognitive dissonance (which desire thinking is not necessarily). Moreover, the term preoccupation could be understood as a collective term for the impairment caused by various cognitive processes (not only desire thinking) in the context of addiction, rather than as a synonym for single processes. As King and Delfabbro (2014) point out, preoccupation might be a multi-faceted phenomenon with individual characteristics regarding different behavioral disorders. That is, patients with anorexia nervosa might be preoccupied with thoughts about their body shape whereas pathological gamblers might be preoccupied with planning their gambling sessions. Likewise, also people who use social networks or game problematically might have several thoughts and hold beliefs that are more specific to their problem behavior.

According to this understanding, individuals could be similarly preoccupied by desire thoughts, craving, or the activation of permissive beliefs. Thus, the preoccupation by respective cognitive processes may lead to the expression of increased priority as an ICD-11 symptom criterion, but do not necessarily have to.

Table 1

Exemplary operationalizations for presented concepts

Concept	Exemplary operationalization
Imaginal prefiguration	<i>Imagination of playing computer games in the usual place</i>
Associated pleasure/relief	„It's pleasant to imagine myself gaming."
Availability of resources	„I'd have plenty of time tonight to play computer games."
Planning the activity	„I will turn on my PC as soon as I get home."
Associated deficit	„I'm missing playing my favorite game right now."
Urge	„I really want to play computer games now."
Trivializing negative consequences	„After all, playing computer games is not dangerous per se."
Deservedness of reward	„I deserve to play my favorite game after this long day."
Affective and cognitive preoccupation	"All the thoughts about gaming make it hard for me to think about something else."
Symptom of increasing priority	"I experience that gaming determines my way of thinking, feeling, and behaving; and takes precedence over my other life interests."

Note. Since the sensory imageries are multi-faceted and more complex to describe, an operationalization would also consist of several items that are not all depicted here.

Compared to the model around desire thinking postulated in Paper 3 (Brandtner et al., 2021) and also compared to the assumptions in the EIT (Kavanagh et al., 2005), Figure 8 makes a decided distinction between the associated reward and relief experienced during the desire thinking process (e.g., "It is pleasurable to imagine myself watching porn later") and the urge for pleasure and relief that may arise from desire thinking (e.g., "I really want to watch porn now"). The EIT only postulates the experienced reward and relief during desire thinking, and interprets it as a motivational component of urge (c.f., Canale et al., 2019). On a measurement level, however, an urge and the associated reward and relief during an imagination have different implications for operationalization. Table 1 provides examples of the subprocesses adopted in Figure 8. The distinction between the subfacets of permissive beliefs (trivialization

of negative consequences and deservedness of reward) stems from yet unpublished data from a questionnaire development in the context of Internet-use disorders.

5.2 Practical implications

By working Paper 1 and 2 toward a theoretical model in Paper 3, the writings of the Cumulus provide much ground for a theoretical discussion of the relevance of desire thinking in the behavioral addiction context and its proximity to or distinctiveness from other constructs. With a focus on Paper 1, 2, and 4 of the Cumulus, additional practical implications can be derived, which will be discussed below for the clinical context (see Chapter 5.2.1) as well as for the research context (see Chapter 5.2.2).

5.2.1 Clinical and therapeutic relevance of desire thinking

Two studies of the Cumulus (Paper 1; Brandtner, Wegmann, et al., 2020; Paper 2; Brandtner & Brand, 2021) equally emphasize a role of desire thinking in the context of addictive behaviors, but give indication for different prevention or intervention options. Paper 1 (Brandtner, Wegmann, et al., 2020) makes clear that desire thinking could be a proximal antecedent of decision making in the computer game context, and possibly other behaviors as well. Deriving an intervention according to this finding could involve sensitizing individuals to the influence of desire thoughts on decision-making processes, thus starting at a point in the sequence of affective and cognitive processes where desire thoughts already exist, but trying to prevent them from becoming behaviorally relevant. As Figure 8 illustrates, there may be some affective and cognitive processes that could occur along with desire thinking and thus could be modified before decision-making or actual behavior takes place. Thus, the modification of desire thinking could lead to less craving and less permissive beliefs, and consequently to a decrease in the likelihood of engaging in a certain (potentially addictive) activity.

For addressing desire thinking, Caselli and Spada (2015) put emphasis on techniques of metacognitive therapy. Metacognitive therapy, unlike cognitive behavioral therapy, addresses not the content of desire thinking (and other cognitive processes) but knowledge and beliefs about these processes (e.g., "Imagining computer gaming will improve my mood" or "I need to control my thoughts about computer gaming"). A study of patients with alcohol-use disorder concluded that this form of metacognitive therapy is superior to a control condition in reducing beliefs about alcohol-associated thoughts (Caselli et al., 2016). Consequently, Caselli and Spada (2016) suggest that desire thinking and its regulation (through maladaptive metacognitions) should be an appropriate treatment focus. Studies also suggest that metacognitions appear to have a strong influence on the maintenance of behavioral addictions

(e.g., Allen et al., 2017; Casale et al., 2016; Casale et al., 2021; Spada et al., 2008). Referring to the proposed model in Paper 3 of this Cumulus (Brandtner et al., 2021) and the assumption of a relief-oriented as well as a pleasure-oriented pathway (see Figure 7) it might be helpful to reflect on the initiation reasons for desire thinking within metacognitive therapy. As Paper 2 points out (Brandtner & Brand, 2021), desire thinking might follow as a coping response to aversive stimuli in the context of addictive behaviors. Recognizing this connection could allow clients to better detect situations in which they commonly initiate desire thinking. It could further enable them to initiate functional coping mechanisms instead. Several techniques are part of the repertoire of metacognitive therapy, such as detached mindfulness. The goal of the technique is to develop a new (detached) perspective on thought streams by learning, among other things, that (1) thoughts can be transient, unimportant processes, (2) attempts to control these thoughts can occur, and (3) it is harmless to relinquish control of these thoughts (Caselli et al., 2016). This shift in perspective on thoughts is close to the mindfulness techniques described in Chapter 4.4 (Paper 4; Brandtner et al., 2022) where one of three modes of action by the means of which craving might be good to address is "surfing the urge" (Baer, 2003; Bowen & Marlatt, 2009). This approach is based on the understanding that craving is a state or phenomenon rather than a cognitive process. This understanding allows to conceive craving as a passing event. However, this mode of action might be less appropriate for addressing desire thinking because desire thinking is less described as a transient state and thus less comparable to a wave that subsides on its own. Instead, desire thinking is a voluntary elaboration that might also need to be interrupted volitionally. Therefore, mindfulness techniques that may hold promise for desire thinking are the focusing of attention on the here and now rather than on the prefiguration of the desired activity, and the depletion of working memory capacity achieved by attentional focus on stimuli other than the desire. Systematic studies on the effectiveness of mindfulness techniques on desire thinking are still lacking to date. Only one study by Chakroun-Baggioni et al. (2017), using a correlative cross-sectional design, suggests that desire thinking appears to confound the protective effect that mindfulness might have on craving. When testing the opposite model (mindfulness as a mediating variable in the relationship between desire thinking and craving), it was noticed that the effects of desire thinking on craving remained significant. This finding may confirm the assumption made above that the mere acceptance and assumption that desire thinking may pass ("surfing the urge") may not be sufficient to reduce it. The other two modes of action through which mindfulness techniques might influence desire thinking (i.e., attentional focus on the here and now, depletion of working memory resources) remain promising and require future experimental attention. Consistent with the idea of limited working memory capacity (Baddeley, 2003; Baddeley & Hitch, 1974), approaches that intend

to modify mental imagery might also show efficacy for desire thinking. Because of the dominant imaginative component of desire thinking, the possibility exists to disrupt the imaginal prefiguration and thereby prevent the elaboration of further desire thoughts and the emergence of craving. The theoretical basis for respective techniques is provided by the working memory model (Baddeley, 2000; Baddeley & Hitch, 1974) which assumes a limited capacity of the visual sketchpad as a subcomponent of working memory. Accordingly, several processes which draw on the resources of this component (e.g., visual imagination and simultaneous eye movements), should reduce its performance (Idzikowski et al., 1983). The assumption of sensory (and especially visual) reprocessing as a part of craving is not limited to the EIT, but can also be found in other theories of desire (e.g., Hofmann & Van Dillen, 2012; Kavanagh et al., 2005; Papies & Barsalou, 2015). It is therefore conceivable that a cognitive load on working memory and especially its visual processing component (i.e., via the disruption of desire thinking) should consequently lead to decreased craving responses. This effect already emerged in the context of alcohol (Kaag et al., 2018), food (McClelland et al., 2006), and nicotine use (Littel et al., 2016), among others. That disruption of mental imagery affects craving experience in the context of behavioral addictions was shown in the context of pathological gambling (Cornil et al., 2021) and problematic gaming (Brandtner, Pekal, et al., 2020). Although the authors interpret the results as a proof-of-concept finding for an imagery component of craving, they also point to the relevance of imaginative elaborations in the area of problematic behaviors and thus to a possible clinical and therapeutic relevance of addressing desire thinking in this context.

5.2.2 Measuring desire thinking

In addition to its initial English version (Caselli & Spada, 2011) the DTQ has already been translated into French (Chakroun-Baggioni et al., 2017), Dutch (Markus et al., 2018), Hebrew (Efrati et al., 2020), Persian (Karami et al., 2020; Khosravani et al., 2022), Norwegian (Solem et al., 2020), German (Paper 2: Brandtner & Brand, 2021), Polish (Dragan & Grajewski, 2021), and Turkish (Aydın et al., 2022). This means that the studies devoted to psychometric testing of the questionnaire account for about a quarter of the total number of publications on desire thinking (as of July 2022). First, this high publication density highlights the increasing interest of desire thinking in this research context. The use of validated measurement instruments in answering research questions is an essential preparation for meaningful and credible results, and the multiple translations of the DTQ thus promise a good research basis for future projects. Second, the number of validation studies also illustrates the construct's relevance in a clinical context. Some studies indicate that desire thinking is associated with symptom severity of

various addiction problems (e.g., Caselli, Ferla, et al., 2012; Fernie et al., 2014; Marino et al., 2019; Solem et al., 2020) and that it is more prominent in people with alcohol problems than in people who drink for social reasons (Caselli et al., 2020). That is, the DTQ also appears to be an instrument whose scoring rises and falls with high and low addictive tendencies and desire thinking could thus be an underlying mechanism of addiction. However, what cannot yet be mapped by means of the existing DTQ, but certainly is a useful extension of test batteries of various research questions, are situational fluctuations of desire thinking. So far, the 10 items measure a stable ability to imagine activities pictorially and to be verbally engaged with them - and so do the writings of the Cumulus summarized here. Items like "I start to imagine the desired activity every time it comes to my mind" rather measure a general tendency to produce desire thoughts and thus a trait variable. For research that aims to investigate the immediate effects of experimentally manipulated conditions on the occurrence of desire thoughts, or that wants to conduct manipulation checks of desire thinking in the experimental setting other than, for example, with pre- and post-experimental craving measures, it is currently not possible to measure desire thinking as a state variable using a validated measurement instrument. Alternatively, visual analog scales that capture both vividness and emotional charge of imaginings are often used here (e.g., Brandtner, Pekal, et al., 2020; Engelhard et al., 2011). However, precisely because the (experimental) manipulation of desire thinking is directly associated with increasing craving (Caselli et al., 2017; Caselli et al., 2013), increasing psychological distress (Caselli et al., 2017), and increasing permissive beliefs (Caselli et al., 2020), it is important to be able to measure the situational extent.

Another limitation of the DTQ is the selected unipolar response scale, which with four Likert levels from (1) almost never to (4) almost always represents a constantly increasing frequency, starting from a zero point (Caselli & Spada, 2011). With the decision for this Likert gradation, no middle category exists, although it is a frequency query of experiential states and thus it would be quite conceivable that subjects also experience the described mental experiences half of the time, that is, "sometimes". Thus, the questionnaire does not necessarily fully exploit the construct's range of variation of interest. Instead, with this type of response range, people completing the questionnaire could be forced to choose a non-applicable response and thus over- or underestimate the occurrence of desire thoughts, which could also make the exploration of desire thinking and its interrelationships with other constructs subject to systematic measurement error and compromise the validity of the measurement instrument.

5.3 Summary and conclusion

The writings of this Cumulus confirm model assumptions about desire thinking from the EIT (Kavanagh et al., 2005) and the S-REF model (Spada, Caselli, Nikčević, et al., 2015; Spada et al., 2013) in the context of potentially addictive behaviors, thus highlighting the relevance of the process in this context. The studies suggest that desire thinking is possibly initiated as a coping mechanism to reduce negative emotional states (Paper 2; Brandtner & Brand, 2021). Thus, it is conceivable that the experience of stress motivates one to reduce this aversive state by initiating and elaborating thoughts of a pleasurable activity (e.g., using social networks, playing computer games, etc.). This is not problematic per se and may indeed distract from unpleasant experiential states. However, the writings of the Cumulus also show that the cognitive elaboration of an activity may lead to craving (Paper 2; Brandtner & Brand, 2021) and to decisions to play computer games despite relevant alternative options (Paper 1; Brandtner, Wegmann, et al., 2020). In both cases, the attempt to regulate negative affect states can become a maladaptive coping mechanism that could promote the development or maintenance of addictive tendencies. Accordingly, the empirical studies of this Cumulus suggest that desire thinking seems to be a relevant process in the context of addictive behavioral problems, but that it is not yet based on a holistic theoretical model understanding in this area. Considerations of interrelationships with other constructs could previously be taken from the EIT or the S-REF, which share fundamentally similar assumptions about desire thinking, but go into different detail about other constructs involved. With the theoretical work of the Cumulus (Paper 3; Brandtner et al., 2021) a position for desire thinking in the behavioral addiction context was proposed, summarizing the connections between already established addiction-associated mechanisms and desire thinking to provide a theoretical foundation for future research in this area. Beyond the writings of the Cumulus, this thesis critically reflected on the proximity of desire thinking and related constructs. The reflection shows that desire thinking might be theoretically understood as an independent process, that is closely intertwined with other relevant processes (e.g., craving, permissive beliefs). Hence, desire thinking requires a definitional breakdown regarding its similarity and interaction with similar mechanisms. This breakdown has been addressed in initial approaches in this work. Most importantly, the proposal is made to conceptualize craving as a motivational state or phenomenon, whereas desire thinking may be conceptualized as a volitional process or mechanism that contributes to and may accompany the emergence of craving, yet represents a separate entity. Accordingly, desire thinking may be a tangible process for clients, as it functions consciously and thus offers a good starting point for (therapeutic) modifications. Mindfulness techniques are candidate interventions that can probably generalize the positive effects they have on craving (Paper 4;

Brandtner et al., 2022) to desire thinking, although the effects that mindfulness techniques have on desire thinking and craving might be mediated via different mechanisms of action (e.g., acceptance of craving versus shifting attention to the here and now). Mindfulness training for desire thinking should therefore focus less on acceptance of a condition; instead, it should promote the volitional shift of attention to addiction-independent stimuli and the modification of metacognitive beliefs about desire thinking.

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Appendix

In the following, find attached Paper 1, 2, 3 and 4 of this Cumulus as published by the respective scientific journals.

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Desire thinking promotes decisions to game: The mediating role between gaming urges and everyday decision-making in recreational gamers

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ABSTRACT

Introduction: Desire thinking is a voluntary cognitive process that involves the imaginal forecast of a desired activity and the verbal perseveration with plans and good reasons for engaging in it. Considering theoretical models arguing that specific decision-making processes may be involved in the development of gaming disorder, we hypothesized that an initial urge to game might be accelerated by desire thinking, leading to the decision to game in an everyday setting although the gaming behavior may conflict with another activity or certain other goals.

Methods: A pre-study helped developing a catalogue of situations that provides forced-choice scenarios warranting a decision for or against gaming. To explore the postulated sequence of cognitive and affective events, a serial mediation model with urge to game as predictor, decision to game as dependent variable, and imaginal prefiguration and verbal perseveration as mediators was tested in a sample of 118 recreational gamers with varying degrees of gaming intensity.

Results: The pre-study revealed a catalogue of 18 conflicting situations that likely happen in the daily life of gamers, containing conflicting activities such as job/educational performance and meeting friends/family/acquaintances. In the sequential mediation model, the desire thinking facets imaginal prefiguration and verbal perseveration fully mediated the relation between an initial urge and the decision to game.

Conclusions: The mediation model emphasizes the serial ordinance of desire thinking facets and their role in motivating decisions to game after an initial urge has been experienced. Results may indicate that desire thinking plays a considerable role in problematic gaming tendencies.

1. Introduction

Videogames are developed to serve a variety of needs of their users, such as the need to escape from or discover another fantastic reality, to relax after a long day, to socialize online or improve one's own handling of the game mechanics (Demetrovics et al., 2011). Some games are equipped with strong rewarding and immersive features in order to ensure that gamers keep on playing, which shapes the potentially addictive nature of videogames. The one-year prevalence of gaming disorder as a disorder due to addictive behaviors (World-Health-Organization, 2018) is estimated to approximate 3.5% among German adolescents (Wartberg, Kriston, & Thomasius, 2020), indicating that a substantial part of gamers experiences a considerable level of problems related to their gaming behaviors. Besides the motivational aspects and structural characteristics of a game, the psychological characteristics essentially determine if a gamer actually develops addictive behaviors (Király, Griffiths, & Demetrovics, 2015). Accordingly,

what keeps research busy since the first reports of exceptional gaming behaviors in the early 1980s (e.g., Ross, Finestone, & Lavin, 1982; Soper & Miller, 1983) is the question which psychological processes are involved in the development and maintenance of problematic gaming.

Considering the willpower that is necessary in order to resist temptations in our everyday life, the process of decision-making has been put into spotlight in addiction research (Bechara, 2003, 2005). Regarding the cognitive mechanisms underlying decisions, dual-process and tripartite models of addictions assume that an interaction of reward anticipation and top-down control mechanisms becomes progressively imbalanced (Bechara, 2005; Everitt & Robbins, 2005, 2016). Consequently, behaviors can change from being initially impulsive to more habitual behaviors, mainly driven by a sensitization of the reward system (Berridge & Robinson, 2016; Robinson & Berridge, 2008). Decision-making processes are considered relevant across a range of addictive behaviors (Brevers & Noël, 2013) including problematic gaming (Dong, Li, Wang, & Potenza, 2017) and are integrated

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into prevailing neurocognitive models describing the development and persistence of gaming disorder (e.g., Brand et al., 2019; Dong & Potenza, 2014; Wei, Zhang, Turel, Bechara, & He, 2017). One of these models is the I-PACE model (Brand, Wegmann, et al., 2019; Brand, Young, Laier, Wöfling, & Potenza, 2016) which emphasizes the role of a variety of cognitive and affective processes that may directly or interactively influence repeated decisions to game despite the occurrence of negative consequences in the long run. More specifically, the updated version of the I-PACE model (Brand, Wegmann, et al., 2019) differentiates between early and later stages in the development and maintenance of addictive behaviors. Accordingly, a mild urge to game might initially be experienced in the early stages which leads to intentional decisions to game (Brand, Wegmann, et al., 2019). Throughout the later stages, reinforcing learning mechanisms and neural sensitization (Berridge & Robinson, 2016; Robinson & Berridge, 1993) might cause reductions in inhibitory control and executive functions (Argyriou, Davison, & Lee, 2017; Weinstein, 2017), an attentional bias towards gaming-associated cues (Jeromin, Nyenhuis, & Barke, 2016; Zhou, Yuan, & Yao, 2012), enhanced reward sensitivity (Dong, DeVito, Huang, & Du, 2012; Liu et al., 2017; Lorenz et al., 2013), and the occurrence of cravings to game (Dong et al., 2020; Ko et al., 2013). An interplay of these mechanisms is thought to progressively reduce willpower to resist playing videogames and cause more seemingly habitual and dysfunctional gaming patterns (Brand, Rumpf, et al., 2019; Brand, Wegmann, et al., 2019). Thus, whereas researching the later stages is important to understand maintaining forces of addictive behaviors, depicting cognitive processes that lead to initial decisions to game in the early stages are just as relevant for explaining the development of problematic gaming.

