



Universiteit
Leiden
The Netherlands

Be more mindful: targeting addictive responses by integrating mindfulness with cognitive bias modification or cue exposure interventions

Larsen, J.K.; Hollands, G.J.; Garland, E.L.; Evers, A.W.M.; Wiers, R.W.

Citation

Larsen, J. K., Hollands, G. J., Garland, E. L., Evers, A. W. M., & Wiers, R. W. (2023). Be more mindful: targeting addictive responses by integrating mindfulness with cognitive bias modification or cue exposure interventions. *Neuroscience & Biobehavioral Reviews*, 153. doi:10.1016/j.neubiorev.2023.105408

Version: Publisher's Version

License: [Creative Commons CC BY 4.0 license](https://creativecommons.org/licenses/by/4.0/)

Downloaded from: <https://hdl.handle.net/1887/3715333>

Note: To cite this publication please use the final published version (if applicable).



Be more mindful: Targeting addictive responses by integrating mindfulness with cognitive bias modification or cue exposure interventions

Junilla K. Larsen^{a,*}, Gareth J. Hollands^b, Eric L. Garland^c, Andrea W.M. Evers^d, Reinout W. Wiers^e

^a Behavioural Science Institute, Radboud University, PO Box 9104, 6500 HE Nijmegen, the Netherlands

^b EPPI Centre, UCL Social Research Institute, University College London, UK

^c Center on Mindfulness and Integrative Health Intervention Development, College of Social Work, University of Utah, Salt Lake City, USA

^d Health, Medical and Neuropsychology Unit, Leiden University, NL, and Medical Delta, Leiden University, TU Delft and Erasmus University, UK

^e Addiction Development and Psychopathology (ADAPT)-lab, Department of Psychology, University of Amsterdam and Centre for Urban Mental Health, University of Amsterdam, the Netherlands

ARTICLE INFO

Keywords:

Mindfulness-based interventions
Cognitive bias modification trainings
Cue-exposure interventions
Stimulus-response, Goal-directed
Cue-devaluation, Cognitive biases
Expectancy violation
Craving
Addiction

ABSTRACT

This review provides an overview of the most prominent neurocognitive effects of cognitive bias modification (CBM), cue-exposure therapy and mindfulness interventions for targeting addictive responses. It highlights the key insights that have stemmed from cognitive neuroscience and brain imaging research and combines these with insights from behavioural science in building a conceptual model integrating mindfulness with response-focused CBM or cue-exposure interventions. This furthers our understanding of whether and how mindfulness strategies may i) facilitate or add to the induced response-focused effects decreasing cue-induced craving, and ii) further weaken the link between craving and addictive responses. Specifically, awareness/monitoring may facilitate, and decentering may add to, response-focused effects. Combined awareness acceptance strategies may also diminish the craving-addiction link. The conceptual model presented in this review provides a specific theoretical framework to deepen our understanding of how mindfulness strategies and CBM or cue-exposure interventions can be combined to greatest effect. This is important in both suggesting a roadmap for future research, and for the further development of clinical interventions.

1. Introduction

Addiction is a prevalent and serious health problem, resulting into various detrimental effects for both physical and mental health (Geller et al., 2017; Hanna et al., 2001), with tremendous costs for not only the individual, but also society (Effertz and Mann, 2013; Sussman et al., 2011). Addictive behaviours are not limited to substance dependence, but also include gambling, and, more contentiously, other behaviours like gaming, internet use and addictive-like eating (Gearhardt and Hebebrand, 2021; LaFata, 2022; Sussman et al., 2011; Webb et al., 2010; Yau and Potenza, 2015). Relapse rates following behavioural and/or pharmacological addiction treatment are high, particularly for those with co-morbid mental health problems (Bradizza et al., 2006; Walitzer and Dearing, 2006). Given that relapse in addictive behaviours has been strongly linked to impulsivity characteristics, particularly strong approach behaviours and a reduced ability to inhibit behaviours (Gullo

et al., 2014; Kotov et al., 2010; Pepe et al., 2023; Wiers et al., 2013), researchers have sought to develop intervention techniques that aim to downregulate automatic processes with the aim to prevent relapse. We have recently defined such techniques aimed at individuals with more impulsive characteristics as ‘response-focused’ strategies (Larsen and Hollands, 2022), as they target cue-induced craving (Rosenthal et al., 2022) and aim to downregulate automatic unwanted (i.e., impulsive) responses during intervention through response modulation and directly changing automatic associations, attentional biases and action tendencies (Larsen and Hollands, 2022). Response-focused techniques for treating addictive behaviours include, but are not limited to, Cognitive Bias Modification (CBM) training and cue-exposure therapy (Larsen and Hollands, 2022). CBM belongs to a family of computerized tasks directly targeting cognitive biases and perception of cues, including Attentional Bias Modification (AtBM), Approach Bias Modification (ApBM), evaluative conditioning and ‘selective inhibition training’ (e.g., through a

* Corresponding author.

E-mail address: junilla.larsen@ru.nl (J.K. Larsen).

<https://doi.org/10.1016/j.neubiorev.2023.105408>

Received 20 June 2023; Received in revised form 1 September 2023; Accepted 22 September 2023

Available online 25 September 2023

0149-7634/© 2023 Published by Elsevier Ltd.

Go/No-Go task) (Hollands et al., 2011; Houben et al., 2012; Masterton et al., 2020; Rinck et al., 2018; Wiers, 2018; Wiers et al., 2018; Wiers et al., 2013). Exposure therapy directly changes automatic associations by exposing individuals to cues (i.e., in vivo, imagery or virtual exposure) without being allowed to act on them (Conklin and Tiffany, 2002; Ghiță et al., 2019).

In this conceptual review, we propose that response-focused treatment can benefit from mindfulness-based interventions (MBIs), in which people learn to monitor their present moment experiences with non-reactivity and acceptance, and, as such, increase a state of meta-awareness (Creswell, 2017). We aim to precisely describe and demarcate the specific conditions under which mindfulness techniques may optimally benefit response-focused techniques, namely CBM and cue-exposure training techniques. Previous conceptual papers exist on combining cue-exposure and mindfulness specifically (Treanor, 2011; Vinci et al., 2021). However, there is an absence of a model that explains which mindfulness strategies may add to, or interact with, response-focused techniques in targeting cue-induced craving and/or subsequent addictive responses - a gap we aim to address. Notably, craving is considered to be a prominent mechanism in addictive behaviours (Bernard et al., 2021; Cavicchioli et al., 2020; Sun and Kober, 2020; Vafaei and Kober, 2022). Many theories recognize the importance of learning stimulus-response associations with cues acquiring 'incentive salience', i.e. motivational significance through conditioning to the reinforcing properties of a drug, and the transition from goal-directed to learnt 'compulsive' behaviours (Boswell and Kober, 2016; Hogarth et al., 2013; Lüscher et al., 2020; Perales et al., 2020; Robinson and Berridge, 1993). However, it should be noted that addiction and stimulus-response learning are not purely habitual, but are driven by goal-directed 'drug choice' and inferential learning (Hogarth, 2020; Hogarth et al., 2019; Van Dessel et al., 2018). We use these insights in contextualizing our conceptual model. Such a model is important as it could stimulate theoretically-based future interventions with greater potential for improving health outcomes than those lacking a theoretical foundation (Glanz and Bishop, 2010).

1.1. Article outline

In contextualizing the model, we first outline mechanisms of response-focused and mindfulness strategies separately and discuss limitations of studies combining these strategies. In doing so, we will draw principally on examples from the substance use (e.g., smoking, alcohol, opiates, cannabis, and amphetamines) and addictive-like eating literatures, as illustrative examples of a wider set of addictive-like domains. Despite controversies surrounding addictive-like eating (Gearhardt and Schulte, 2021; Ickes et al., 2021), we specifically include examples regarding binge eating, food-cue reactivity (e.g., attentional bias) and cue-induced unhealthy eating here, given (i) the many prominent examples in the literature and (ii) our conceptual model's focus on cue-induced craving, and the parallels of food-cue reactivity, cue-induced unhealthy eating and binge eating with drug cue reactivity and addiction (Bodell and Racine, 2023; Boswell and Kober, 2016; Gearhardt and Schulte, 2021; Levalius et al., 2022). We also pay specific attention to the underlying neural substrates of response-focused and mindfulness strategies, based on insights from electroencephalogram (EEG) and task-based as well as resting state magnetic resonance imaging (i.e., fMRI and MRI respectively), as this may enhance our understanding regarding mechanisms underlying specific strategies. Moreover, we extend our discussion using important insights from mental health research where this adds to our understanding of mechanisms that may explain addictive outcomes.