A voluntary cognitive process which is thought to foster the enactment of a desired activity is desire thinking (Caselli & Spada, 2011, 2015; Kavanagh, May, & Andrade, 2009). Deriving from the Elaborated Intrusion (EI) theory of desire (Kavanagh, Andrade, & May, 2005; Kavanagh et al., 2009; May, Andrade, Panabokke, & Kavanagh, 2004), desire thinking is the conscious cognitive elaboration of spontaneous and automatic associations that contain information and memories about a desired object or activity, and which have intruded into awareness. Desire thinking is thought to be a multi-dimensional concept including a first imaginal prefiguration of a desired activity which leads to a verbal perseveration with desire-related content (Caselli & Spada, 2011, 2015). An imaginal elaboration of positive target-related associations is characterized by the prefiguration of multi-sensory images or recall of memories that form around the desired target (Kavanagh et al., 2009). Future forecasts may involve scenarios where an individual sees itself engaging in the desired activity and imagines how good this could possibly feel, which may possibly be present in recreational gamers (Brandtner, Pekal, & Brand, 2020). The elaboration of the desired target at a verbal level is characterized by repetitive self-talk that involves content including the evaluation of good reasons to engage in the desired activity and planning how to do so (Caselli & Spada, 2015). On a conceptual level, desire thinking is assumed to be closely related to craving (Green, Rogers, & Elliman, 2000; Tiffany & Drobles, 1990), yet distinct from it as craving is more likely considered a motivational and/or emotional state (Cox & Klinger, 2002; Tiffany & Wray, 2009). However, being a super-ordinate cognitive process it is assumed to be operating during craving

episodes (Caselli & Spada, 2015). Moreover, the persistence and escalation of craving seems to be dependent on the strength of desire thoughts that are activated during the craving experience (Green, Rogers, & Elliman, 2000; Kavanagh, May, & Andrade, 2009; Tiffany & Drobles, 1990). Desire thinking therefore determines the prolongation and increase of craving until a relieve from a sense of deficit or an increasing urge may only be achieved by engaging in the desired activity (Caselli & Spada, 2011, 2015). To date, research has addressed the role of desire thinking in the inducement of craving (Allen, Kannis-Dyand, & Katsikitis, 2017; Caselli, Manfredi, Ferraris, Vinciullo, & Spada, 2015; Caselli, Soliani, & Spada, 2013; Chakroun-Baggioni, Corman, Spada, Caselli, & Gierski, 2017) and in predicting the extent of symptom severity of the addictive or problematic behaviors (Ferne et al., 2014; Marino et al., 2019; Martino et al., 2017; Spada, Langston, Nikčević, & Moneta, 2008). More specifically and in the context of addictive behaviors, desire thinking has been investigated as a predictor of pathologic gambling (Ferne et al., 2014), problematic Internet use (Spada, Caselli, Slaifer, Nikčević, & Sassaroli, 2013), problematic Facebook use (Marino et al., 2019), and problematic pornography use (Allen et al., 2017). For a recent review on desire thinking across addictive behaviors, see Mansueto et al. (2019).

According to the theoretical considerations in the I-PACE model (Brand, Wegmann, et al., 2019), an initial urge to game can approach a level of strength that leads to the actual decision to play. This process is not considered isolated, but in interaction with reinforcing mechanisms one of which is thought to be desire thinking. Integrating it into the I-PACE model and considering the early stages of the addiction process, desire thinking might also determine the prolongation of an initial urge to play that has intruded into awareness in the same way that it leads to the escalation of craving (Caselli & Spada, 2015). An imaginal prefiguration of gaming and a verbal preoccupation with good reasons for gaming and planning how to do so might accelerate this initial urge until it is strong enough to cause the actual decision to game. Researching this chain of affective and cognitive events contributes to understanding which processes are involved in decisions to game. Moreover, with respect to the dimensional nature of urges and desire thinking, and although researched in a sample of recreational gamers, the results may give indication if and how desire thinking is possibly involved in the development of problematic gaming behavior. However, and to our best knowledge, the expediting effects of desire thinking in the sense that it promotes the actual decision to play has not been investigated. The main study (Study 2) therefore aims at evaluating a hypothesized serial mediation model where desire thinking in its two sub-components imaginal prefiguration and verbal perseveration is investigated as a mediator between an initial urge to game and the actual decision to play (see Fig. 1). Decision-making is a theoretical consideration throughout prevailing models that describe the development and persistence of disordered gaming behavior (e.g., Brand et al., 2019; Dong & Potenza, 2014; Wei, Zhang, Turel, Bechara, & He, 2017). However, actual decisions to game in the context that they are made, namely in the daily life of gamers, have not been researched so far although this kind of assessment would provide a high degree of external validity. Therefore, a pre-study (Study 1) aims at exploring how conflicting decisional situations look like in the daily life of gamers. On the basis of the pre-study, a catalogue of conflicting

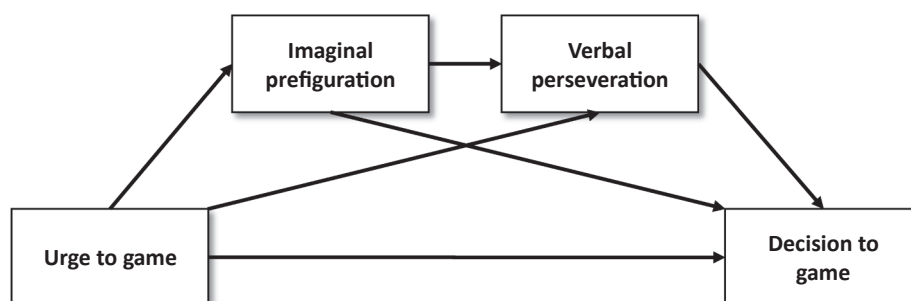


Fig. 1. Theoretically hypothesized sequential mediation model of the mediating effect of desire thinking between urge and decisions to game in everyday life.

situations was developed and used to measure everyday-life decisions for or against gaming. This measure was used in the sequential mediation model and was further put in relation with the symptom severity of the recreational gamers in this sample in order to test for the theoretical consideration that more decisions for gaming might be associated with the experience of more negative consequences due to gaming.

2. Study 1

The first part is a focus group that was conducted to explore conflicting situations in daily life, wherein gamers have or want to decide whether to game or not. The aim here was to detect activities that are most commonly in conflict with gaming. Ethical proposals were made distinctively for the focus group and the online survey. Both gained a positive vote of the local ethics committee of the University Duisburg-Essen, Germany.

2.1. Method

2.1.1. Participants

A focus group with $N = 6$ gamers (3 female) that met the inclusion criterion of a weekly playtime of at least 14 h was conducted at University Duisburg-Essen. The mean age of participants was 28.17 ($SD = 6.01$), ranging from 18 to 34, who played averagely 29.17 h per week ($SD = 13.2$). Among the played genres were massively multiplayer online role-playing games, first person shooter, multiplayer online battle arenas, other action and adventure games, real-time tactics, and side-scroller.

2.1.2. Procedure

The discussion consisted of four phases, (1) an introduction to the topic, (2) a single work, (3) a subgroup work and (4) a re-assembly of the whole group with a final discussion. During the single work, participants were asked to think of situations that force them to decide whether they now start or quit gaming, or do another activity that is experienced as conflicting. They were instructed to write down as many situations as they could think of on flashcards, and to make detailed descriptions of the conflicting situations. They wrote down the exact same scenario twice on two different flashcards whereupon the group was divided into two subgroups of three individuals each. Each subgroup now worked with a similar set of the flashcards and was instructed to sort the scenarios by frequency of occurrence in daily life. In the re-assembly phase, the whole group was asked to reflect on all situations they had created and to consider, if there were any common situations missing. Each participant was then asked to indicate with stickers the three most frequently occurring situations.

Table 1

Exemplary scenarios representing a decisional conflict between gaming and another activity with percentage values of their occurrence.

Examples of the Conflicting Situations Catalogue for Gaming (CSC-G)	(0)	(1)	(2)	(3)	(4)
Your friends ask if you would like to meet up with them. The activity they propose sounds fun. You think for a moment – actually you wanted to play right now. What do you do?	9.3%	25.4%	44.1%	16.1%	5.1%
The laundry heap in your room that has accumulated needs to be done. To make sure that the laundry is dry again in time so that you have fresh clothes, you have to finish your game now. However, you would like to continue playing. What do you do?	11%	24.6%	36.4%	17.8%	10.2%
It is already late and tomorrow is a usual day at work/training/university with nothing special scheduled. You should turn off your computer soon in order to be well rested. However, you would like to continue playing right now. What do you do?	5.9%	19.5%	33.1%	25.4%	16.1%
You come home and realize that you should tidy up. It will take some time to bring order into the most important things in your apartment. Actually, you would rather like to play right now. What do you do?	2.5%	15.3%	39%	31.4%	11.9%
You come home in the evening after a long day and could take a shower, shave and cut your nails. You know you won't get around to that today if you don't do it now. However, you would rather like to play right now. What do you do?	17.8%	22%	28%	19.5%	12.7%
In order to be better prepared for next week, you want to sort some important documents. You only have time for this today and need to quit your game in order to get it done. But you would actually like to continue playing right now. What do you do?	10.2%	30.5%	32.2%	16.9%	10.2%

Note. $N = 118$; (0) = never, (1) = seldom, (2) = sometimes, (3) = often, (4) = very often; percentage values are calculated on the basis of Study 2; see Appendix for English and German versions of all 18 scenarios.

2.1.3. Results

Resulting from the second phase, participants produced a total number of 17 scenarios that oppose the option to game with another activity. With some situations being redundant, this phase resulted in conflicting activities that were thematically classified in (1) academic/job performance (e.g., meeting a deadline, learning for an exam), (2) meeting friends/family/acquaintances (e.g., a party, spontaneous invitation), (3) self-care (e.g., eating, sleeping, body hygiene), (4) housekeeping (e.g., laundry, cleaning), (5) other hobbies (e.g., sport). Situations that were rated to happen most frequently in both subgroups during the third phase were conflicts between gaming and academic/job performance. Activities conflicting with gaming that were rated to occur most frequently in the last re-assembly phase with stickers were sleeping (5 points), housekeeping (3 points), academic/job performance (3 points), meeting friends offline (3 points), and preparing a meal (2 points). The other scenarios gained one or zero points.

2.1.4. Development of the conflicting situations catalogue for gaming

On the basis of the first evaluation of conflicting activities and focus group discussions, an initial pool of 36 hypothetically conflicting situations that likely occur in the daily lives of gamers was created on the basis of consideration. For the purpose of comparability, each scenario follows a three-sentence structure (cf., Singer, Kreuzpointner, Sommer, Wüst, & Kudielka, 2019) and contains two forced-choice options (gaming vs. conflicting activity). It was made sure that frequently occurring conflicting activities are represented by several scenarios in the catalogue. Moreover, the number of situations wherein a decision against gaming meant to quit or to not start gaming was systematically varied. For exemplary scenarios, see Table 1.

3. Study 2

The second part of the study was a mere online-survey. It comprised self-report questionnaires as well as the catalogue of 36 conflicting situations that was previously developed on the basis of the focus group.

3.1. Method

3.1.1. Participants

A total number of $N = 118$ gamers (53 female) who indicated to play videogames at least 7 h per week fulfilled the requirements of a minimum age of 18 years. Participants averagely played 3.2 h ($SD = 1.9$) on weekdays and 4.0 h ($SD = 2.8$) during days on the weekend, resulting in a mean of 21.4 h ($SD = 14.6$) per week. The mean age for this German sample was 34.1 years ($SD = 9.7$), ranging from 18 to 56.

3.1.2. Self-report measures

3.1.2.1. *Urge to game.* The urge to game was measured using a Visual Analogue Scale (VAS) asking for the experience of a momentary state of urge to play videogames (“How strong is your urge to play videogames right now?”). Anchors ranged from 0 = *not strong at all* to 100 = *very strong*.

3.1.2.2. *Desire thinking.* The Desire Thinking Questionnaire (DTQ; Caselli & Spada, 2011) is a 10-item self-report measure to assess levels of trait desire thinking modified for online gaming (e.g., “I mentally repeat to myself that I need to play videogames.”). The measure includes two sub-scales of 5 items each. The first subscale depicts the tendency to envisage imagery of gaming-related content (imaginal prefiguration; DTQimaginal). The second subscale refers to the perseveration of verbal thoughts about gaming-related content and experiences (verbal perseveration; DTQverbal). Items are rated on a 4-point Likert Scale ranging from 1 = *almost never* to 4 = *almost always*. Due to the lack of a validated German version, the DTQ was translated and re-translated twice by four independent researchers of the department who were blind to the respective previous versions. In this sample, the DTQ showed good internal consistency (Cronbach’s alpha in the current sample = 0.94).

3.1.2.3. *Conflicting situations catalogue for gaming.* The initial Conflicting Situations Catalogue for Gaming (CSC-G) consisting of 36 situations was presented to the participants within the online survey in a randomized order. They were instructed to read the scenario and to decide (in a forced-choice format with 1 = *gaming*, 0 = *conflicting activity*) how they would usually decide in this situation (CSC-G decision). If they never experienced such a conflicting situation, they were instructed to imagine how they would most likely decide. Afterwards, participants rated on 5-point Likert scales for each scenario how frequently they experienced this or a similar situation in general (CSC-G frequency), ranging from 1 = *never* to 5 = *very often*; and how much they had thought about their decision as an indicator of gamers’ ability to reflect their decisions (CSC-G reflection), ranging from 1 = *thought only little* to 5 = *thought a lot*. The initial pool of 36 items was reduced before the mediation analyses according to criteria described in Section 3.2.1.

3.1.2.4. *Symptom severity.* The tendency for problematic gaming was measured with the Internet Gaming Disorder Test (IGDT-10; Király et al., 2017) to provide a better sample description. This self-report measurement is constructed on the basis of the DSM-5 criteria of gaming disorder (American-Psychiatric-Association, 2013). According to the authors, the IGDT-10 can be used to assess both online and offline gaming by easily adapting the instruction. In this study, the term video gaming was used to take account of both online and offline gaming and was therefore inserted into the instruction of the IGDT-10. Each DSM-5 criterion is operationalized by one item, except for one criterion (i.e., “jeopardy or losing a significant relationship, job, or educational or career opportunity because of participation in videogames”), which is

represented by two items due to its complexity. Each item is rated on a 3-point Likert Scale (0 = never, 1 = sometimes, 2 = often), resulting in sum scores ranging from 0 to 20. So far, there is no German validation of the IGDT-10 (Király et al., 2019) wherefore the questionnaire was translated and re-translated by four independent members of the research department. In this sample, the IGDT-10 showed good internal consistency (Cronbach’s alpha = 0.84).

3.1.2.5. *Statistical analyses.* In a first selection procedure, we identified conflicting situations out of the pool of 36 items that were representative according to specific criteria explained in Section 3.2.1. Afterwards, in order to test if desire thinking promotes the effect of an initial urge to game on the actual decision to do so, a sequential mediation analysis was conducted using MPlus 8. (Muthén & Muthén, 2011). Urge to game was entered as independent variable, the decisions to game, operationalized by the sum score of the variable CSC-G decision (see Sections 3.1.2.3 and 3.2.1) as dependent variable, and the subfacets of desire thinking (imaginal prefiguration and verbal perseveration) were sequentially entered as mediators. As a requirement for mediation analyses (Baron & Kenny, 1986), the independent, mediator, and dependent variables are intercorrelated (see Table 2). Indirect effects were assessed without bootstrapping. Further, age and gender were entered as covariates in order to control for their influence on each variable.

3.2. Results

3.2.1. The conflicting situations catalogue for gaming for further analyses

To identify situations that regularly happen to gamers and in order to gain representative items we used the basis of three criteria: (1) A preferable combination of incidence ratings. On the basis of this criterion, 14 items were rejected, ensuring that 50% of participants experienced a situation at least sometimes. (2) A criterion of preferable item-difficulties led to the exclusion of two further items due to a relatively high percentage of decisions to game (> 0.7) which might be an indication that situations were not experienced as conflicting. (3) Two items were discarded due to a poor discriminatory power (< 0.3), indicating that these items were not prototypical enough for this catalogue. Consequently, 18 scenarios were used for further analyses (for all 18 scenarios, see Appendix). With decisions for gaming being coded with 1, and decisions in favor of the conflicting activity being coded with 0, a higher sum score in the CSC-G (ranging from 0 to 18) depicts a greater tendency to choose the gaming option instead of the conflicting activity. For CSC-G frequency and CSC-G reflection, mean scores were calculated. The CSC-G decision showed good internal consistency in this sample (Cronbach’s alpha = 0.83).

3.2.2. Descriptive statistics and data configuration

In this sample, 6.8% of the participants indicated 5 or more symptoms, 35.6% indicated one to 4 symptoms, and 57.6% reported to not experience a single symptom according to the IGDT-10 (Király et al., 2017). Descriptive

Table 2
Mean, standard deviation, ranges, and two-tailed Pearson correlations of study variables.

	M	SD	Range	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Age	34.1	9.7	18–56	1	–0.26**	–0.23*	–0.21*	–0.17	–0.24**	0.17	–0.32**
(2) Urge to game	60.7	26.2	0–100		1	0.50**	0.46**	0.36**	0.38**	0.09	0.39**
(3) DTQimaginal	10.6	3.9	5–20			1	0.82**	0.45**	0.57**	0.35**	0.68**
(4) DTQverbal	9.8	4.0	5–20				1	0.51**	0.61**	0.49**	0.74**
(5) CSC-G decision	7.2	4.2	0–18					1	0.52**	0.34**	0.53**
(6) CSC-G frequency	2.9	0.8	1–4.6						1	0.54**	0.56**
(7) CSC-G reflection	2.4	0.8	1–4.3							1	0.38**
(8) IGDT-10	5.6	4.2	0–17								1

Note. *p < .05, **p < .01; DTQimaginal = subscale imaginal prefiguration of the Desire Thinking Questionnaire (DTQ), sum score; DTQverbal = subscale verbal perseveration of the DTQ (Caselli & Spada, 2011), sum score; CSC-G decision = number of decisions that were made in favor of gaming in the Conflicting Situations Catalogue for Gaming, sum score; CSC-G frequency = rating of how often these situations happen, mean score; CSC-G reflection = rating of how much was thought about the decisions, mean score; IGDT-10 = Ten-Item Internet Gaming Disorder Test, sum score (Király et al., 2017).

statistics for the variables of interest in this study are presented in Table 2. In preliminary correlation analyses, increasing age in this sample was associated with lower incidence ratings of conflicting situations (see Table 2). Due to a possible confounding effect, age and gender were considered covariates in the mediation analysis in the main study. The presence of multivariate outliers was tested by comparing the distance of Mahalanobis against a chi-square distribution with the same degrees of freedom which did not reveal outliers in the sample. The Tolerance Index (T_i) and the Variance Inflation Factor (VIF) were calculated to examine multicollinearity of independent variables. A value over 0.02 for T_i and a value under 5.0 for VIF are considered reliable indicators for the absence of multicollinearity between independent variables and covariates. This assumption could be verified for gender ($T_i = 0.94$; VIF = 1.07), age ($T_i = 0.92$; VIF = 1.09), urge to game ($T_i = 0.68$; VIF = 1.43), DTQimaginal ($T_i = 0.30$; VIF = 3.35), and DTQverbal ($T_i = 0.31$; VIF = 3.16). An inspection of skewness coefficients indicated rather symmetrical distributions. Lastly, skewness (0.22), kurtosis (0.28), and a Kolmogorov-Smirnov test ($D(118) = 0.06$, $p > .05$) indicated that residuals met the requirement of normality. Additionally, a scatterplot of standardized residuals against predicted values did not reveal heteroscedasticity. The Durbin Watson statistic was 2.16, indicating the absence of autocorrelation in residuals.

3.2.3. Sequential mediation analysis

The mediation analysis confirmed that imaginal prefiguration and verbal perseveration mediated the effect of urge to game on decisions to game in the CSC-G (see Fig. 2). The final equation model accounted for 28.3% of variance ($p < .001$). The only significant indirect path between urge and decisions to game is via imaginal prefiguration and verbal perseveration ($\beta = 0.16$, $SE = 0.06$, $p = .007$), whereas the indirect pathways urge, imaginal prefiguration, decisions to game ($\beta = 0.01$, $SE = 0.07$, $p = .938$) and urge, verbal perseveration, decisions to game ($\beta = 0.02$, $SE = 0.03$, $p = .567$) are not significant. The direct effect of urge to game on everyday decision-making was not significant ($\beta = 0.17$, $SE = 0.09$, $p = .070$). The covariates age and gender did neither show significant effects on decisions to game (age: $\beta = -0.40$, $p = .623$; gender: $\beta = 0.04$, $p = .589$), nor on imaginal prefiguration (age: $\beta = -0.11$, $p = .167$; gender: $\beta = 0.01$, $p = .870$), nor on verbal perseveration (age: $\beta = -0.02$, $p = .763$; gender: $\beta = -0.06$, $p = .303$).

4. Discussion

This bipartite study, consisting of a pre- and a main study, aimed at exploring if desire thinking functions as an accelerating cognitive process in the sense that it mediates the relationship between an initial urge to play videogames and the actual decision to do so in the daily life of recreational gamers. With the help of a focus group, a qualitative pre-study revealed a new assessment tool, the Conflicting Situations Catalogue for Gaming (CSC-G), that is able to measure the tendency to decide in favor of gaming although this conflicts with another activity by providing fictive conflicting situations with bivariate forced-choice options. The CSC-G depicts the realistic nature of gaming-specific conflicting situations close to everyday life and more specifically, which

activities exactly are experienced as being in conflict with gaming.

The focus in the main study of this project was to identify a sequence of affective and cognitive incidents that may contribute to the decision to game in daily life, although a conflicting activity needs or is willed to be done. Results in form of a sequential mediation model tested in this study support the important role of desire thinking as a mediator between an initial urge and deciding to play videogames. Here, the only significant path through this series of affective and cognitive events was the indirect path via imaginal prefiguration and verbal perseveration on decisions to game (see Fig. 2). This finding emphasizes the serial ordinance of desire thinking facets. In accordance with the EI theory (Kavanagh et al., 2005; May et al., 2004), an initial gaming-related association seems to be primarily elaborated by mentally foreseeing and pre-sensing an actual gaming scenario. Not until then, repetitive self-talk including the verbal evaluation of how urgently one wants to engage in gaming with a focus on decision-making (Caselli & Spada, 2016) might lead to the actual decision to do so in daily settings. In the sense that it is not possible to crave less by thinking more about it (Caselli & Spada, 2015), these results support the role of desire thinking being a cognitive response that may become dysfunctional if oriented towards temptations that are being tried to resist (i.e., gaming). Interestingly, the mere imaginal prefiguration of a gaming scenario is not a significant predictor of decisions to game in the sequential mediation model. This is remarkable as research constantly underpins the important property of mental imagery to motivate behavior (e.g., Renner, Murphy, Ji, Manly, & Holmes, 2019). Accordingly, the motivating power of mental imagery is often discussed as due to its capacity to simulate obtaining gratification (Andrade, May, & Kavanagh, 2012). This finding could, however, contribute to this association insofar as the imagination of a gaming situation and the planning to get involved in it seem to be conceptually different processes that take place sequentially. Markedly, desire thinking as a faculty is not per se a clinically relevant issue since it may motivate effort in order to achieve goals and enables to adequately plan behavior by foreseeing its consequences (Caselli & Spada, 2015). However, it can become dysfunctional when the target of desire conflicts with other goals (e.g., quit gaming in order to get work done). Accordingly, the dysfunctional character of desire thinking may be closely related to decision-making processes that are thought to be involved in addictive gaming behaviors (e.g., Brand et al., 2019; Dong & Potenza, 2014; Wei, Zhang, Turel, Bechara, & He, 2017). As a voluntary cognitive process, desire thinking is assumed to contain information about planning how to engage in a desired activity (i.e., gaming; Caselli & Spada, 2015). Hence, the results of this study let assume that in the early stages of developing addictive behavior, finding seemingly good reasons to game may lead to conscious decisions to game in daily life. With this decision-making process being repeated and gratification being experienced through gaming, resulting neural sensitization and aggravated top-down controlling (Berridge & Robinson, 2016; Goldstein & Volkow, 2011; Robinson & Berridge, 1993), that are argued to be transferable to addictive gaming behaviors (Brand, Rumpf, et al., 2019), are thought to facilitate the entry into states of craving. This is supported by several findings in the field of desire thinking that have shown a direct influence on craving (e.g., Caselli & Spada, 2015). With the assumption that addiction-related cognitions become increasingly reflexive and automatic in the

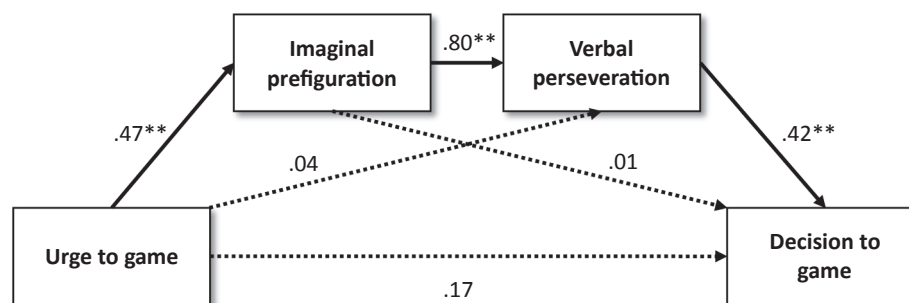


Fig. 2. Conceptual sequential mediation model of the mediating effect of desire thinking between desire/craving and decisions to game in everyday life; effect estimates are standardized coefficients; * $p < .05$, ** $p < .01$; $N = 118$.

maintenance of addictive gaming behaviors (Brand, Rumpf, et al., 2019), the question for further research remains whether or not also the voluntary process of desire thinking becomes less conscious, or whether it becomes more easily accessible or triggered, respectively. Nevertheless, the aggregation of previous findings and results of this study demonstrate the necessity to consider desire thinking when exploring neurocognitive mechanisms in gamers.

Notably, prior research investigated the role of desire thinking in explaining craving (e.g., Caselli, Manfredi, Ferraris, Vinciullo, & Spada, 2015; Caselli, Soliani, & Spada, 2013; Chakroun-Baggioni, Corman, Spada, Caselli, & Gierski, 2017), symptom severity, and problematic behavior patterns (e.g., Caselli, Canfora, et al., 2015; Fernie et al., 2014; Marino et al., 2019; Martino et al., 2017) instead of investigating the urge to game as a predictor of desire thinking. These investigations find their origin in the metacognitive model of desire thinking (Caselli & Spada, 2015) that assumes the development and magnitude of craving experiences due to the perseveration of unregulated desire thinking. However, it is assumed that desire thinking processes might be activated during the experience of urges, desires, or cravings and determine their prolongation, wherefore a model was tested that assumed and depicted the mediating effect of desire thinking between an initial urge and the decision to game.

The decision-making task used in this study forces participants to decide for or against gaming. The decision for gaming always implies the neglect of another activity that needs or is willed to be done. Activities that were commonly reported throughout several genres subsumed job or academic performance (i.e., meeting a deadline or the necessity to learn), cultivating contacts with family and friends (i.e., joining spontaneous or planned activities), and daily obligations or housekeeping (i.e., cleaning the kitchen, doing the laundry). Not surprisingly, the conflicting activities can be found to be involved when individuals with problematic or addictive gaming behaviors report negative consequences due to gaming. That is, common negative consequences due to gaming encompassing the degeneration of academic or job performance, the loss of real-life relationships, the neglect of previously enjoyed activities, and decreased psychological well-being due to gaming (Kuss, 2013) are also mirrored in the catalogue of conflicting situations. A significant relationship between everyday gaming-related decision-making and the severity of gaming disorder symptoms in this sample of recreational gamers (see Table 2) underpins the notion, that decisions to the detriment of jobwise and social obligations are associated with the experience of negative consequences the more the behavior approximates addictive tendencies (Brand, Rumpf, King, Potenza, & Wegmann, 2020). Further, a positive correlation between symptom severity and the reflection about the decisions in the CSC-G was found. Assuming that more habitual behaviors imply less cognitive effort when making decisions, this seemingly contradicts with the theoretical approach in the I-PACE model, stating that a shift from experiencing gratification from gaming to compensating negative consequences due to gaming is determined by increasingly habitual or compulsive behavior patterns (Brand, Wegmann, et al., 2019). Possibly, this association is of methodological origin and rather mirrors the ability to reflect on mental processes and situational circumstances in this sample of recreational gamers. As the item asking for how much participants had thought about their decision requests to become aware of one's own thoughts, it has improbably measured habitual behaviors. More likely, the positive association seems interpretable as a response set of participants in this sample, mirroring that the ability to reflect on gaming-related decisions is closely related to the ability to reflect on gaming-related problems in daily life.

In the light of practical implications on the basis of these results, it might be mentionable how the discovered chain of affective and cognitive events might be interrupted in case it is aimed at preventing the decision to game. Regarding the occurrence of urges, the metaphor or surfing one's urges exists in the context of mindfulness approaches that educate in perceiving and accepting the peak and descend of urges and cravings (Baer, 2003; Tapper, 2018). This aligns with the notion of Caselli and Spada (2015) who deduce from their findings that desires are not the problem themselves, but that the way of thinking about them is relevant. Hence, strengthening mindfulness and self-regulatory faculties could be beneficial for becoming more aware of

urges in order to deal with them (Caselli & Spada, 2015; Chakroun-Baggioni et al., 2017). Additionally, as desire thinking shares facets with other extended perseverative thinking styles such as ruminating and worry (Caselli & Spada, 2016), techniques that directly address the modification of perseverative thinking such as training to refocus situational attention and detached mindfulness (Caselli & Spada, 2015) might be profitable in terms of metacognitive techniques to address extended thinking. Moreover, the efficacy of Metacognitive Therapy (Wells, 2009) addressing these thinking styles has proven to be successful among patients with alcohol-use disorder (Caselli, Martino, Spada, & Wells, 2018), paving the way for a closer investigation of corresponding techniques also in the field of behavioral addictions. Regarding the component of decision-making, the fact whether or not gamers show impairments in the behavioral inhibition of impulses is controversially discussed due to diverging results regarding beneficial training effects of some genres (Bavelier & Green, 2019; Hilgard, Sala, Boot, & Simons, 2019; Steenbergen, Sellaro, Stock, Beste, & Colzato, 2015). However, a greater preference for immediate rewards in gamers in the sense of decisional impulsivity might be addressed with a combined intervention of reality therapy and mindfulness meditation (Yao et al., 2017).

Notably, some limitations have to be mentioned with regard to this study. Due to a subclinical sample of mainly recreational gamers, states of clinically relevant urges/craving and dysfunctional desire thoughts could only be approximated. Further, it might be valuable to consider comparing the mediation models between pathological and recreational gamers, as this would give further insight into potentially different characters of desire thinking when investigated according to symptom severity. However, as this sample only consists of undiagnosed regular gamers who were not seeking treatment, an artificial classification of the sample leads to sample sizes that might be too small for sequential mediation analyses. Therefore, we recommend investigating different effects of desire thinking between healthy and treatment-seeking participants in future studies. Further, given the cross-sectional design of this study, causal interferences from the sequential mediation model can only be deduced with caution.

5. Conclusion

The results of this study emphasize the prominent role of desire thinking in the elaboration of an initial urge to play videogames. That is, the proposed and statistically validated chain of affective and cognitive events tends to explain how actual decisions to game in daily settings are promoted. However, due a cross-sectional design and a non-clinical sample, results need to be interpreted with caution.

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CRedit authorship contribution statement

AB conducted literature research, designed the studies, and was responsible for data management. EW and MB supervised these processes and provided crucial advice. AB and EW ran statistical analyses and interpreted the results. AB conceptualized and wrote the first version of the manuscript. MB finalized the manuscript. All authors contributed to and have approved the final manuscript. AB: Conceptualization, Data curation, Investigation, Writing – original draft. EW: Supervision, Methodology, Writing – review & editing. MB: Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

See [Table A1](#).

Table A1

Everyday conflicting situations of the CSC-G in English and German.

- You're home, and the dinner table's been set. In order to eat with the others, you must finish your game now. But you are in the middle of the game and would like to continue playing. What do you do?**
Du bist zu Hause und der Abendbrottisch wurde gedeckt. Um mit den Anderen gemeinsam zu essen, musst Du jetzt Dein Spiel beenden. Du bist aber mitten im Spiel und möchtest gerade eigentlich gerne weiterspielen. Was tust Du?
- In a couple of days, you will take an important exam/attend an important meeting. In order to be well prepared you want to finish some things off today. Before you begin you notice that you would rather like to play. What do you do?**
Dir steht in wenigen Tagen eine wichtige Prüfung/Besprechung bevor. Um gut vorbereitet zu sein, möchtest Du heute noch ein paar Dinge dafür erledigen. Bevor du beginnst merkst Du, dass Du gerade eigentlich gerne spielen möchtest. Was tust Du?
- Your acquaintances spontaneously ask you if you want to do something with them. The activity they suggest sounds quite OK. You think for a moment - actually you just wanted to start playing. What do you do?**
Deine Bekannten fragen Dich spontan, ob Du etwas mit ihnen unternehmen möchtest. Die Unternehmung, die sie vorschlagen, klingt ganz OK. Du überlegst kurz – eigentlich wolltest Du gerade beginnen zu spielen. Was tust Du?
- You just walked in the door hungry after a long day. You look into the fridge and realize that you have nothing left to eat at home. So you have to set off again, although you actually would like to play right now. What do you do?**
Du bist nach einem langen Tag gerade hungrig zur Tür reingekommen. Du schaust in den Kühlschrank und merkst, dass Du nichts mehr zu essen zu Hause hast. Du musst also nochmal los, obwohl Du jetzt eigentlich gerne spielen möchtest. Was tust Du?
- You come home and realize that you should tidy up. It will take some time to bring order into the most important things in your apartment. Actually, you would rather like to play right now. What do you do?**
Du kommst nach Hause und bemerkst, dass Du mal wieder Ordnung in Deiner Wohnung schaffen solltest. Das Wichtigste aufzuräumen wird einige Zeit in Anspruch nehmen. Allerdings wolltest Du eigentlich gerade gerne spielen. Was tust Du?
- The laundry heap in your room that has accumulated needs to be done. To make sure that the laundry is dry again in time so that you have fresh clothes, you have to finish your game now. However, you would like to continue playing. What do you do?**
In Deinem Zimmer hat sich ein Wäschehaufen angesammelt, der mal wieder gewaschen werden muss. Damit die Wäsche rechtzeitig wieder trocken ist und Du frische Kleidung hast, musst Du jetzt Dein Spiel beenden. Allerdings möchtest Du gerade eigentlich gerne weiterspielen. Was tust Du?
- You are at home and just in the middle of the game when you remember that you are about to meet friends. You will certainly enjoy the activity. To keep your appointment, you have to finish your game and get on your way, even though you would like to continue playing. What do you do?**
Du bist zu Hause und gerade mitten im Spiel als Dir einfällt, dass Du gleich mit Freunden verabredet bist. Die Unternehmung wird Dir sicher Spaß machen. Um die Verabredung einzuhalten, musst Du Dein Spiel beenden und Dich auf den Weg machen, obwohl Du gerade eigentlich gerne weiterspielen möchtest. Was tust Du?
- You come home late in the evening and tomorrow is an ordinary day at work/training/university. You know that if you start now, you will play for a long time and have little time to sleep. However, you would like to play right now. What do you do?**
Du kommst abends spät nach Hause und für Dich steht morgen ein gewöhnlicher Arbeitstag/Tag bei der Ausbildung/in der Uni an. Du weißt, dass Du lange spielen und wenig Zeit zum Schlafen haben wirst, wenn Du jetzt anfängst. Allerdings möchtest Du gerade gerne spielen. Was tust Du?
- You are invited to a friend's birthday party today. You probably don't know many people at the birthday party, but your friend will be happy if you come. To be on time, you have to finish your game and set off, although you would like to continue playing. What do you do?**
*Du bist heute auf dem Geburtstag eines*r Bekannten eingeladen. Du kennst auf dem Geburtstag wahrscheinlich wenig Leute, aber Dein*e Bekannte*r wird sich freuen, wenn Du kommst. Um pünktlich zu sein, musst Du Dein Spiel beenden und Dich auf den Weg machen, obwohl Du eigentlich gerne weiterspielen möchtest. Was tust Du?*
- You come home in the evening after a long day and you need to take a shower, shave and cut your nails. You know you won't get around to that today if you don't do it now. However, you would rather like to play right now. What do you do?**
Du kommst abends nach einem langen Tag nach Hause und könntest mal wieder eine Dusche nehmen, Dich rasieren und Nägel schneiden. Du weißt, dass Du dazu heute nicht mehr kommen wirst, wenn Du es nicht sofort tust. Allerdings möchtest Du gerade eigentlich gerne spielen. Was tust Du?
- Tomorrow you have a day off and there are only a few hours left until sunrise. You know you'll be playing for a long time if you don't turn off your PC soon and finish your game. But you would like to continue playing right now. What do you do?**
Morgen hast Du frei und es sind nur noch wenige Stunden bis zum Sonnenaufgang. Du weißt, dass Du noch lange Spielen wirst, wenn Du nicht bald den PC ausmachst und Dein Spiel beendest. Du möchtest aber gerade eigentlich gerne weiterspielen. Was tust Du?
- You recently arranged with your parents that you would visit them today. They don't live far, but to meet them, you have to set off and finish your game now. However, you would like to continue playing right now. What do you do?**
Du hast neulich mit Deinen Eltern vereinbart, dass Du sie heute besuchen kommst. Sie wohnen nicht weit, aber um sie zu treffen, musst Du jetzt los und Dein Spiel beenden. Allerdings möchtest Du gerade eigentlich gerne weiterspielen. Was tust Du?
- In order to be better prepared for next week, you want to sort some important documents. You only have time for this today and need to quit your game in order to get it done. But you would actually like to continue playing right now. What do you do?**
Um für die nächste Woche besser vorbereitet zu sein, willst Du dieses Wochenende wichtige Unterlagen sortieren. Du hast nur noch heute dafür Zeit und musst dafür jetzt Dein Spiel beenden. Du möchtest aber eigentlich gerade gerne weiterspielen. Was tust Du?
- Your friends ask you spontaneously if you want to do something with them. The activity they suggest sounds quite OK. You think about it for a moment - actually you just wanted to play. What do you do?**
Deine Freunde fragen Dich spontan, ob Du etwas mit ihnen unternehmen möchtest. Die Unternehmung, die sie vorschlagen, klingt ganz OK. Du überlegst kurz – eigentlich wolltest Du gerade gerne spielen. Was tust Du?
- You come home in the evening after a long day and the kitchen should be cleaned and tidied up. You know that you will be too lazy for that later if you don't do it now. However, you would rather like to play right now. What do you do?**
Du kommst abends nach einem langen Tag nach Hause und die Küche sollte mal wieder aufgeräumt und geputzt werden. Du weißt, dass Du später zu faul dafür sein wirst, wenn Du es nicht direkt machst. Allerdings möchtest Du gerade eigentlich gerne spielen. Was tust du?
- You have a date with your friends tonight. You decide spontaneously what you want to do. To get there on time, you have to finish your game now and get going. However, you would like to continue playing right now. What do you do?**
Du bist heute Abend mit Deinen Freunden verabredet. Was ihr machen wollt, entscheidet ihr spontan. Um rechtzeitig da zu sein, musst Du jetzt Dein Spiel beenden und Dich auf den Weg machen. Allerdings möchtest Du eigentlich gerade gerne weiterspielen. Was tust Du?
- It is already late and tomorrow is a usual day at work/training/university with nothing special scheduled. You should turn off your computer soon in order to be well rested. However, you would like to continue playing right now. What do you do?**
Es ist schon ziemlich spät und morgen ist ein gewöhnlicher Tag auf der Arbeit/bei der Ausbildung/in der Uni, für den nichts Besonderes ansteht. Du solltest langsam den PC ausmachen, um ausgeschlafen zu sein. Allerdings möchtest Du gerade eigentlich gerade gerne weiterspielen. Was tust Du?
- Your friends ask if you would like to meet up with them. The activity they propose sounds fun. You think for a moment – actually you wanted to play right now. What do you do?**
Deine Freunde fragen Dich, ob Du etwas mit ihnen unternehmen möchtest. Die Unternehmung, die sie vorschlagen, klingt Spaßig. Du überlegst kurz – eigentlich wolltest Du gerade gerne spielen. Was tust Du?

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Fleeing through the mind's eye: Desire thinking as a maladaptive coping mechanism among specific online activities

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ABSTRACT

Introduction: Desire thinking is defined as a voluntary cognitive activity aimed at imaginatively and verbally elaborating a future scenario of performing a desired behavior. Although not problematic per se, desire thinking can become dysfunctional if it is used to regulate negative mood states and due to its ability to induce craving. This study tests a mediation model where desire thinking is hypothesized to mediate the association between emotional reactivity and craving among specific online activities.

Methods: The study comprised an online survey that was completed by 925 participants who indicated that their first-choice online activity was one out of social-networks use, shopping, gaming, gambling, or pornography viewing. In this sample, a structural equation model was tested where negative emotional reactivity, desire thinking, and craving were latently modelled in this serial order.

Results: Results indicated that higher levels in negative emotional reactivity significantly predicted higher desire thinking tendencies, which in turn significantly predicted higher cravings for online activities. The direct path between negative reactivity and craving was not significant. Further, our results support the two-factorial structure of a German version of the Desire Thinking Questionnaire (Caselli & Spada, 2011).

Discussion: The findings show that desire thinking might be initiated as an attempt to regulate negative affective states. This highlights its possible role as a maladaptive coping mechanism in the context of specific online activities due to the resulting craving responses, which in turn could promote the emergence of unwanted behaviors.