It is important to note that this paper does not provide a systematic review of the literature. Instead, we integrate diverse research fields and provide a conceptual review based on a narrative synthesis of the literature. Where possible, we synthesized findings from systematic reviews and meta-analyses across a wide range of different literature

fields. Nevertheless, we applied a substantially systematic search strategy for exploring the neural literature. Specifically, we selected EEG and (f)MRI studies according to the following criteria: (i) randomized controlled trials with pre-post neural measurements that compared response-focused or mindfulness treatments/training manipulations with a control condition on addiction-related neural outcomes, or (ii) within-subject designs where the same participant's brain function was measured and compared during response-focused or mindfulness versus control manipulations and related to addiction-related neural outcomes. An initial literature search performed in Google Scholar was carried out in March 2023, consisting of a combination of search words related to response-focused or mindfulness strategies (e.g., cognitive bias modification, approach-avoidance training, Go/No-Go, cue-exposure therapy, mindfulness), neural measures (e.g., neural, fMRI, EEG), addictive outcomes (e.g., addiction, alcohol, smoking, eating) and review studies (e.g., narrative review, systematic review, meta-analysis). The reference lists of included review studies were hand-searched to identify additional eligible articles. Finally, using Google Scholar, we checked cited references of included studies to identify more recent studies, with a last check performed in August 2023. Searches were limited to articles in the English language that were published after 2000. After discussing the mechanisms of response-focused and mindfulness strategies, we present a new conceptual model that explains whether and how mindfulness strategies may i) facilitate or add to the induced response-focused effects decreasing cue-induced craving and ii) further weaken the link between craving and addictive responses. We end our conceptual review by providing recommendations for future research.

2. Narrative synthesis of response-focused and mindfulness mechanisms

2.1. Response-focused strategies

The different types of response-focused strategies have focused on different downregulation mechanisms. A first downregulation mechanism of CBM training tasks includes the targeting of cognitive biases, specifically attentional bias and approach bias. Experts have provided consensus on the relevance of targeting such cue-related cognitive biases in addiction treatment and substance use disorders specifically, and CBM training tasks provide an intervention paradigm to do so (Verdejo-Garcia et al., 2023). Drug-related cues acquire the ability to influence behaviour in part because they acquire incentive motivating properties through stimulus-response learning, and this learning can be 'unlearned' through newly learnt patterns that may reduce cognitive biases (Flagel et al., 2009). CBM techniques can decrease such biases, but their effects often do not generalize to addictive outcomes (Boffo et al., 2019; Cristea et al., 2016; Yang et al., 2019). With regard to alcohol, reviews indicate that CBM effects on cognitive biases most often do not translate into effects on addictive behaviors in non-clinical populations, but do translate into effects on addictive outcomes in clinical populations treated for alcohol use disorders, with the strongest evidence for ApBM tasks (Wiers et al., 2018; Wiers et al., 2023). With regard to addictive-like eating, two recent meta-analyses suggest that although CBM training changed attention bias towards food cues, effects generalized to reductions in unhealthy eating behaviour for specific CBM trainings, with most consistent effects for Go/No-Go and the least effects for ApBM tasks (Aulbach et al., 2019; Yang et al., 2019). For smoking cessation, CBM results have been less consistent (Heitmann et al., 2018; Kopetz et al., 2017; Machulska et al., 2022; Robinson et al., 2022), and new varieties of training are being considered and developed, including trainings focusing on personalized behavioural (rewarding) alternatives to smoking (Bos et al., 2019; Cheval et al., 2021; Kopetz et al., 2017; Wen et al., 2021; Wiers et al., 2020). For opiates, cannabis, and amphetamines, CBM studies have recently begun to test effectiveness, with similarly mixed, albeit preliminary, findings on cognitive biases, cue-induced craving and amount of use (Ghaffari et al., 2021; Heitmann

et al., 2018; Jacobus et al., 2018; MacLean, 2023; Manning et al., 2019; Mayer et al., 2020; Sherman et al., 2018; Zhang et al., 2018).

Besides the targeting of cognitive attentional or approach biases, a second downregulation mechanism (i.e., cue devaluation) includes the targeting of an evaluative bias (Wiers et al., 2013). According to the Behavioural Stimulus Interaction (BSI) theory, appetitive stimuli trigger strong approach reactions, and continuous withholding of these responses to appetitive cues may produce conflicts by continuous oscillation between approach and inhibition of this response. As such, attractive cues are devaluated to resolve this conflict (Veling et al., 2008; Veling et al., 2017). A recent value-updating account additionally suggests that devaluation occurs by action and inaction *decisions* rather than motor inhibition and bottom-up stimulus-response learning (Veling et al., 2022). Cue devaluation mechanisms have mostly been examined using a Go/No-Go training task. Several meta-analytic studies in the field of addictive-like eating, and some studies of alcohol and smoking, have shown evidence for lower explicit, rather than implicit, evaluations of trained No-Go compared to Go and/or untrained pictures, interpreted as evidence for devaluations (Adams et al., 2021; Chen et al., 2018; Chen et al., 2016; Houben et al., 2012; Keeler et al., 2022; Najberg et al., 2021; Quandt et al., 2019; Scholten et al., 2019; Veling et al., 2021; Yang et al., 2022). However, two recent studies, including one well-powered study (Schenkel et al., 2023), suggest that Go/No-Go training did not change explicit alcohol-specific cue-devaluation (Schenkel et al., 2023; Stein et al., 2023). Besides Go/No-Go training tasks, other response-focused strategies in the addiction field may work by modifying explicit cue evaluations. This has been little examined, but there are more recent exceptions (Di Lemma and Field, 2017; Kakoschke et al., 2017; Machulska et al., 2022; Veling et al., 2021). Additional adequately powered and rigorous studies comparing different CBM tasks within the same study are needed to examine whether or not specific CBM techniques may influence cue-devaluation differently, and whether these effects may also differ based on the addiction or target group under consideration.

A final, more 'top-down' cognitive downregulation mechanism includes 'expectancy violation', explaining cue-exposure effects on binge eating (Magson et al., 2021). Specifically, cue-exposure directly interferes with automatically activated processes through exposing individuals to cues without being allowed to act on them, maximizing the mismatch between the expected (e.g., 'If I see cookies, I can't control my eating') and actual cue exposure outcome (i.e., the amount of 'expectancy violation') (Schyns, Roefs et al., 2020; Schyns, van den Akker et al., 2020). A systematic review suggests consistent 'expectancy violation' mechanisms across five studies, stimulating reductions in the frequency of binge eating (Magson et al., 2021). Moreover, in the field of mental health – where exposure therapy for anxiety disorders is a gold standard treatment (Chowdhury and Khandoker, 2023; Weisman and Rodebaugh, 2018) – violation of dysfunctional expectancies is a key mechanism determining exposure therapy outcomes (Craske et al., 2014; Foa and McLean, 2016; Pittig et al., 2016; Rief et al., 2022; Schemer et al., 2020). Of note, in contrast to these promising findings in the field of binge eating and mental health, effects of cue-exposure therapy prove less consistent for substance-related addictions (Kiyak et al., 2022; Langener et al., 2021; Lee et al., 2009; Malbos et al., 2022; Marissen et al., 2007; Mellentin et al., 2017; Pericot-Valverde et al., 2019; Trahan et al., 2019; Wang et al., 2019). We speculate that this may be because specific substance-use related withdrawal effects may elicit intrusive thoughts and craving experiences that interfere with the generalization of cue-exposure effects to daily life. Of note, the efficacy of cue exposure therapy on alcohol use disorders is greater if combined with specific coping skills training (Kiyak et al., 2022). Moreover, studies that added aversive counterconditioning to exposure therapy (e.g., through explicitly pairing drug-related cues with adverse consequences or nausea during virtual reality that was accidentally associated with tobacco cues) also appear more promising than standard cue exposure therapy studies regarding reductions in craving and use (Lee

et al., 2009; Malbos et al., 2022; Wang et al., 2019), although rigorous studies comparing different cue-exposure procedures within the same study are needed. Overall, the idea that challenging beliefs regarding the ability to withstand substance use craving is important for cue exposure effectiveness has been widely acknowledged, but researchers have not yet systematically studied its mechanisms in the field of addiction (Byrne et al., 2019).