1. Introduction

Desire thinking is defined as a voluntary cognitive process aimed at forming sensory forecasts and recalling positive memories around an appetitive target or activity, finding good reasons to engage in it and planning how to do so (Caselli & Spada, 2011, 2015; Kavanagh, Andrade, & May, 2005). Although desire thinking is a human faculty and therefore not problematic per se, it can nevertheless take on a dysfunctional character as it predicts various problematic addictive behaviors. For example, within research on online activities, desire thinking is associated with the problematic use of the internet in general (Faghani, Akbari, Hasani, & Marino, 2020; Spada, Caselli, Slaifer, Nikčević, & Sassaroli, 2014), problematic Facebook use (Marino et al., 2019), problematic pornography use (Allen, Kannis-Dymand, & Katsikitis, 2017), and decisions to game despite competing activities (Brandtner, Wegmann, & Brand, 2020).

An explanatory approach for the dysfunctionality of desire thinking stems from the perspective of a triphasic metacognitive formulation of problem drinking and addictive behaviors. Here, desire thinking is part of the voluntary and conscious Self-Regulatory Executive Function (S-REF) system which is supposed to be active in order to maintain control over unpleasant thoughts and affective states and to attain immediate relief (Spada, Caselli, Nikčević, & Wells, 2015; Spada, Caselli, & Wells, 2013). In this sense, desire thinking is activated as a form of extended thinking (a rigid, maladaptive, and perseverative form of coping with negative thoughts and emotions). Next to thought suppression, threat monitoring, and avoidance, extended thinking styles (i.e., rumination, worry, and desire thinking) are thought to be part of the cognitive attentional syndrome which is activated through metacognitions. Metacognitions include beliefs about the benefits of engaging in these thinking styles with the objective of relieving the individual from negative sensations (Spada et al., 2013, 2015; Wells & Matthews, 1994).

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Initial exploratory findings on desire thinking confirm that when asking individuals why they engaged in desire thinking, 60.87% reported engaging in it to escape negative emotions and thoughts (Caselli & Spada, 2010). In line with these assumptions, desire thinking has already been predicted by difficulties in emotion regulation (Faghani et al., 2020) and emotional intolerance (Caselli, Canfora, et al., 2015), where desire thinking functions as a mediator to predict addictive behaviors. In the short term, desire thinking might indeed be helpful in relieving negative sensations. Imagining how it would feel to play the next game, to check likes of uploaded content, or to stroll through online shops can quickly induce pleasant feelings as the imagined scenarios can simulate anticipated reward (Andrade, May, & Kavanagh, 2012). Moreover, self-motivational statements about target acquisition might induce a feeling of motivation or a sense of control. However, in the long run, desire thinking can become a dysfunctional attempt to control negative states as they might persist and, as the triphasic formulation of the S-REF model for addictive behaviors posits in the pre-engagement phase, lead into states of craving that can be hard to resist although the behavior may interfere with other goals (Spada et al., 2013, 2015; Wells & Matthews, 1994).

Another theory that puts desire thinking and craving into relation is the Elaborated Intrusion Theory of desire (EIT; Kavanagh et al., 2005). Here, the constructs of desire and craving are thought to range along a continuum (Kavanagh et al., 2005; May et al., 2014) and are considered closely related to, yet distinct from desire thinking (Caselli & Spada, 2015). Whereas desire thinking refers to the voluntary imaginal and verbal elaboration of an appetitive target, desires and cravings refer to motivational experiences within conscious awareness (Kavanagh et al., 2005). That is, cognitive elaboration (i.e., desire thinking) transfers incentive salience attributions into states of ‘wanting’ (Robinson & Berridge, 2003) where thoughts and imageries might become difficult to control. Accordingly, desires and cravings are cognitive events where mental images and verbal thoughts are experienced as less controllable and are accompanied by a motivational sense of urge (May et al., 2014). Furthermore, Cornil et al. (2018) argue that *urge* is the perspective of positive and/or negative reinforcement and is therefore an accompanying factor within desire and craving. Thus, neither does it constitute the experience alone, nor is it a synonym for desire or craving (Canale, Cornil, Giroux, Bouchard, & Billieux, 2019).

Whereas desire thinking is an inherent, per se unproblematic human faculty that enables individuals to plan behavior and anticipate its consequences (Caselli & Spada, 2015), craving counts as a psychological mechanism that may cause and uphold addictive behaviors. As an addiction-specific cognitive phenomenon, craving does not only occur among substance-related addictive behaviors but has also been discovered to play an important role among specific online activities that may be used in an uncontrolled way, including gaming, gambling, shopping, pornography viewing and social-networks use (Antons, Trotzke, Wegmann, & Brand, 2019; Cornil et al., 2018; Dong, Wang, Du, & Potenza, 2017; Trotzke, Starcke, Müller, & Brand, 2019; Wegmann, Stodt, &

Brand, 2018).

Integrating the assumptions within the S-REF model (Spada et al., 2013, 2015; Wells & Matthews, 1994) and EIT (Kavanagh et al., 2005), desire thinking might function as an explicit attempt to regulate negative affective states that might lead to the experience of craving (Caselli, Soliani, & Spada, 2013; Caselli, Gemelli, & Spada, 2017; Martino et al., 2017, 2019). Former studies investigated the role of desire thinking in mediating the effect between emotional dysregulation and symptom severity with regard to alcohol and general internet use (Caselli et al., 2015; Faghani et al., 2020), but the mediating role of desire thinking in the relation between emotional reactivity and the occurrence of craving in the context of specific online activities has not been investigated to the best of our knowledge. Hence, the goal of this study was to investigate the mediating effect of desire thinking between the experience of negative emotions and craving for specific online activities in a structural equation model (see Fig. 1).

2. Methods

2.1. Participants

In order to test the structural equation model, 925 participants (450 female, 2 diverse) aged between 18 and 65 years ($M = 41.32$, $SD = 13.00$) took part in an online survey that was approved by the local ethics committee at University Duisburg-Essen. The data was collected between 14 and 16 December 2020 with the help of the German panel provider GapFish GmbH that incentivized participants with 2.8€ for the completed survey. Within this sample, 45.6% participants indicated social-networks use, 36.1% indicated shopping, 14.1% indicated gaming, 2.7% indicated the use pornography, and 1.5% indicated gambling as their first-choice online activity. Per week and regarding the first-choice applications only, participants spent, on average, 20.47 h ($SD = 19.06$) using social networks, 17.41 h ($SD = 11.96$) gaming, 13.21 h ($SD = 14.44$) online gambling, 10.48 h ($SD = 10.92$) using online pornography, and 5.42 h ($SD = 8.14$) online shopping.

2.2. Self-report instruments

2.2.1. Desire thinking

Desire thinking was assessed with the Desire Thinking Questionnaire (DTQ; Caselli & Spada, 2011) which measures, on two subscales with 5 items each, the tendency to prefigure imagery (e.g., “I imagine myself doing the desired activity”) and the verbal perseveration about desire-related information (e.g., “I repeat mentally to myself that I need to practice the desired activity”). Each item is answered on a four-point Likert scale ranging from 1 *almost never* to 4 *almost always*, with higher mean scores depicting a higher tendency for desire thinking. We used the current sample to confirm the factorial structure of a German version of the DTQ with a confirmatory factor analysis (CFA) in MPlus 8 (Muthén & Muthén, 2011). Standardized root mean square residuals

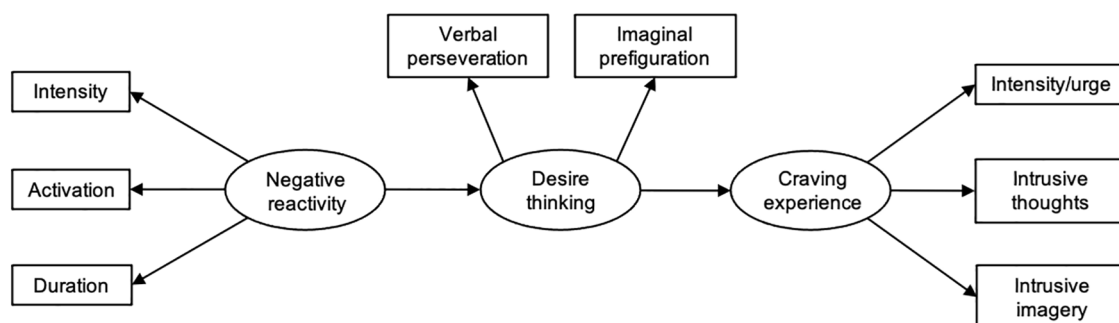


Fig. 1. Hypothesized structural equation model. Note. The structural equation model shows latent variables (in circles) and manifest variables (in rectangles); operationalization of manifest variables is described in the methods section.

(SRMR) below 0.08 and root mean square error of approximation (RMSEA) values below 0.08 with a probability of error below 0.05 indicate good fit with the data (Hu & Bentler, 1995, 1999). Comparative fit indices (CFI/TLI) above 0.90 represent a good fit, those above 0.95 an excellent fit. Moreover, a degrees of freedom ratio (χ^2/df) < 3 is considered satisfactory (Schermelleh-Engel, Moosbrugger, & Müller, 2003). The two-factor model for the questionnaire did not sufficiently fit the data with RMSEA = 0.116, $p < .001$, CFI = 0.93, TLI = 0.90, and SRMR = 0.044. $\chi^2(34)$ was 459.07 with $\chi^2/df = 13.50$. However, this model still represented the data better as a one-factor solution ($\chi^2(35) = 593.91$, $p < .001$, $\chi^2/df = 16.97$). After allowing correlations of error terms according to modification indices and due to content similarity (DTQ01 - DTQ02, DTQ01 - DTQ03, DTQ02 - DTQ03, DTQ04 - DTQ05, DTQ05 - DTQ06) as recommended by Kline (2015), the model approximated an acceptable fit with RMSEA = 0.049, $p = .526$, CFI = 0.99, TLI = 0.98, SRMR = 0.018 and $\chi^2(29) = 93.94$ with $\chi^2/df = 3.23$. Factor loadings are shown in Table 3. The introduced corrections demonstrated a significant improvement in fit over the more restrictive model ($\Delta\chi^2 = 365.13$, $\Delta df = 5$, $p < .001$). Cronbach's alpha for the imaginal prefiguration subscale was 0.876 and for the verbal perseveration subscale 0.887.

2.2.2. Negative emotional reactivity

A tendency to intensively experience negative emotions was measured using the short Perth Emotional Reactivity Scale (PERS; Becerra, Preece, Campitelli, & Scott-Pillow, 2017). The PERS consists of three subscales for negative reactivity, including the intensity (e.g., "My negative feelings feel very intense."), activation (e.g., "I tend to get upset very easily."), and duration (e.g., "It's hard for me to recover from frustration.") of negative emotions. Three items per subscale were answered on a five-point Likert scale ranging from 1 *very unlike me* to 5 *very like me* with higher sum scores indicating higher negative emotional reactivity. Cronbach's alpha was 0.716 for the negative-intensity subscale, 0.668 for the negative-activation subscale, and 0.820 for the negative-duration subscale in the current sample.

2.2.3. Craving experience

The imagery and thought component of craving was measured using the Craving Experience Questionnaire (CEQ-S; May et al., 2014) adapted for gambling (Cornil et al., 2019) and transferred to online activities assessed in this study. Two subscales measure the intensity of imagery (e.g., "Right now, how vividly do you picture it?") and intrusiveness of thoughts (e.g., "Right now, how hard are you trying not to think about it?"). Three items per subscale are answered from 0 *not at all* to 10 *extremely* with a higher overall mean score indicating higher craving intensity. Cronbach's alpha for the imagery subscale was 0.897 and 0.937 for the thought subscale in this sample. Additionally, the perspective of positive and/or negative reinforcement inherent in craving (i.e., urge; Canale et al., 2019; May et al., 2014) was measured using the Craving Assessment Scale for Behavioral Addictions (CASBA, cf. Antons et al., 2019). 9 items (e.g., "Using the application now would make me feel less stressed."; "Using the application now would give me satisfaction.") are rated on a five-point Likert scale ranging from 1 *completely disagree* to 5 *completely agree* with higher sum scores indicating higher craving. In this sample, the Cronbach's alpha for the CASBA was 0.954.

3. Results

3.1. Descriptive statistics and correlational analyses

The following tables show descriptive statistics (Table 1) and intercorrelations (Table 2) of all manifest variables within the structural equation model (see Figs. 1 and 2). Further, Table 3 shows standardized and unstandardized factor loadings of the items of the Desire Thinking Questionnaire on the proposed two factors, imaginal prefiguration and

Table 1

Descriptive statistics of variables within the structural equation model.

	Min	Max	M	SD
PERS negative-intensity	3	15	9.58	2.72
PERS negative-activation	3	15	9.13	2.73
PERS negative-duration	3	15	8.98	2.99
DTQ imaginal prefiguration	5	20	10.33	3.78
DTQ verbal perseveration	5	20	9.61	3.75
CEQ-S intrusiveness of thoughts	0	10	2.64	2.75
CEQ-S imagery	0	10	3.47	2.79
CASBA	0	45	13.54	12.03

Note. PERS = Perth Emotional Reactivity Scale, DTQ = Desire Thinking Questionnaire, CASBA = Craving Assessment Scale for Behavioral Addictions; CEQ-S = Craving Experience Questionnaire Strength.

verbal perseveration, after allowing the correlations of respective error terms of specific items (see Section 2.2.1).

3.2. Structural equation model

The structural equation model showed mostly acceptable fit indices except for the χ^2/df ratio. The RMSEA was 0.056 ($p = .225$), CFI was 0.99, TLI was 0.98, and the SRMR was 0.019. $\chi^2(17)$ was 66.30 ($p < .001$) with a χ^2/df ratio of 3.9. As a requirement for mediation analyses, all variables for the structural equation model were correlated with each other (Baron & Kenny, 1986; see Table 2). The modification indices indicated the intercorrelation of errors of the imagery components of desire thinking and craving (DTQ imaginal prefiguration WITH CEQ-S imagery; shared variance 30.36%) as well as the verbal components of desire thinking and craving (DTQ verbal perseveration WITH CEQ-S thoughts; shared variance 32.38%). According to Caselli and Spada (2015), desire thinking and craving are distinct, yet interrelated constructs, and their source of variance not caused by the factors might be similar, wherefore we allowed the two correlations of residual variances of these two pairs of manifest variables. The final model showed a good fit with the data. The RMSEA was 0.043 ($p = .732$), CFI was 0.99, TLI was 0.99, and the SRMR was 0.018. $\chi^2(15)$ is 41.13 ($p < .001$) with χ^2/df being 2.74. The model explained nearly half of the variance (46.4%) within the craving experience, $R^2 = 0.464$, $p < .001$. Fig. 2 shows the results of direct effects within the structural equation model, including factor loadings, β -weights, and levels of significance. The indirect pathway from negative reactivity over desire thinking to the craving experience was significant ($\beta = 0.231$, $SE = 0.025$, $p < .001$). The direct path from negative reactivity to the craving experience was no longer significant ($\beta = 0.040$, $SE = 0.031$, $p = .199$).

4. Discussion

The results of this study indicate that the proposed structural equation model adequately mirrors the data of the 925 participants who participated in the survey. All latent variables were well represented by the manifest variables with consistently high and significant loadings (see Fig. 2). Further, the two-factorial structure of the Desire Thinking Questionnaire (Caselli & Spada, 2011) could be replicated in a German translation. Nearly half of the variance could be explained within the dependent variable through a mediation model where desire thinking fully mediates the relationship between a tendency to show a general negative emotional reactivity and the strength of a craving experience.

These findings implicate that not only difficulties in emotion regulation or emotional intolerance predict desire thinking (Caselli et al., 2015; Faghani et al., 2020), but also a more general, trait-like tendency to feel negative emotions easily, intensely, and for a long time (Becerra et al., 2017; Preece, Becerra, & Campitelli, 2019). This means, independently of existing or lacking mood regulation strategies, desire thinking may be a strategy that is used in order to regulate negative emotions although other mood regulation strategies might be available.

Table 2
Bivariate correlations of variables within the structural equation model.

	2.	3.	4.	5.	6.	7.	8.
1. PERS negative-intensity	0.673**	0.726**	0.260**	0.308**	0.219**	0.195**	0.194**
2. PERS negative-activation	1	0.715**	0.225**	0.289**	0.245**	0.182**	0.210**
3. PERS negative-duration		1	0.197**	0.273**	0.229**	0.164**	0.211**
4. DTQ imaginal prefiguration			1	0.786**	0.518**	0.551**	0.562**
5. DTQ verbal perseveration				1	0.569**	0.527**	0.568**
6. CEQ-S intrusiveness of thoughts					1	0.758**	0.812**
7. CEQ-S imagery						1	0.805**
8. CASBA							1

Note. PERS = Perth Emotional Reactivity Scale, DTQ = Desire Thinking Questionnaire, CASBA = Craving Assessment Scale for Behavioral Addictions; CEQ-S = Craving Experience Questionnaire Strength, ** $p < .01$.

Table 3
Unstandardized and standardized factor loadings for the German DTQ.

Item	B	β	S.E.
Imaginal prefiguration			
DTQ01	1.000	0.609	0.023
DTQ02	1.238	0.694	0.019
DTQ03	1.234	0.679	0.020
DTQ08	1.449	0.827	0.013
DTQ09	1.460	0.795	0.015
Verbal perseveration			
DTQ04	1.000	0.718	0.018
DTQ05	1.036	0.742	0.017
DTQ06	1.048	0.768	0.016
DTQ07	1.070	0.780	0.015
DTQ10	1.188	0.830	0.013

Note. DTQ = Desire Thinking Questionnaire, $N = 925$.

This underpins the relevance of emotional reactivity as a more general vulnerability factor besides difficulties in emotion regulation (Kavanagh et al., 2005). The mood-regulating properties of desire thinking may be predominant due to the capability of mental images to immediately provoke emotional reactions and mimic anticipated reward and relief (Andrade et al., 2012). That is, if the imagined scenario is positively connotated, the emotions stimulated by imageries might relieve negative sensations at short notice. Here, both the experience of pleasure and an experience of relief associated with thoughts and, according to the EIT most prominently with imagery, might be experienced as reinforcing (Kavanagh et al., 2005; May, Andrade, Panabokke, & Kavanagh, 2004). Accordingly, although desire thinking is not explicitly termed as a (maladaptive) coping mechanism in the EIT, Kavanagh et al. (2005) formulate that negative affect is both a possible precursor and consequence of desire. However, whereas the S-REF model posits a direct link

between an aversive trigger and the activation of desire thinking as part of the cognitive attentional syndrome (Spada et al., 2013, 2015; Wells & Matthews, 1994), this relationship is assumed to be mediated via a sense of deficit in the EIT (Kavanagh et al., 2005). In this sense, further studies could address the question whether desire thinking is a direct consequence of aversive triggers or if this link is indeed mediated by a sense of deficit. Nevertheless, the structural equation model for this sample shows that only 12% of variance within desire thinking can be explained by negative emotional reactivity. This is comparatively similar to Faghani et al. (2020) who found that difficulties in emotion regulation explained about 17% of variance within desire thinking. This leaves a noteworthy amount of unexplained variance, letting us conclude that there might be more important predictors of desire thinking in the context of online activities. According to the S-REF model (Spada et al., 2013, 2015; Wells & Matthews, 1994), not only negative emotions but also the experience of unpleasant thoughts can activate desire thinking. Further, Caselli, Manfredi, Ferraris, Vinciullo, and Spada (2015) found that a high tendency for sensation seeking can predict desire thinking. Possibly, there might be (at least) two pathways for ‘entering’ the desire thinking mode. One pathway of compensating negative experiences has been replicated in this study for specific online behaviors. Another pathway of seeking novel and exciting experiences, and therefore seeking gratification in desire thinking, is already mirrored in positive metacognitions about desire thinking (Caselli & Spada, 2013) and might deserve a specific focus in future research. However, the question remains as to which extent negative mood states are predominantly coped by elaborative desire thoughts, and not by the actual behavior among different types of online activities. That is, the increasing accessibility of online-based content via mobile devices could be the reason why desire elaboration might not be a necessary coping strategy as the possibility of immediately pulling out the smartphone might serve as a reliable (but possibly dysfunctional) mood regulator itself (Kardefelt-Winther, 2014). Thus, the questions if and how different internet-use disorders might

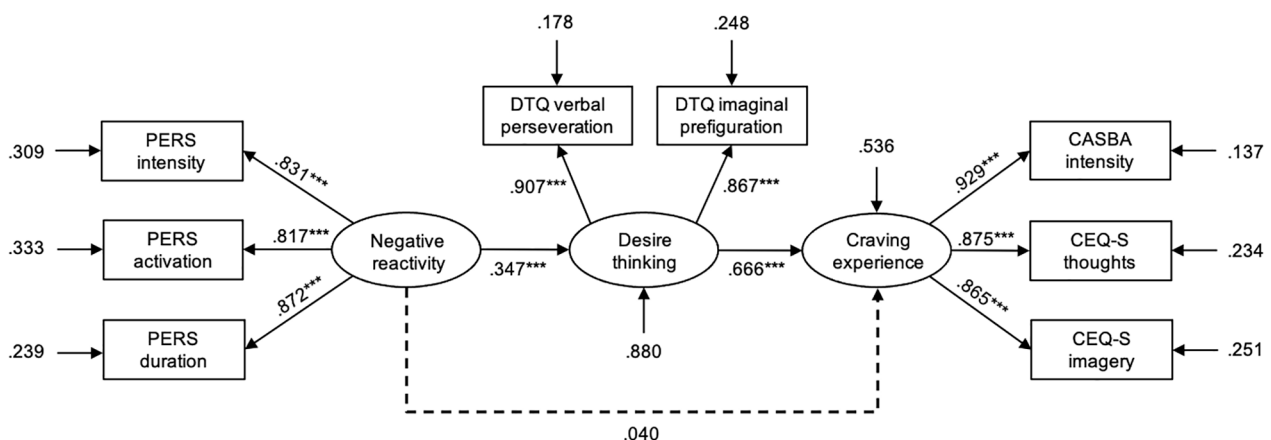


Fig. 2. Structural equation model tested. Note. Figure shows factor loadings for the latent variables, residual variances, and direct effects with their respective β -weights and levels of significance. *** $p < .001$.

vary in the degree to which desire thinking emerges in daily life might be a focus for future research.

Referring to the link between desire thinking and the craving experience, the results of this study underpin the possible dysfunctional character of desire thinking when used as an attempt to regulate negative states. The findings are therefore consistent with the assumptions of the S-REF model (Spada et al., 2013, 2015; Wells & Matthews, 1994) and underline the proposed definition of desire thinking being a maladaptive coping mechanism. The results of this study extend the results of the comprehensive model of Faghani et al. (2020) in that desire thinking does not only predict the symptom severity of a problematic behavior but predicts craving in the first instance. In addition to empirical findings that emphasize a direct link between aversive states (e.g., subjective stress level) and the experience of craving (e.g., Childs & de Wit, 2010; Fox, Bergquist, Hong, & Sinha, 2007), the findings of this study show that desire thinking might fully mediate such a relationship and therefore might cancel out the direct effect in some situations with regard to online activities. This highlights the important role of desire thinking being a leverage point in the modification of craving and provides the important implication that the visual or verbal interference with conscious desire elaboration processes might prohibit or alleviate craving reactions in the context of non-substance problematic behaviors. That is, whereas a general negative emotional reactivity as a trait-like faculty might only be modified in the long-term, addressing the voluntary process of desire thinking seems promising in the reduction of spontaneous craving reactions. Given the strong link between the experience of craving and the occurrence of possibly unwanted behaviors (cf., Brand, Young, Laier, Wölfling, & Potenza, 2016; Brand et al., 2019), systematically tackling desire thinking might also further contribute to the reduction of addictive behaviors and/or relapses. In this context and according to the claimed dominant role of imagery in craving (Kavanagh et al., 2005), diverse studies could show beneficial effects of visuospatial interference in the reduction of substance cravings (e.g., Littel, van den Hout, & Engelhard, 2016; Rooijmans, Rosenkamp, Verholt, & Visser, 2012), which Brandtner, Pekal, and Brand (2020) could replicate in the context of gaming cravings. Moreover, Cornil, Rothen, De Timary, and Billieux (2021) found that both imaginal and verbal interference tasks are similarly able to alleviate gambling craving reactions, which somehow questions the supposed superiority of visual interference methods - besides the imaginal elaboration of an appetitive target, its verbal elaboration and consequently its interference might be just as important in the occurrence of craving.

Some limitations have to be mentioned with regard to this study. The results in terms of the craving experience in this study are limited in that our sample predominantly used internet applications recreationally. Although there might be individuals with problematic behaviors who experienced high craving levels when completing the survey, the construct of craving still needs to be understood as aligning on a continuum with mild desires (Kavanagh et al., 2005). Another limitation is the unequal distribution of assessed internet activities. Whereas 81.7% percent of first-choice applications are represented by social-networks use and online shopping alone, gaming, gambling, and the use of pornography are underrepresented in this sample wherefore generalization of the present results for these subsamples can only be made to a limited extent.

5. Conclusion

The present study is the first to show in a structural equation model that desire thinking is associated with the experience of desire or craving and might occur as a reaction to negative emotions among individuals who engage in specific online activities, namely social-networks use, shopping, gaming, gambling, and pornography use. Thus, the results emphasize and align with theoretical models and empirical findings that desire thinking might function as a maladaptive coping strategy. Further, these results implicate that tackling conscious desire

elaboration might be useful in inhibiting craving reactions as well as addictive behaviors and/or relapses.

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CRediT authorship contribution statement

Annika Brandtner: Conceptualization, Methodology, Software, Formal analysis, Writing - original draft. **Matthias Brand:** Conceptualization, Methodology, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Integrating Desire Thinking into the I-PACE Model: a Special Focus on Internet-Use Disorders

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Abstract

Purpose of Review This manuscript aims to propose an integration of desire thinking into the Interaction of Person-Affect-Cognition-Execution (I-PACE) model based on theoretical considerations within the Elaborated Intrusion Theory of Desire and Self-Regulatory Execution Function model and empirical evidence from the field of internet-use disorders.

Recent Findings Theory and research on desire thinking in the context of internet-use disorders suggest considerable relations to craving, metacognitive beliefs, and emphasizes its nature when initiated as a reaction towards unpleasant triggers. Accordingly, we postulate that desire thinking may be located at the position for affective and cognitive reactions towards triggers within the I-PACE model.

Summary The suggested integration of desire thinking into the I-PACE model specifically implies the assumption of a *relief-oriented* and *pleasure-oriented* entry pathway into desire thinking and a feedback loop between desire thinking and the experience of gratification and compensation. The model pathways proposed here may serve as a theoretical basis for future research and need further empirical verification.

Keywords Desire thinking · Internet use · Craving · Inhibitory control · Metacognition · Reward expectancy

Introduction

The ability of generating and constructing mental representations of the future appears to have many faces in the scientific literature. *Episodic foresight*, *future-oriented mental time travel*, *prospective imagery*, or *future thinking* all refer to the crucial human faculty that allows us to generate a narrative of a future event, anticipate (the consequences of) our behaviors, and therefore subserves future-oriented decision-making [1]. Thus, it is not surprising that this ability has a central role when experiencing desires as it enables us to cognitively elaborate the acquisition of a desired object or

activity which is further proximately linked to behavioral activation. That is, it arouses and drives us to achieve what we seek [2, 3] which is an inherently important and adaptive advantage in motivating behaviors [4]. In the context of desire and craving, this elaboration process is termed desire thinking and is defined as a conscious, cognitive, and emotional process aiming to generate and elaborate desire-related content around an appetitive target [5, 6]. Desire thinking subsumes two key components that are conceptually distinct but are thought to occur together in the process of desire elaboration [e.g., 7, 8]. The first component, imaginal prefiguration, involves multi-sensorial imageries that integrate sight, sound, and smell, as well as auditory information associated with a desired activity [9–11]. More specifically, sensory imageries hold and produce affective target-related information that are accompanied by the experience of emotions when anticipating and mentally simulating reward [11–13] which assigns a strong motivational power to them. The verbal component of desire thinking is termed verbal perseveration [5] and is a linguistic capacity to verbally represent thoughts about the target. Such verbal thoughts might include self-motivational statements about why engaging in the activity or acquiring a certain object

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is reasonable (e.g., “Strolling through online shops would really help to take my mind off things.”), specifications about the availability of resources or capacities needed for target acquisition (e.g., “Do I have the time to play my favorite videogame this evening?”), and also action plans that involve specific ideas about how to achieve the desired target (e.g., “As soon as I am on the bus, I will check my messages.”). Thus, this form of inner self-talk enables us to plan more specifically how the object or activity can be achieved and to find good reasons for doing so. As with other affective and cognitive processes specific for addictive disorders (e.g., craving, cue reactivity), desire thinking is observable among substance-use disorders as well as addictive behaviors and internet-use disorders, respectively. It has been investigated in the context of problem alcohol drinking [8, 14–19] next to a few studies on tobacco use [5, 20, 21] and eating behaviors [22–24] and successively gains an attentional focus among addictive behaviors (for a meta-analysis, see [25•]) and specific internet-use disorders. As such, it has been investigated in the context of gaming [26–29], pornography viewing [27, 30], social networks use [20, 27], shopping and gambling [27], and the general use of the internet [5, 7, 31•, 32, 33], indicative of its relevance among (potentially problematic) online behaviors.

The Elaborated Intrusion Theory of Desire

Desire thinking is theoretically embedded into the Elaborated Intrusion Theory of Desire [EIT; [10, 34] which draws a cognitive-emotional approach to desire. Although being essential to the experience of craving, desire thinking and craving are assumed to be different processes. Desire thinking refers to a conscious and voluntary cognitive elaboration process [5], whereas craving refers to an affective experience where images and verbal thoughts get accompanied by a sense of urge ([35]; see Fig. 3) and might be experienced as less controllable. Within the original EIT model, the output of cognitive processes (e.g., desire thoughts) is depicted in boxes rather than the processes themselves (e.g., desire thinking; cf. Fig. 1). However, the process of desire thinking may be assigned to specific mechanisms within the subjective experience of desire (e.g., attentional/working

memory allocation; see Fig. 1). Engaging in desire thinking can immediately create a feeling of pleasure or relief which is considered to result in the motivational component of the desire experience (i.e., urge; for a discussion see [36•]). Experiencing this motivational urge (formed of pleasure and/or relief) may then again accelerate the conscious elaboration of desire thoughts because this, besides actual target acquisition, is the only way to satisfy the desire, leading into a cognitive cycle which often results in engaging in the desired activity [34]. Desire thinking also promotes the constant comparison between the actual and the desired/imagined situation. This discrepancy reinforces a sense of associated deficit which may further be accelerated by internal triggers (i.e., negative affect and physiological deficit, see Fig. 1). To relieve this deficit, one elaborates more desire thoughts or gives in to desire.

The Self-Regulatory Execution Function Model

An explanatory approach for a problematic extent of desire thinking is put forward within the pre-engagement phase of the triphasic metacognitive formulation of problem drinking which is based on the Self-Regulatory Execution Function model (S-REF; [37–39]; see Fig. 2). Originally, the S-REF model was formulated as a metacognitive approach to explain emotional disorders by a dysfunctional style of managing cognition and attention [37], but it also finds its application in the realm of addictive behaviors where it explicitly encompasses desire thinking [39, 40]. According to the main ideas within the S-REF model, a certain cognitive style, the cognitive attentional syndrome (CAS), is activated through metacognitions as an attempt to regulate unpleasant thoughts and emotions. The CAS encompasses a variety of (alleged) cognitive coping strategies, namely extended thinking styles (i.e., desire thinking, worry, and rumination), threat monitoring, thought suppression, and avoidance [39, 40]. Positive metacognitions that activate these cognitive coping strategies refer to the anticipated positive reward generated by the CAS (e.g., “Desire thinking will help me cope.”), whereas negative metacognitions refer to the uncontrollability of thoughts once the cognitive coping strategy is initiated (e.g., “Once I start thinking about the desired activity, I cannot

Fig. 1 Simplified model of the Elaborated Intrusion Theory of Desire [34]

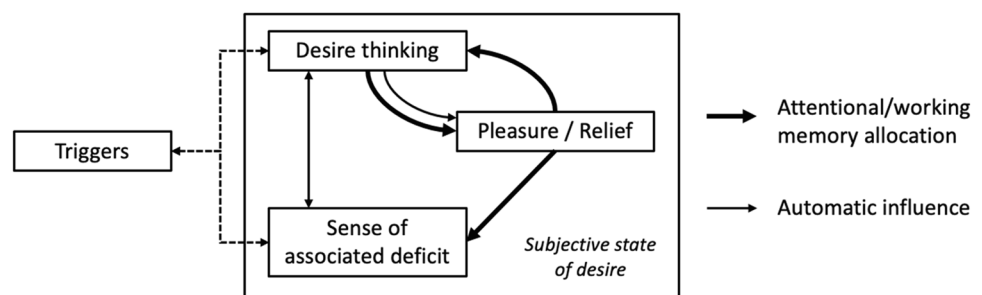


Fig. 2 Schematic model of the pre-engagement phase of the triphasic formulation of problem drinking, in accordance with the S-REF model [38–40]. Only extended thinking styles (i.e., desire thinking, rumination, and worry) are shown as part of the cognitive attentional syndrome (CAS)

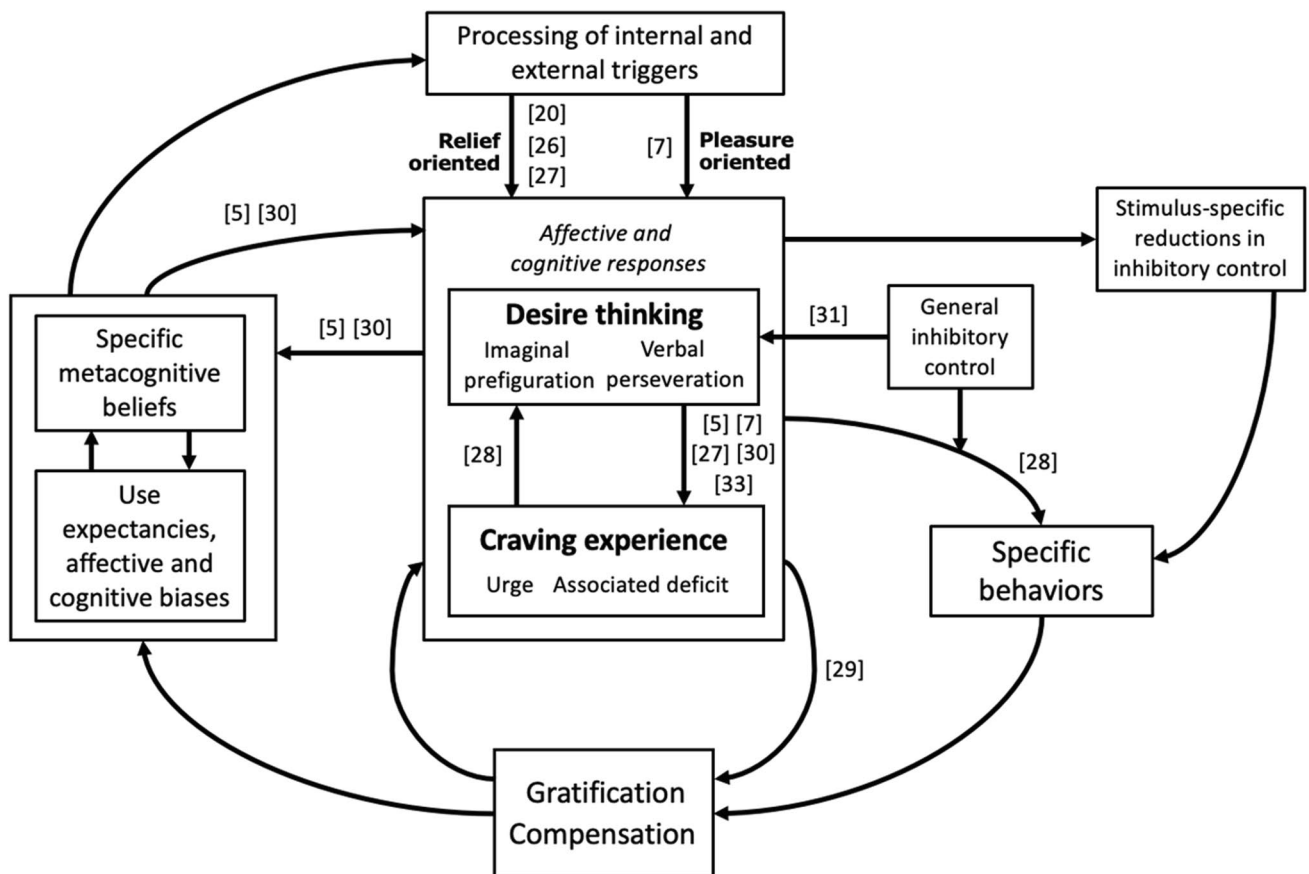
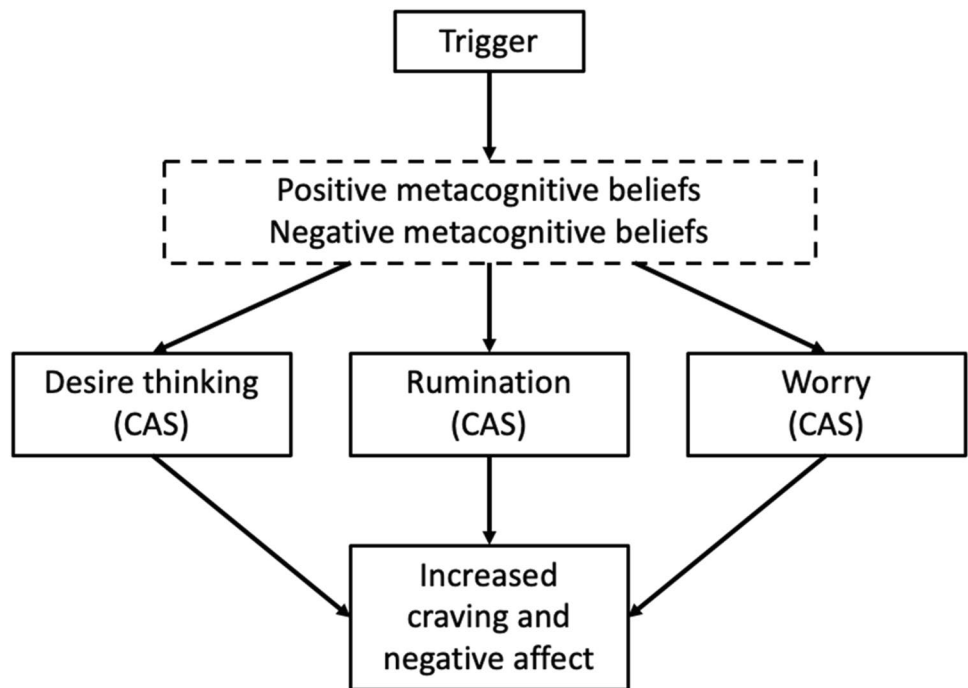


Fig. 3 This model illustrates the assumed position of desire thinking within the inner circle of the I-PACE model according to theoretical assumptions of the EIT and S-REF model. The references refer to

empiric studies that have investigated the proposed pathways in the context of specific internet-use disorders

stop.”). The strategies of the CAS have in common that they elaborate and maintain intrusive experiences by allocating attentional resources to them rather than reflecting on the content of such experiences [40, 41]. Therefore, the nature of these thinking patterns, and desire thinking in specific, can become dysfunctional as they do not help to downregulate negative thoughts and emotions but rather favor their prolongation [41] as well as the experience of craving [15, 39, 40].

The Interaction of Person-Affect-Cognition-Execution (I-PACE) Model

The Interaction of Person-Affect-Cognition-Execution (I-PACE; [42, 43]) model is a comprehensive theoretical framework to systematize relevant personality characteristics and affective and cognitive mechanisms in order to explain the development and maintenance of addictive behaviors. Initially developed in the context of internet-use disorders [43], the I-PACE model has been expanded to a broader range of addictive behaviors where it also becomes possible to distinguish between early and later stages of the addiction process [42]. As an integrative approach, the I-PACE model has been derived from and combines current theories that are crucial to the explanation of substance-use disorders and behavioral addictions. As such, the *incentive sensitization theory* [44, 45], *impaired response inhibition and salience attribution model* [46, 47], *reward deficiency syndrome* [48], *dual-process approaches* of addiction (e.g., [49–51]), and different associative learning theories (i.e., classical and operant conditioning) are mirrored in the core assumptions within the inner circle of the I-PACE model [42, 43]. The I-PACE postulates that the perception of internal triggers (e.g., negative or positive mood, stress) or external triggers (e.g., an advertisement, hearing a sound) may facilitate the experience of cue reactivity and desire or craving as a reaction to these cues. Especially regarding the state of unpleasant emotions, the experience of gratification and compensation can take on a reinforcing role for the craving experience in the later stages of addictive behaviors as it may have been operantly learned that engaging in a certain activity might relieve the individual from these unpleasant emotions [52]. With stronger craving reactions, represented on a neural level by a hyper-reactive reward system [44, 45], inhibitory control processes might become impaired as prefrontal control processes become less effective in overriding the reward system [46, 47], leading to impulsive decisions to engage in an activity, or habitualized behaviors in the later stages, respectively. The positive and negative reinforcement through these behaviors creates certain reward expectancies (e.g., “Checking my messages will help me feel better.”); wherefore it may become more likely that specific behaviors are adapted as coping styles. Simultaneously, reinforcement

mechanisms may facilitate the attentional allocation of activity-related internal and external triggers (i.e., cognitive biases [53, 54]) which may again facilitate the experience of cue reactivity and craving.

Objective

The I-PACE model is a generic approach to the underlying processes of addictive behaviors and therefore does not specify the role and place for each specific cognitive or affective process. Hence, it allows to sort in specific processes that might not be explicitly defined into more generic subgroups of affective and cognitive processes (e.g., affective and cognitive responses, decision to behave in a specific way). The current review aims at integrating the theoretical assumptions on desire thinking within the EIT [10, 34] and S-REF [38–40] into the I-PACE model [42, 43]. Further, we briefly review the literature on desire thinking in the context of internet-use disorders in order to justify the theoretical considerations with empiric findings. This shall assign a conceptual place for desire thinking within the I-PACE model and provide researchers with a framework around desire thinking that enables to derive testable research hypotheses.

Integration of Theoretical Assumptions and Empirical Findings

The theoretical composition of desire thinking’s place within the I-PACE model is illustrated in Fig. 3. In the following, we outline the assumed relations between desire thinking and other proposed constructs within the I-PACE model based on theoretical assumptions and empiric findings on desire thinking in internet-use disorders. Different from the formal model language in the EIT and more similar to the one within the S-REF model, boxes in the I-PACE model represent cognitive processes (i.e., cognitive activity rather than results from activity), whereas arrows indicate influential associations between cognitive processes on a structural level which may become stronger throughout the development and maintenance of specific internet-use disorders (see early and later stages in [42]).

Craving and Desire Thinking

From the view of the EIT [34], desire thinking is an essential part of the craving experience. That is, the outcomes of desire thinking (i.e., imagery and verbal thoughts) fuel the strength of the craving experience. This is not only stated in the EIT but is also reflected within the simulated enactment of an earlier appetitive experience in the grounded theory of desire [55], in the cognitive reprocessing within the dynamic

model of desire [56], or within the thought and imagery components of the Craving Experience Questionnaire [35]. The concepts of desire thinking and craving are therefore theoretically assumed [5, 34] and empirically supposed (e.g., [15, 30, 33]) to be intertwining constructs; wherefore, cognitive imaginal and/or verbal methods that interfere with desire thinking have repeatedly also led to a reduction of desire or craving (e.g., [29, 57–60]). In turn, the experience of a craving component (i.e., urge, associated deficit) may also activate (further) desire thinking, leading to an escalation of craving [5, 61, 62] which is indicated with bi-directional arrows between desire thinking and craving in Fig. 3. This conceptual distinction has allowed the development of the Desire Thinking Questionnaire [6] and further supports the formulation and testing of hypotheses on the relationship between desire thinking and craving (e.g., [15, 19, 33]). For the context of internet-use disorders, the impact of desire thinking on craving has been studied most frequently (see Fig. 3) and in the specific contexts of pornography use [27, 30]; gaming [27, 29]; shopping, social networks use, and gambling [27]; and the general use of the internet [5, 7, 33]. Worth highlighting is the experimental manipulation of desire thinking that caused craving even when controlling for baseline craving and perceived stress [33], indicative of the individual predictive power of desire thinking for craving. In turn, the components of craving may also activate desire thinking, either as an immediate reaction towards triggers or as a cognitive process paralleling and enfolding the craving experience [5, 40]. One study so far has investigated this inversed path and revealed a mediating effect of desire thinking components in the relation of experiencing urges to game and the subsequent decisions to do so [28].

Processing of Triggers and Desire Thinking

In the I-PACE model, a *perception* of internal and external triggers is designated to describe how stimuli might lead to affective and cognitive reactions within a person. Here, we propose to consider the *processing* of triggers because (1) several models of desire and craving imply that subconscious, automatic, or implicit processing of environmental and/or bodily experiences can result in a problematic behavior without awareness of the perception (e.g., [56, 63, 64]), and (2) this allows to derive hypotheses about how certain triggers may cause desire thinking in an expectational sense. Here, explorative interviews revealed that about two-thirds of participants used desire thinking to relieve negative emotions and thoughts, whereas about a third indicated to use it as a mean to experience gratification and positive sensations [65]. Finding gratification and compensation in desire thinking as a response to triggers is also postulated in the EIT ([34]; see Fig. 1). Further, the expectation of gratification and compensation is also mirrored in metacognitions about

desire thinking [66]. This duality of seeking gratification and compensating negative feelings from thinking styles or behaviors is borrowed from operant conditioning theories and therefore appears in various theoretical considerations on craving and specific behaviors (see [67, 68]). The suggested specification of the I-PACE model that integrates desire thinking therefore posits two entering pathways into desire thinking as a reaction towards internal and external stimuli: A *pleasure-oriented pathway* (mirroring gratifying expectations of desire thinking) and a *relief-oriented pathway* (mirroring compensating expectations of desire thinking). Empiric evidence for the *pleasure-oriented pathway* in the context of internet-use disorders may so far only be approximated by a study investigating novelty seeking as a predictor of desire thinking in a convenience sample wherein only 5.6% indicated the use of the internet as the desired target [7]. Nevertheless, this study gives a first impression that the temperamental constitution of seeking novel and exciting sensations seems to contribute to the mental simulation of experiences in order to experience gratification. The postulated *relief-oriented pathway* gathers two studies in the context of internet-use disorders that found mild bivariate correlations between desire thinking and psychological distress (e.g., depressive symptoms) among individuals playing internet games [26] and individuals using social networks problematically [20], indicative of a relation that cannot be interpreted causally. However, an investigation of desire thinking within a structural equation model revealed the idea that desire thinking may be used to alleviate negative mood states in the context of potentially addictive online activities [27]. Nevertheless, we propose that both entering pathways into desire thinking may become dysfunctional as one way or another, desire thinking may induce craving.

Inhibitory Control and Desire Thinking

The problematic use of online activities likely incorporates features such as diminished control over the behavior, indicated by an escalated use over time and failing attempts to limit the use [69]. From the perspective of current models of problematic internet use, these behavioral phenomena might be manifested in cognitive failures including impaired working memory, maladaptive decision-making, and diminished inhibitory control [42, 70] which may be considered both a consequence and vulnerability factor for addictive behaviors [71]. The I-PACE model differentiates between a more general inhibitory control and a stimulus-specific inhibitory control. Whereas general inhibitory control can be understood as trait-like self-regulatory capabilities, the stimulus-specific inhibitory control may be affected by affective and cognitive mechanisms (e.g., craving, desire thinking) due to neural changes in reward-related circuits [71, 72] in situations in which addiction-related cues are present. General

inhibitory control is treated differently within the here postulated specification of the I-PACE model with regard to desire thinking and craving. We postulate that general inhibitory control may have a direct effect on desire thinking but that its mode of action with regard to craving has a moderating nature as proposed in the I-PACE model (see Fig. 3). That is, general inhibitory control may unfold its effect right before or during desire thinking as associated executive functions (e.g., attention and monitoring [73]) can modulate working memory content and shift attentional resources that aim at elaborating on desire-related thoughts. However, with urges and a sense of deficit becoming overwhelming, general inhibitory control might have a moderating role in preventing the enactment of the desired activity. Reductions in stimulus-specific inhibitory control may equally be initiated by desire thinking and craving in advanced stages of addiction where altered neural reward circuits may become less influenceable by top-down control processes [12, 45, 74]. Regarding desire thinking in the context of problematic internet use, a structural equation model indicates a medium direct effect of difficulties in emotion regulation on desire thinking and a significant mediation effect of desire thinking in the relation between dysregulated emotionality and problematic internet use, indicating that low capabilities to regulate negative emotions might be a vulnerability factor for desire thinking as a mean to regulate mood [31•]. For reductions in stimulus-specific inhibitory control due to desire thinking, results are still pending for the context of internet-use disorders. At the same time, findings on diminished stimulus-specific inhibitory control due to craving and cue reactivity are steadily increasing for the context of internet-use disorders (e.g., [75, 76]), providing first impressions that investigations on desire thinking and inhibitory control might be beneficial.

Specific Behaviors and Desire Thinking

Desire thinking encompasses processes of episodic future thinking but also the recall of target-related memories that shall activate and prepare the individual to acquire the desired target. For behaviors that are unproblematic, this mental preparation serves a harmless yet substantial motor of human motivation as they enable the individual to foresee the beneficial consequences of the behavior. However, if directed towards behaviors that are in conflict with other obligations or that are harmful to the individual, desire thinking may promote decisions to enact these behaviors although they might not be wanted. According to EIT, two cycles are involved in the behavioral enactment of desire thoughts. First, desire thoughts allow the individual to partially fulfill craving by the simulation of pleasure or relief through imagery-related processes [11, 34]. This pleasure and relief (or gratification and compensation, respectively;

see Figs. 1 and 3) may have previously been learned from the actual behavior itself and simulate, albeit to a lesser extent, the same gratification and compensation that may be experienced from the behavior. This again may cause more desire thoughts to arise. Second, the simulated gratification and compensation creates a mental gap between the imagined scenario (e.g., how good it would feel to game right now) and the actual situation (e.g., sitting in a meeting and not being able to play). This comparison between the imagined and actual situation creates a sense of associated deficit (see Fig. 1) which may be understood as a state of discomfort or withdrawal and may either be mitigated by more desire thoughts or by engaging in the behavior [34]. Through these two cognitive cycles, desire thinking may enfold a powerful force to induce craving as stated in the EIT [34] and S-REF [40] and may further motivate specific behaviors as postulated in the I-PACE model [42] which has been shown for in-the-moment alcohol drinking behaviors [77]. In the context of internet-use disorders, only one study has investigated the effect of desire thinking in accelerating an initial urge and promoting decisions to game despite other competing activities [28]. Further studies in this context could benefit the research in disentangling the specific mechanisms that constitute the relation between desire thinking and specific behaviors. That is, further studies could address the question of how and under which conditions specific metacognitions, the experience of gratification/compensation due to desire thinking, and reward/relief craving interact in predicting specific behaviors.

Metacognitive Beliefs, Use Expectancies, and Desire Thinking

Metacognition is constituted by knowledge about and cognitive processes involved in monitoring, appraising, and regulating cognition which could more colloquially be described as thinking about thinking or knowing about knowing [78]. Broadly, two subtypes of metacognitions can be distinguished that differentiate between the mere knowledge about cognition and strategies or beliefs about how to regulate it [79]. More specifically, metacognitive beliefs in the context of addiction have been conceptualized in the S-REF model modified for addictive disorders [39, 40] and refer to the beliefs that are held about specific coping mechanisms in regulating inner cognitive-affective events [37, 80] one of which is desire thinking (see Fig. 2). Theoretical considerations and subsequent pathway model testing in the context of problematic internet pornography use and internet use in general revealed that positive metacognitive beliefs about desire thinking (e.g., “Imagining the desired activity makes me feel energized and ready to act.”) may activate desire thinking processes, whereas desire thinking may in turn lead to negative metacognitive beliefs (e.g., “I cannot avoid

thinking about a desired activity/object when it comes to my mind.”) [5, 30, 66]. Similar to how metacognitions describe beliefs about cognitive strategies in regulating inner cognitive-affective states, use expectancies refer to the evaluation of an anticipated behavioral outcome and are beliefs that a specific behavior or activity might regulate these states [81, 82]. The term metacognitive beliefs is also used to describe beliefs about certain coping strategies (e.g., [83, 84]) that equally subsume behaviors and cognitive styles. This, however, creates a discrepancy between the mere definition of metacognitions (cognition about cognition) and its application in certain contexts (e.g., cognition about the usefulness of a certain behavior). We therefore claim to use the term metacognitive beliefs exclusively for beliefs that are hold about the *usefulness of a cognitive style* (e.g., “Desire thinking/worrying/ruminating will help me cope.”) and to use the term use expectancy (also outcome or reward expectancy) to describe specific beliefs concerning the *usefulness of a behavior* to experience gratification and/or compensation (e.g., “Playing a video game will help me cope.”). To clarify this distinction between cognition and metacognition, specific metacognitive beliefs are placed in a separate box in the I-PACE model as proposed here (see Fig. 3). As for the relation between these constructs, we propose a bidirectionality between metacognitive beliefs about desire thinking and outcome expectancies about the usefulness of a certain behavior (see Fig. 3). That is, specific metacognitive beliefs about desire thinking may influence use expectancies of the actual behavior and vice versa. Also, as adapted from the I-PACE model [42, 43], we assume a bidirectional relationship between specific metacognitive beliefs and affective and cognitive biases. Regarding the empiric verification of these relationships there is a research paucity in the context of internet-use disorders. However, research in the context of substance-use disorders points to a considerable interaction between metacognitions and reward sensitivity [e.g., [85].

Conclusions and Future Directions

We theoretically propose and empirically embed a place for desire thinking within the I-PACE model [42, 43] in the realm of internet-use disorders including gaming [26–29], pornography viewing [27, 30], social networks use [20, 27], shopping and gambling [27], and the general use of the internet [5, 7, 31•, 32, 33]. Evidence suggests a close link between desire thinking and aversive triggers, where desire thinking might be used as a maladaptive coping mechanism. Besides this *relief-oriented* pathway, we here propose another *pleasure-oriented* pathway of entering the mode of desire thinking, which both need further empiric investigation. Examining several motivations for entering desire thinking are crucial in understanding and preventing

maladaptive desire thoughts that result in irresistible craving experiences and may contribute to unwanted behaviors. For the specific context of internet-use disorders, a close link between desire thinking and craving has been observed. Therefore, desire thinking may provide an important leverage point for therapeutic interventions. Moreover, the experienced compensation due to desire thinking might be an indicator for its dysfunctional character. Further studies could therefore investigate the roles of experienced gratification and compensation due to desire thinking in the course of addiction development and maintenance, how these experiences contribute to specific metacognitive beliefs about desire thinking, and how this spiral of experiencing pleasure/relief and forming expectations about desire thinking may be interrupted.

Author Contribution AB reviewed the literature; AB, SA, AC, and MB substantially contributed to model conceptualization; AB conceptualized and wrote the first draft of the manuscript; SA, AC, and MB critically revised the manuscript; all authors approved the final version to be published.

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Code Availability Not applicable.

Declarations

Conflict of Interest MB receives (to University of Duisburg-Essen) grants from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), the German Federal Ministry for Research and Education, the German Federal Ministry for Health, and the European Union. MB has performed grant reviews for several agencies; has edited journal sections and articles; has given academic lectures in clinical or scientific venues; and has generated books or book chapters for publishers of mental health texts. AB, SA, and AC have no conflicts of interest to declare.

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A Preregistered, Systematic Review Considering Mindfulness-Based Interventions and Neurofeedback for Targeting Affective and Cognitive Processes in Behavioral Addictions

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Psychological core processes that underpin disorders due to addictive behaviors, including craving, inhibitory control, maladaptive decision-making, and cognitive biases, are important factors to target and modify in interventions. Mindfulness-based and neurofeedback techniques have been particularly promising interventions. The aim of the present systematic review (PROSPERO ID: CRD42020200113) was to evaluate the research evidence on their effectiveness for behavioral addictions. Empirical intervention studies in the realm of nonsubstance addictive behaviors fulfilled the inclusion criteria, which led to 15 studies and 297 participants being included in this review among PubMed, Scopus, and Web of Knowledge. Results suggest that mindfulness-based interventions are effective in reducing mental distress and craving reactions. Reductions in craving levels were reported in four of six studies with biggest effects for mindfulness-based cognitive therapy and mindfulness-enhanced cognitive behavioral therapy. Successful reductions in mental distress were identified in five of seven studies that used diverse mindfulness-based techniques. However, no more than one study on mindfulness-based interventions reporting improvements in self-control, inhibitory control, maladaptive decision-making, and cognitive biases could be identified. No research could be found on neurofeedback. This review highlights the potential of mindfulness interventions for these disorders, and the specific mechanisms of therapeutic change warrant further investigation.

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Public Health Significance Statement

Mindfulness-based interventions may reduce mental distress and craving reactions. Mindfulness-based cognitive therapy and mindfulness-enhanced cognitive behavioral treatment show the largest effect for gaming and gambling disorder. No study on neurofeedback was identified in the present context.

Keywords: addictive behaviors, mindfulness, intervention, neurofeedback, affective/cognitive mechanisms

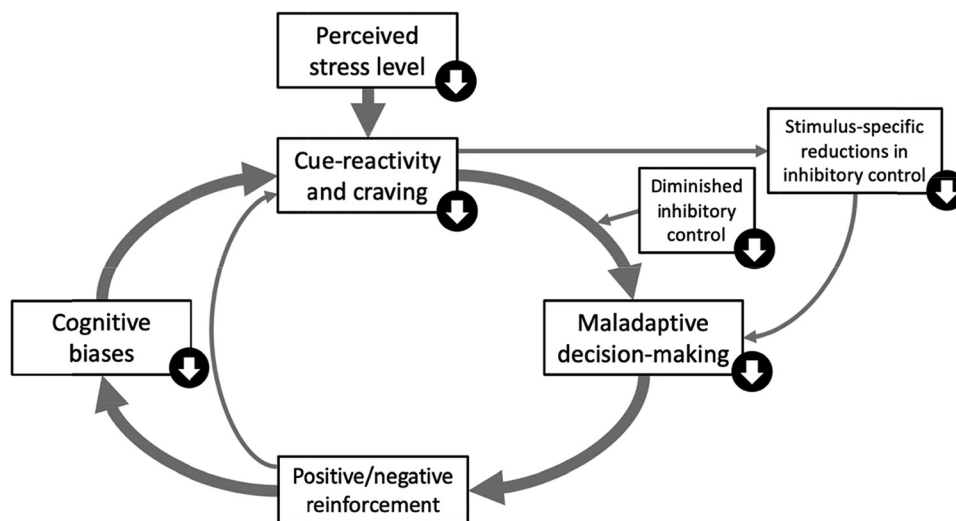
Addictive disorders are characterized by poorly controlled and repeated engagement in specific behaviors, strong cravings in their absence, and continued engagement despite negative consequences. Until the 1980s, with the recognition of gambling disorder in the third edition of the *Diagnostic and Statistical Manual of Mental Disorders*, “addiction” had been primarily associated with dependence on psychotropic substances (e.g., alcohol and other drugs; Holden, 2001). In recent years, research has considered a wider range of non-substance-based addictive behaviors, including gambling (Potenza, 2006) and video gaming (King et al., 2020). One rationale for considering these behaviors as addictive has been research identifying common neurocognitive mechanisms underlying the development and maintenance of substance use disorders (SUDs) and nonsubstance addictive behaviors (e.g., Brewer & Potenza, 2008; Kiefer et al., 2013). Psychological core processes proposed to underpin the development and maintenance of nonsubstance addictive behaviors are described in several models of behavioral addictions (e.g., Brand et al., 2019; Dong & Potenza, 2014; Wei et al., 2017). That is, these models integrate neurocognitive findings and theories from the field of SUDs, such as the *impaired response inhibition and salience attribution* (Goldstein & Volkow, 2011), *incentive sensitization theory* (Berridge & Robinson, 2016; Robinson & Berridge, 2008), and/or *reward deficiency syndrome* models (Blum et al., 1996), and adapt and transfer them into the context of nonsubstance addictive behaviors where they provide theoretical frameworks that facilitate investigation of these processes. As such, the interaction of person-affect-cognition-execution (I-PACE) model (Brand et al., 2019, 2016) derives, integrates, and highlights these psychological core processes (see also Figure 1). It postulates that the perception of internal and external triggers (e.g., stress) may facilitate the allocation of attentional resources toward addiction-related cues, provoking cue reactivity and craving responses. If these craving reactions become strong enough and ability or willingness to inhibit approach tendencies toward the target become diminished, a decision to engage in the behavior may be more likely to occur. Such decisions may over time lead to habitual behaviors and related motivations linked to predominance of reward system inputs in the setting of decreased top-down cognitive control (e.g., Brewer & Potenza, 2008; Everitt & Robbins, 2005; Koob & Volkow, 2010). With the experience of positive and/or negative reinforcement through the behavior, reward anticipation processes may become modified in that cognitive biases toward target-associated cues become more pronounced (Wiers & Stacy, 2006). These alterations may in turn mobilize attentional resources and therefore facilitate the perception of target-associated stimuli. Thus, proposed core processes (i.e., stress responsiveness, craving,

inhibitory control, decision-making, and cognitive biases) that are individually determined may interact and promote engagement in addictive behaviors.

Research on these cognitive mechanisms, among other important lines of evidence (e.g., phenomenological, epidemiological, and treatment studies), has supported the classification of gaming and gambling disorder as disorders due to addictive behaviors (Petry et al., 2015; Potenza, 2006; Potenza et al., 2009; World Health Organization, 2019). The validity of other proposed disorders due to addictive behaviors, such as buying-shopping disorder (Müller et al., 2019), compulsive sexual behaviors (Mauer-Vakil & Bahji, 2020; Potenza et al., 2017), and the use of specific internet applications, referred to as specific internet-use disorders (Brand et al., 2019, 2016), is currently under debate (Brand et al., 2020). Nevertheless, data suggest that interactions of proposed core mechanisms contribute importantly to problematic pornography use and other sexual behaviors (e.g., Antons & Brand, 2020; Chen et al., 2018; Stark et al., 2018), buying and shopping (e.g., Kyrios et al., 2018; Trotzke et al., 2020), and social networks use (e.g., Wegmann et al., 2020), consistent with potential classification as disorders due to addictive behaviors (Brand et al., 2020; Choi et al., 2019). Thus, the identification of core processes and their interactions in nonsubstance addictive behaviors is necessary not only for understanding their addictive potential but also for potentially using them as targets for clinical interventions (e.g., Dong & Potenza, 2014). Promising evidence for the usefulness of mindfulness and neurofeedback techniques in tackling the neurocognitive mechanisms of behavioral addictions stems from research in the context of SUDs (for reviews, see Garland & Howard, 2018; Martz et al., 2020; Sunder & Bohnen, 2017) where both techniques are considered successful in treating addictions.

Derived from Buddhist traditions, mindfulness has been transferred to secular contexts where it is defined as a state where an individual pays attention, on purpose, in the present moment, and in a nonjudgmental way (Kabat-Zinn, 1994). However, the term “mindfulness” is sometimes used ambiguously in scientific literature as it is similarly used to describe practices and a trait. Therefore, Garland and Howard (2018) proposed a differentiation of the state of mindfulness (i.e., a state of being metacognitively aware of inner processes), the practice of mindfulness (i.e., techniques that aim at attending to and observing thoughts, physical and emotional states), and dispositional mindfulness (i.e., stable quality to be mindful even when not practicing). For the purpose of this review, mindfulness techniques can be described as a group of varied and related practices that derive from different streams of contemplative traditions. These include, though are not limited to, Hinduism and Theravada, Mahayana, and Vajrayana Buddhism (Wielgosz et al.,

Figure 1
Proposed Effects of Mindfulness and Neurofeedback Techniques on Psychological Core Mechanisms in Nonsubstance Addictive Behaviors



Note. The figure represents the inner circle of the I-PACE model (Brand et al., 2019); arrows pointed downward indicate our hypotheses of expected downregulation of dysfunctional affective and cognitive processes.

2019). The practice of mindfulness is proposed to involve two main elements (i.e., focused attention and open monitoring; Lutz et al., 2008). Focused attention may include different tools and techniques that utilize internal or external attention in either a focused or distributed fashion (Amihai & Kozhevnikov, 2015), whereas open monitoring has no specific focus on objects and rather refers to a nonreactive metacognitive awareness (Lutz et al., 2008). Mindfulness techniques became more widespread and recognized as a therapeutic approach in the late 1980s with the popularization of mindfulness-based stress reduction (MBSR; Kabat-Zinn et al., 1985, 1984). MBSR inspired the development of various mindfulness-based interventions (MBIs) specific to addictive disorders such as mindfulness-based relapse prevention (Bowen et al., 2009; Witkiewitz et al., 2005), mindfulness-oriented recovery enhancement (Garland, 2016), and mindfulness-based cognitive therapy, which has affect-regulating elements to assist the treatment of addictions (Hoppe, 2006). The mode of action of these techniques, from a neurocognitive perspective, may relate to targeting underlying mechanisms that create and sustain addictive behaviors, particularly for individuals sensitive to stress and affective concerns (Brewer et al., 2010). For instance, research suggests that, through faster and more reliable sensing of somatic sensations or arousal, mindfulness practices might mobilize self-regulatory resources (Posner et al., 2007; Tang et al., 2015) and augment emotion regulation (Tang et al., 2016; Teper et al., 2013), which may be advantageous when managing states of desire and craving (Bowen et al., 2009; Tapper, 2018). Besides the awareness of the immediate experience, mindfulness practices teach acceptance of current feelings and circumstances and allow individuals to nonreactively and nonjudgmentally tolerate rather than resist or deny these sensations (Baer et al., 2006; Marlatt, 1994). This way, some MBIs may encourage a relief from suffering and stress (Bowen et al., 2009; Vallejo & Amaro, 2009; Witkiewitz et al., 2005). Since the experience of stress is a strong predictor of craving and continued addictive behaviors (Law

et al., 2016; Reichenberger et al., 2021; Sinha et al., 2006), strengthening the capacity to cope with stress, implementing self-care habits, and promoting more skillful behavioral decisions may decrease the risk for relapse and enhance psychological well-being (Bowen et al., 2009; Vallejo & Amaro, 2009). Moreover, meditative aspects in practicing mindfulness refer to self-regulation methods. Thus, awareness is practiced in order to deliberately control cognitive processes and regulate attention (Walsh & Shapiro, 2006), which may strengthen the ability for inhibitory control and executive function.

Neurofeedback is another technique that systematically considers neurocognitive mechanisms of addictions. As a form of biofeedback that measures brain activity and provides real-time feedback, neurofeedback aims to change cognitive responses (Hammond, 2011). From a systems-level perspective, it enables participants to view and learn from an interpreted version of their brain-activity data. Thus, neurofeedback is a noninvasive neuro-modulation training technique to systematically measure and self-regulate potentially pathological neural activity patterns with an aim of improving perception, cognition, attention, and/or behavior through the optimization of brain activity. Brain regions implicated in addictions and that may be controlled volitionally with the help of neurofeedback include self-regulatory hubs such as the anterior cingulate cortex (e.g., Canterberry et al., 2013; Tang et al., 2015), posterior cingulate cortex (e.g., Garrison et al., 2013), and prefrontal regions (e.g., Sherwood et al., 2016), as well as reward- and emotion-processing areas including the ventral striatum (e.g., Kirsch et al., 2016), amygdala (e.g., Paret et al., 2016), and anterior insula (e.g., Yao et al., 2016). Regarding the regulation of neural activity in these areas, it may be differentiated between the upregulation and downregulation of certain brain activity patterns involved in prefrontal-limbic-striatal addiction circuitry (Dickerson, 2018). For example, downregulation training techniques addressing neurocognitive mechanisms in addiction that are

associated with subcortically driven impulsive systems, such as cue reactivity and craving (Hanlon et al., 2013; Hartwell et al., 2016; Karch et al., 2019; Kirsch et al., 2016), have been investigated in order to weaken a hyperreactive reward system toward addiction-related cues and weaken impulses or craving responses. The approach of upregulating certain brain activity is rooted in the theory that whereas drug-related stimuli become increasingly salient throughout the process of becoming addicted, activities that had previously been enjoyed and served as naturally rewarding reinforcers become devalued (Volkow et al., 2011). By extension, systematically training individuals with addictions to upregulate neural responses toward non-drug-related cues, perhaps involving the substantia nigra and ventral tegmental area and connected cortical and limbic regions, has been described as a promising technique for cocaine use disorder and possibly other addictions (Kirschner et al., 2018).

Although both mindfulness and neurofeedback techniques share a strategy of focusing attention, they are shaped by slightly different foci or targets of intervention, which make them interesting objectives for comparison in the context of treating behavioral addictions. Notably, mindfulness techniques promote awareness and acceptance of inner mood states and thoughts. Therefore, the aim is the acceptance of cognitions and emotions rather than changing them. Oppositely, neurofeedback techniques specifically aim at changing these affective and cognitive responses such that the individual gains control over cognitive and emotional processes with the clear aim of regulating them.

The purpose of this article was to systematically review and evaluate the evidence base on several mindfulness-based and neurofeedback interventions in the specific context of cognitive and affective processes involved in disorders due to nonsubstance addictive behaviors. This aim discriminates this systematic review from existing reviews that addressed mindfulness techniques among addiction in general (e.g., Rosenthal et al., 2021), focused on one specific behavioral addiction (e.g., de Lisle et al., 2011), or evaluated generic health outcomes rather than addiction-specific processes (e.g., Sancho et al., 2018). Specific research questions addressed (a) the nature of mindfulness and neurofeedback techniques, (b) the effectiveness of these techniques in influencing addiction-related affective and cognitive mechanisms (i.e., stress responsiveness, craving, inhibitory control, decision-making, and cognitive biases; see Figure 1), and (c) effects of these techniques on symptom severity in the realm of gaming disorder, gambling disorder, problematic use of social media, problematic pornography use and other compulsive sexual behaviors, and problematic buying-shopping. The position of this review was that the potentially addictive character of these phenomena is supported due to the similar neurocognitive processes in addictive disorders that are observable among them (e.g., Brand et al., 2019; Choi et al., 2019; Leeman & Potenza, 2013). Further, the consideration of poorly controlled eating as an addiction and food as an addictive substance is discussed (e.g., Albayrak et al., 2012; Gearhardt et al., 2011; Schulte et al., 2017). Given that the intake of substances (e.g., sugar, fat) is essential to these behaviors and therefore distances them from nonsubstance addictive behaviors, we decided not to focus on food/eating addiction in the current review. Moreover, we do not consider here other potentially addictive or compulsive behaviors (e.g., hoarding, punding, hobbyism) that might occur in the setting of neurological disorders (e.g., in Parkinson's disease

and restless legs syndrome) and their treatment with dopaminergic and other types of medication treatments.

Method

The protocol for the present systematic review was preregistered on PROSPERO (available from https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020200113). PROSPERO adheres to the PRISMA guidelines (Moher et al., 2009).

Search Strategy and Study Selection

Two researchers independently searched the electronic databases PubMed, Scopus, and Web of Knowledge for peer-reviewed articles published from January 1, 1985, to December 20, 2020. The search was conducted among abstracts and titles using the search terms as depicted in Table 1. In the database PubMed, the MeSH term "behavioral addiction" was also used. Search terms reflecting the intervention methods (e.g., mindfulness, meditation), the extent of the behavioral problem (e.g., addict*, problem*), and the specific addictive behaviors (e.g., videogam*, gamb*) were combined within parentheses using a Boolean OR. These parenthesized entities were combined using a Boolean AND. In addition, we searched the reference lists of retrieved articles. The identification and selection process, including abstract and full text review of identified studies, was performed by three independent researchers. Figure 2 presents the identification and selection process. Articles were excluded if they were not empirical, not written in English, did not involve an intervention, or did not deal with nonsubstance addictive behaviors. Further, this review focuses on studies that consider mindfulness-based and neurofeedback techniques as independent treatment options; therefore, we did not consider treatments that solely integrate mindfulness or neurofeedback techniques as an element. However, a combination with another treatment option was accepted if both interventions are distinct, separable treatments. Finally, we identified 15 relevant studies.

Effect Interpretation and Effect Size Calculations of Interventions

Significant decreases in maladaptive affective and cognitive mechanisms were indicated in cases where authors interpreted their results as significant decreases, for example, based on significant *t* tests, significant analysis of variance or analysis of covariance interaction effects, or significant *Z* statistics. Additionally, we provided effect sizes for the specific mindfulness interventions on psychological core processes, which we decided to calculate on the basis of raw descriptive statistics provided in the manuscripts (means and standard deviations). Therefore, we screened each of the studies (except for case studies) and contacted the corresponding authors if descriptive statistics were missing. In cases with missing descriptive statistics, we marked the respective effect in Table 2 with a superscript "a." According to the recommendation of Dunlap et al. (1996), effect sizes for the pre-to-post measurements were calculated as independent variables instead of dependent variables as effect sizes for the latter are often overestimated. Although we extracted data from the manuscripts, we decided to not proceed to a meta-analysis since the studies we found were not homogenous enough.

Table 1
Search Terms and Their Boolean Combination

“mindfulness”	OR	AND	“addict*”	OR	AND	“gaming”	OR
“mindful”	OR		“disorder*”	OR		“videogam*”	OR
“meditation”	OR		“problem*”	OR		“video gam*”	OR
“meditate”	OR		“pathologic*”	OR		“video-gam*”	OR
“MBSR”	OR		“compulsive”	OR		“gamb*”	OR
“MBCT”	OR		“hyper*”	OR		“porn*”	OR
“IBMT”	OR		“impulsive”	OR		“cybersex”	OR
“breathing”	OR		“excessive”	OR		“cyber-sex”	OR
“breath counting”	OR		“obsessive”	OR		“cyber pornography”	OR
“body scan”	OR		“dependen*”	OR		“cyber-pornography”	OR
“neuro-feedback”	OR					“sexual*”	OR
“neuro feedback”	OR					“sex addiction”	OR
“neurofeedback”	OR					“sex-addiction”	OR
“EEG biofeedback”	OR					“sex dependency”	OR
“EEG-biofeedback”	OR					“buying”	OR
“EEG feedback”	OR					“shopping”	OR
“EEG-feedback”	OR					“social media”	OR
“fMRI feedback”	OR					“social networks”	OR
“fMRI-feedback”	OR					“facebook”	OR
“fMRI biofeedback”	OR					“whatsapp”	OR
“fMRI-biofeedback”	OR					“instagram”	OR
“ERP biofeedback”	OR					“twitter”	OR
“ERP-biofeedback”	OR					“communication”	OR
“ERP feedback”	OR					“internet”	OR
“ERP-feedback”	OR					“mobile phone”	OR
						“smartphone”	OR

Note. In the database PubMed, the MeSH term “behavioral addiction” was also used.

* Indicates wildcard for every possible word ending.

Results

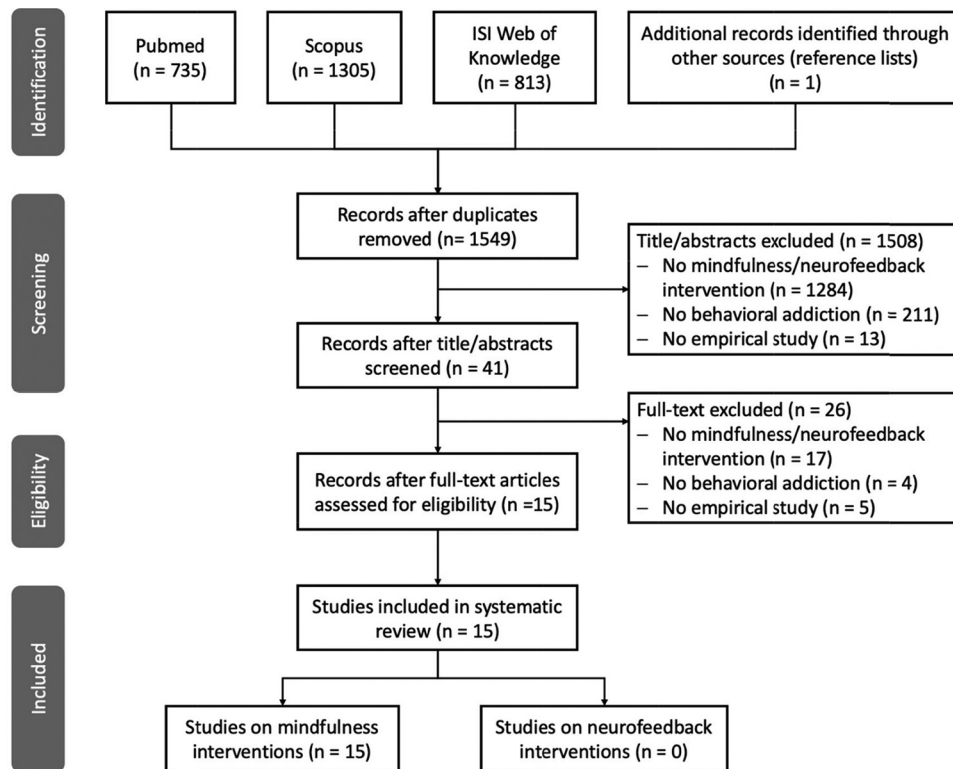
The 15 identified studies included solely research on mindfulness-based programs. We did not identify any studies investigating effects of neurofeedback either based on electroencephalography or functional MRI, in any kind of behavioral addiction. Among the included studies were eight randomized controlled studies, two controlled studies, two cohort studies, and three case studies. Studies considered gambling ($n = 7$), gaming ($n = 3$), general use of the internet or smartphone usage ($n = 4$), and sexual behavior ($n = 1$). The included studies are shown in Table 2, sorted by their experimental design and case studies, respectively. In total, 297 participants were pooled in the included studies (respective subsamples of each study can be seen in Figure 3). The last two columns indicate changes in psychological processes and symptom severity from immediately before to immediately after mindfulness interventions. In the following, we count the studies of Li et al. (2018, 2017) as one as they were conducted on the basis of the same sample. Figure 3 summarizes the number of studies and effectiveness of mindfulness interventions among all studies with regard to psychological core mechanisms and under consideration of measured values collected immediately before and immediately after the interventions. In the following, we also considered follow-up results where they were conducted and provided.

Mindfulness and Craving

Six studies investigated the potential effects of mindfulness on craving, with a focus on gambling ($n = 4$) and gaming ($n = 2$). Li et al. (2018, 2017) studied mindfulness-oriented recovery enhancement that includes formal mindfulness training, third-wave cognitive

behavioral therapy (CBT), and principles from positive psychology. The authors adapted the program regarding the symptoms and underlying mechanisms of gaming disorder and tested it against a control intervention that focused on group discussions regarding participants' experiences, feelings, and thoughts. Within-group comparisons did not reveal significant decreases in craving in the experimental group. However, an interaction effect reported by Li et al. (2017) indicates that the mindfulness-oriented recovery enhancement treatment group showed significantly greater reductions in craving at 3-month follow-up compared to the control group. In their sample of individuals with gambling problems, Shead et al. (2020) reported an interaction effect for the mindfulness-based meditation exercise, conducted daily for 1 week, and observed a significant decrease in craving in their treatment group compared to an audiobook control group from pre- to postassessment. A more traditional approach was investigated by Toneatto et al. (2014). The authors utilized a five-session mindfulness-enhanced cognitive behavioral treatment (MECBT), with each session consisting of a 45-min CBT followed by a 45-min mindfulness session and additional daily practice at home. A waitlist served as the control group condition. Results showed a significant decrease in gambling urges within the treatment group from pre- to postassessment. Melero Ventola et al. (2020) described similar findings by reporting significant reductions in craving from before to after a mindfulness-based cognitive therapy among individuals with gambling disorder in a noncontrolled design. In a CBT-resistant patient with gambling disorder, von Hammerstein et al. (2018) found promising effects with regard to craving reductions during combined mindfulness-based relapse therapy. Further, van der Tempel et al. (2020) tested the therapeutic potential of a 10-week MBI in individuals with gambling problems. The treatment was originally developed

Figure 2
Flow Chart of Identified Articles and Exclusions



for social anxiety (Kocovski et al., 2009) and was modified for gambling triggers and urges. Levels of urges from immediately before to immediately after the treatment did not show significant reductions. However, average daily craving ratings between the sessions during Week 10 of the treatment were significantly lower than average daily cravings during Week 1.

Mindfulness and Cognitive Bias

Only one study focused on cognitive biases in the context of gambling. For their MBI, van der Tempel et al. (2020) reported longer reaction times in a gambling Stroop task toward gambling-related cues compared to neutral cues at pre- and postassessment. However, they did not report reductions in a gambling cognitive bias during the course of treatment. A difference was observed in reaction times toward gambling and neutral cues from pre- to post-treatment. This appeared to be mainly driven by a decrease in variability in reaction times at postassessment and may suggest a cognitive shift toward neutral cues.

Mindfulness and Inhibitory Control

Two studies examined inhibitory control in the context of gambling and smartphone use. Choi et al. (2020) tested the effect of a 12-week mindful subtraction meditation intervention on problematic use of smartphones in high school students, conducted twice a week for 20 min. The authors found increases in self-rated long-term and instant self-control among the experimental group in the

course of treatment but not within a control group. In contrast, von Hammerstein et al. (2018) did not find decreases in self-reported impulsivity measures in their patient with gambling disorder. No study investigated the effects on stimulus-specific reductions in inhibitory control (see Figure 3).

Mindfulness and Decision-Making

Two studies considered maladaptive decision-making among people with gaming and gambling disorders. Shead et al. (2020) hypothesized but did not find a significant interaction effect of decision-making as measured with a monetary delay discounting task when comparing the meditation and audiobook groups from pre- to postassessment. However, Shead et al. (2020) did not differentiate between individuals with and without gambling problems. Yao et al. (2017) investigated effects of a 6-week group-based combined reality therapy and mindfulness meditation in people with problematic gaming behavior. A healthy control group did not play games. Decision-making was measured with a delay discounting task and the balloon analogue risk task. Results indicated a significant decrease in delay discounting following treatment, whereas there was no change in performance in the control group. For the balloon analogue risk task, no significant interaction effects were found.

Mindfulness and Stress

Seven studies investigated the effects of mindfulness interventions on stress. Among those, five studies operationalized stress as

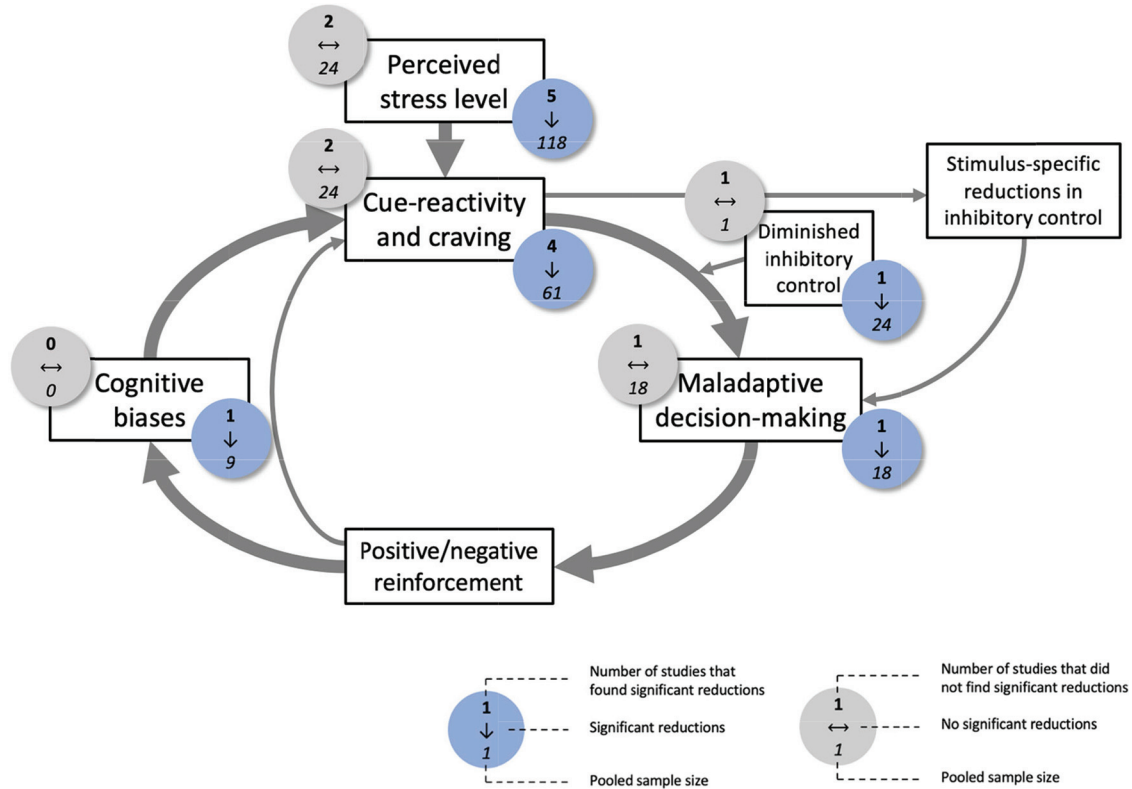
Table 2
Overview of All Included Intervention Studies and Their Effects on Psychological Processes and Symptom Severity

Authors	Behavior	Intervention	Subjects	Duration	Psychological processes	Symptom severity
Randomized Controlled studies Lan et al. (2018)	Smartphone	Mindfulness-based cognitive behavioral intervention	$n = 27$ ($M_{age} = 21.10$, $SD = 1.7$)	8 weeks, weekly, 60 min		$\rightarrow d = -0.44$
Li et al. (2018, 2017)	Gaming	Mindfulness-oriented recovery enhancement	$n = 15$ ($M_{age} = 25$, $SD = 5.4$)	8 weeks, weekly, 120 min	C $\leftrightarrow d = -0.26$	$\downarrow d = -2.17$
McIntosh et al. (2016)	Gambling	Mindfulness meditation	$n = 28$ ($M_{age} = 36.64$, $SD = 9.65$)	S \leftrightarrow $d = -0.20$ 8 weeks, weekly, N/A	S \downarrow $d = -0.44$	$\downarrow d = -1.65$
Quinones and Griffiths (2019)	Internet	Mindfulness meditation	$n = 64$ ($M_{age} = 41$)	2 weeks, daily, 10 min	S \downarrow $d = -0.26$	\downarrow $d = -0.26$
Shead et al. (2020)	Gambling	Mindfulness-based meditation	$n = 18$ ^b	1 week, daily, 10 min	MDM \leftrightarrow $d = -0.26$	\downarrow $d = -1.32$
Toneatto et al. (2014)	Gambling	Mindfulness-enhanced cognitive behavioral therapy	$n = 9$ ($M_{age} = 41.67$, $SD = 10.95$)	C \downarrow $d = -0.26$ 5 weeks, (bi-) weekly, 45 min	C $\downarrow d = -1.46$	$\downarrow d = -1.32$
Controlled studies Choi et al. (2020)	Smartphone	Mind subtraction meditation	$n = 24$ ($M_{age} = 16$)	12 weeks, twice a week, 20 min	S $\downarrow d = -1.11$	$\downarrow d = -0.65$
Yao et al. (2017)	Gaming	Reality therapy and mindfulness meditation	$n = 18$ ($M_{age} = 22.28$, $SD = 1.62$)	DIC \downarrow $d = -0.67$ 6 weeks, weekly, 120 min	MDM \downarrow $d = -0.82$	$\downarrow d = -1.7$
Cohort studies Ke and Shih-Tsung (2019)	Smartphone	Mindfulness smart-phone app	$n = 21$ ($M_{age} = 18-25$)	8 weeks, daily, autonomous	C $\downarrow d = -4.57$	$\downarrow d = -0.58$
Melero Ventola et al. (2020) ^b	Gambling	Mindfulness-based cognitive therapy	$n = 33$ ($M_{age} = 41.91$, $SD = 11.67$)	8 weeks, weekly, 120 min	C $\downarrow d = -4.57$	$\downarrow d = -0.58$
van der Tempel et al. (2020) ^b	Gambling	Modified version of a mindfulness manual for social anxiety	$n = 9$ ($M_{age} = 56.20$, $SD = 1.84$)	10 weeks, weekly, 150 min CB \downarrow $d = -0.34$	C $\leftrightarrow d = -0.17$ S $\leftrightarrow d = -0.25$	$\leftrightarrow d = -0.34$
Case studies de Lisle et al. (2011)	Gambling	Mindfulness based cognitive therapy	$N = 1$ (age = 61)	8 weeks, weekly, N/A	S \downarrow $d = -0.26$	\downarrow $d = -0.26$
van Gordon et al. (2016)	Sex	Meditation awareness training	$N = 1$ (age = early 30s)	10 weeks, weekly, 90 min	S \downarrow $d = -0.26$	\downarrow $d = -0.26$
von Hammerstein et al. (2018)	Gambling	Combined mindfulness-based relapse therapy	$N = 1$ (age = 59)	8 weeks, weekly, 120 min DIC \leftrightarrow $d = -0.26$	C \downarrow	\downarrow $d = -0.26$

Note. C = craving; CB = cognitive bias; DIC = diminished inhibitory control; MDM = maladaptive decision-making; S = stress level. \downarrow = significant decrease; \leftrightarrow = nonsignificant difference, based on the authors' interpretations.

^a Effect sizes could not be calculated due to missing descriptive values. ^b Values from Pression 2 were taken into effect size calculations. ^c Increase of difference between reaction time to gambling versus neutral cues from pre to post, as kindly made available by the authors, is $d = 0.33$. ^d Was measured with two paradigms; only delay discounting was significant. ^e Was measured as long-term and instant self-control; both were significant; effect size for instant self-control is reported. ^f Gambling behavior (i.e., frequency, expenditure, duration). ^g Psychological distress (e.g., anxiety, depression). ^h From a sample of both recreational and pathological gamblers; only the latter were included in this table.

Figure 3
Effects of Mindfulness Techniques on Psychological Core Processes in Nonsubstance Addictive Behaviors Found in This Review



Note. Figure is modified after Brand et al. (2019). See the online article for the color version of this figure.

psychological distress (i.e., anxiety and depression). However, rather being a vulnerability factor for experiencing a higher stress level, we decided to include psychological distress in our results. Li et al. (2018, 2017) did not find decreases in psychological distress during the course of treatment when comparing the experimental with the control group. Also, long-term effects on stress reductions in the follow-up assessments were not significant. In contrast, Choi et al. (2020) reported significant decreases in subjective stress among students who attended a school-based meditation program, but not in students who did not participate. McIntosh et al. (2016) compared a manualized CBT, a mindfulness-based approach, and an individually tailored CBT (treatment as usual) in a cross-over design. Group 1 started with the CBT (CBT-first), whereas Group 2 started with the mindfulness-based approach (MB-first), each with a 2-week “wash-out” period in between. The authors reported significant decreases in psychological distress for the CBT-first, MB-first, and treatment-as-usual groups at cross-over and postassessment. Quinones and Griffiths (2019) compared the effects of a brief mindfulness intervention (10 min) with a classic relaxation intervention and a waitlist control group on problematic internet use. They assessed psychological distress in terms of anxiety and depression and found that both the meditation and the relaxation group showed significantly lower postintervention scores than the control group. However, pre-to-post comparisons were not reported.

Mindfulness and Symptom Severity

Almost all experimental studies and all case studies found improvements with regard to symptom severity from immediately before to immediately after intervention, either in within-subject comparisons (Choi et al., 2020; de Lisle et al., 2011; Ke & Shih-Tsung, 2019; Li et al., 2018, 2017; McIntosh et al., 2016; Toneatto et al., 2014; Van Gordon et al., 2016; von Hammerstein et al., 2018; Yao et al., 2017) or in postintervention group comparisons (Quinones & Griffiths, 2019), except for van der Tempel et al. (2020) and Lan et al. (2018). Shead et al. (2020) and Melero Ventola et al. (2020) did not assess changes in symptom severity. Lan et al. (2018) assessed no psychological processes but only symptom severity. Their group mindfulness-based cognitive behavioral intervention included one 1-hr session per week for 8 weeks and aimed to reduce problematic use of smartphones. Although they did not find significant changes immediately after treatment, Lan et al. (2018) reported significant reductions in problematic smartphone use at 14-week and 20-week follow-ups.

Discussion

The present review evaluated the evidence on mindfulness-based and neurofeedback interventions in the area of addictive behaviors. Studies of mindfulness-based techniques that were identified in this

review included seven on gambling, three on gaming, four on general use of the internet or smartphone usage, and one on compulsive sexual behaviors. Surprisingly, we did not find any study that focused on neurofeedback in the context of affective and cognitive mechanisms in behavioral addictions. Most studies, and arguably the most consistent findings, suggest promising effects of mindfulness techniques in reducing stress and craving among people with nonsubstance addictive behaviors (see Figure 3).

The biggest reductions in craving levels after mindfulness intervention were reported after mindfulness-based cognitive therapy (Melero Ventola et al., 2020) and MECBT (Toneatto et al., 2014) for gambling, according to our effect size measures. These results support the efficacy of mindfulness techniques in the context of gambling disorder and align with reports on the effects that mindfulness techniques have on substance cravings (for an overview, see Schwebel et al., 2020). These findings support the notion that the effectiveness of the identified techniques might also generalize to other behavioral addictions since a similarity of underlying mechanisms is assumed (Brand et al., 2019, 2016). Therefore, the use of mindfulness-based cognitive therapy and MECBT might be promising to alleviate craving in the context of other behavioral addictions, and the experimental investigation of these effects is therefore encouraged. The reasons why mindfulness techniques may successfully impact craving may be considered within the context of existing theories. From the view of the elaborated intrusion theory of desire (Kavanagh et al., 2005), mindfulness techniques may distract the cognitive elaboration of desire by shifting attention away from the desired target toward present-moment awareness (Tapper, 2018), which might serve as a cognitive interruption technique by loading on working memory and occupying limited resources (Baddeley, 2000). Further, proposed mechanisms of action engage the parasympathetic nervous system (e.g., Tang et al., 2019), indicative of a calm and relaxed neurophysiological state that may facilitate awareness and acceptance of cognitive biases toward addiction-related cues as investigated by van der Tempel et al. (2020). However, the sample size in this study is limited to only nine participants wherefore effects are difficult to interpret. Nevertheless, research indicates a considerable link between emotional distress and mindfulness via cognitive biases (Ford & Shook, 2019), wherefore intervention studies addressing this linkage might also be promising in the context of behavioral addictions. Besides the beneficial effect of mindfulness in fostering awareness for such inner processes, this suggests that individuals may benefit if they are encouraged to understand that states of spontaneous cue responses and more elaborated craving experiences come and go like waves, which can be accepted (“surfing the urge”) as natural responses to desired targets (Baer, 2003).

The results for inhibitory control processes do not draw a clear pattern in our review. Besides one case study by von Hammerstein et al. (2018) who found no change in inhibitory control processes, only one study from Choi et al. (2020) suggests that subtraction meditation may upregulate general long-term self-control and also short-term (“instant”) self-control, which is limited to the context of smartphone use. However, this finding resonates with research describing beneficial effects of mindfulness on general self-regulatory processes (e.g., Tang et al., 2007; Vago & Silbersweig, 2012) that are underpinned by specific executive functions (i.e., working memory, inhibitory control, and mental set shifting; cf. Miyake et al., 2000) that may be impacted by mindfulness (e.g., Teper &

Inzlicht, 2013). An important mechanism that may explain the success of mindfulness in exerting self-regulation may involve the practice of attentional control, which is often cultivated in mindfulness meditations by focusing one’s attention on the breath, a noise, or visual targets in the environment (Tang et al., 2007). This practice includes the redirection of attention toward the target when attention has drifted away (Hölzel et al., 2011), which involves a persistent monitoring of attention and regulating its wandering. Hence, focusing attention and noticing when it gets distracted encourages metacognitive monitoring abilities (Garland et al., 2009) that may also help to exert inhibitory control. However, studies of self-regulatory capacities found in this review rather assessed general self-rated self-control. Given the relative importance of response inhibition for several addictive behaviors, such as pornography viewing (e.g., Antons & Brand, 2020), gaming (e.g., Argyriou et al., 2017), gambling (e.g., Lawrence et al., 2009), or buying-shopping (e.g., Trotske et al., 2020), future research is needed to investigate the potential impact that mindfulness techniques may have on stimulus-specific inhibitory control in the context of nonsubstance addictive behaviors.

Regarding decision-making processes, results of this review do not suggest a distinct pattern. Only two studies considered maladaptive decision-making in the context of gambling (Shead et al., 2020) and gaming (Yao et al., 2017). Shead et al. (2020) did not find significant reductions in delay discounting, and the interpretation of this result is complicated as they assessed individuals with and without gambling problems together. Hence, results cannot clearly be drawn regarding gambling-disorder-specific decision-making processes. However, a possible explanation for a null effect could involve mindfulness techniques training individuals to be aware of the present moment, whereas for the effective management of a delay discounting task, the ability to consider future events is important because future rewards need to be evaluated conceptually with respect to more immediate ones. On the other hand, Yao et al. (2017) found reductions in delay-discounting rates but not in risky decision-making among individuals with gaming problems. An explanation provided by the authors is that the reality therapy, as a component of their treatment, focuses on the significance of options that are associated with greater long-term rewards (Yao et al., 2017). The influence of a combined therapy option and the use of healthy participants as a control group suggest the relevance of future research focusing on potential effects of mindfulness in experimental settings.

Stress was investigated in different forms in the reviewed studies. In five studies, stress was measured in terms of psychological distress with anxiety and depression symptom inventories (de Lisle et al., 2011; Li et al., 2018, 2017; McIntosh et al., 2016; Quinones & Griffiths, 2019; Van Gordon et al., 2016). Here, diverse mindfulness techniques were reported to successfully reduce mental distress in five of seven studies (when counting both studies of Li and colleagues as one; see Table 2). However, anxiety and depression symptoms are considered as comorbid or predisposing factors in comprehensive models describing behavioral addictions, although they may also increase within the addiction process as a result of stronger symptom severity (e.g., Brand et al., 2019, 2016). Therefore, subjective stress may influence cognitive and/or affective reaction toward internal or external triggers. In the sense of stress responsiveness, Choi et al. (2020) found reduced stress levels among people who use smartphones exclusively in the mindfulness

group and therefore reported a successful effect of their school program. In contrast, van der Tempel et al. (2020) did not find reductions in stress tolerance among individuals with gambling problems, which is surprising as the most prominent outcome feature of mindfulness practices is typically improved management of stressors and stress reactions (Chiesa & Serretti, 2009). Given that few studies have investigated effects of MBIs on stress responsiveness, this area of research should be pursued further.

Regarding symptom severity (de Lisle et al., 2011; Ke & Shih-Tsung, 2019; Lan et al., 2018; Li et al., 2017; McIntosh et al., 2016; Quinones & Griffiths, 2019; Toneatto et al., 2014; van der Tempel et al., 2020; Van Gordon et al., 2016; von Hammerstein et al., 2018; Yao et al., 2017), the largest effect sizes (Table 2) were found for the mindfulness-oriented recovery enhancement among individuals with gaming problems (Li et al., 2018, 2017) and mindfulness meditation among individuals with gambling problems (McIntosh et al., 2016). It is possible if not likely that symptom severity is reduced if mindfulness techniques successfully address affective and cognitive mechanisms. In all studies that reported decreased symptom severity (except for Lan et al., 2018), at least one affective/cognitive mechanism was also improved (see Table 2). These findings resonate with the I-PACE model (Brand et al., 2019, 2016) that suggests that improvements in stress tolerance, cue responsiveness, and management of craving; improved inhibitory control; and more advantageous decision-making should lead to symptom reductions. Thus, mindfulness techniques may not directly impact symptoms, but their success may be mediated by affective and cognitive mechanisms, and this possibility warrants additional direct investigation.

This systematic review is limited toward clear clinical implications as it focuses on different core mechanisms across several types of addictive behaviors (i.e., gaming disorder, gambling disorder, use of social networks, hypersexual activity and pornography viewing, and buying-shopping disorder). In addition, results among some psychological processes (i.e., diminished inhibitory control, maladaptive decision-making, cognitive biases) are relatively inconsistent because the few studies identified reported contrasting results, and their sample sizes were very small. This makes it difficult to claim that a certain strategy might be the best practice, reflecting a research gap with regard to these processes and their therapeutic suitability. However, the results regarding the effectiveness of mindfulness techniques in addressing craving and stress are more consistent. We found several studies with relatively big effect sizes that point to the efficacy of mindfulness techniques in addressing gambling cravings (see Table 2). This may mainly reflect more studies investigating gambling disorder and suggests a promising approach for other nonsubstance addictive behaviors, as indicated by Zhang et al. (2016). Notably, it might be interesting to investigate differences among several addictions with regard to the addressability of craving and stress. Regarding stress responsiveness, we found mindfulness techniques to be effective among several types of addictive behaviors (i.e., gambling, internet, smartphone, and sexual behaviors; see Table 2). Stress responsiveness is a general, transdiagnostic reaction toward seemingly unmanageable triggers that may become addiction specific. Thus, MBIs may reduce stress across multiple types of addictive behaviors.

Although this review did not identify studies that investigated neurofeedback techniques, promising results in the area of SUDs may nevertheless motivate future similar studies in behavioral

addictions. Neurofeedback techniques have been found to reduce cue reactivity (e.g., Kirsch et al., 2016) and craving (e.g., Canterberry et al., 2013; Hanlon et al., 2013) and may help to enhance emotion-regulation strategies (e.g., Herwig et al., 2019). Further, a combination of mindfulness and neurofeedback techniques warrants investigation. A study by Weiss et al. (2020) on the effects of mindfulness-based relapse prevention on real-time functional MRI neurofeedback in patients with alcohol use disorder has been registered but not yet conducted, and similar studies of people with behavioral addictions are warranted. Weiss and colleagues proposed that the techniques learned in the realm of mindfulness-based relapse prevention will enhance the efficacy of real-time functional MRI neurofeedback as individuals learn how to better attend to inner processes, which is important in order to regulate those processes in neurofeedback sessions, and this argument also applies to behavioral addictions.

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