To conclude, although the literature is not limited to the three downregulation mechanisms discussed above – namely a reduction in cognitive biases, an increased cue-devaluation, and 'expectancy violation' – they act as prominent examples investigated in different addictive-like domains using specific response-focused strategies. Despite differences, all type of response-focused strategies share an overarching common element, namely the focus on the downregulation of cue-induced craving, as mentioned (Larsen and Hollands, 2022; Rosenthal et al., 2022). As such, we can speculate that there are also similarities regarding underlying downregulation mechanisms. This has also been noted by others recently regarding CBM tasks specifically, necessitating further direct comparisons between tasks to elucidate similarities in underlying mechanisms (Houben and Aulbach, 2023).

2.1.1. Neural effects of response-focused techniques

Neuroimaging studies may further improve our understanding of why specific response-focused trainings are effective. Until 2016, addiction studies on the neural effects of CBM were limited to two alcohol-specific ApBM (f)MRI studies (Wiers et al., 2015; Wiers et al., 2015), as identified by different reviews (Cabrera et al., 2016; Verdejo-Garcia, 2016; Wiers and Wiers, 2017). In a first alcohol-specific fMRI study, ApBM, compared to sham control training, decreased amygdala activity while passively viewing alcohol cues, which correlated with decreased craving in the treatment training treatment group only (Wiers, Stelzel et al., 2015). In a second follow-up study, a subset of patients also performed the ApBM in MRI (Wiers, 2015a). Results showed a reduction in medial prefrontal cortex (mPFC) activation in the CBM group only, which was associated with reductions in automatic alcohol approach bias and self-reported bias, but not craving (Wiers et al., 2015b). Although these studies found no effect of CBM on the behavioural approach bias, they suggest that alcohol ApBM training may impact common brain structures involved in cue-reactivity, motivational salience of cues, approach bias and, specifically 'wanting' rather than 'liking' (Hill-Bowen et al., 2021; Warlow and Berridge, 2021; Wiers and Wiers, 2017; Zeng et al., 2021). In line with this, a food-specific ApBM also found that the training group had weaker unhealthy food approach tendencies, paralleled by a lower activation in the right angular gyrus (Mehl et al., 2019), indicating changes in attentional processes (Seghier, 2023), while little evidence was found for altered reward valuation of food (Mehl et al., 2019).

By contrast, and as noted by others (Veling et al., 2022), more recent fMRI Go/No-Go training studies in the field of addictive-like eating found evidence for changes in the reinforcing value of appetitive stimuli and a hedonic 'liking' cue-devaluation mechanism (Stice et al., 2017; Yang et al., 2023), although null results have also been observed, explained by the use of heterogeneous food images (Stice et al., 2022). Specifically, Go/No-Go training, alone or in combination with other CBM tasks, reduced activity in reward-related brain areas in response to high-caloric food images, while no such effects were found in the control sham (non-food) training among individuals with overweight or obesity (Stice et al., 2017; Yang et al., 2023). It is worth noting that one fMRI study examined total effects of five different CBM training tasks, including Go/No-Go training and other inhibitory control and attention training tasks, and could thus not separate the unique contributions of training tasks (Stice et al., 2017), while the other study examined neural mechanisms of Go/No-Go training specifically (Yang et al., 2023). Importantly, reductions in responsivity in the mid-insula were positively associated with food-cue devaluations in both studies (Stice et al., 2017; Yang et al., 2023). This 'mechanistic' role of the insula is in line with

findings of reviews and a meta-analysis of fMRI studies showing that the insula is activated in reward anticipation and translating subjective experiences of craving and urge to use (Droutman et al., 2015; Liu et al., 2011; Naqvi and Bechara, 2009; Naqvi et al., 2007; Noël et al., 2013). However, a recent meta-analysis shows that insula activity was observed after natural reward-related stimuli (sexual or food-related) rather than drug-specific stimuli (nicotine, alcohol, cannabis, cocaine and heroin) (Hill-Bowen et al., 2021). As such, the ‘mechanistic’ role of the insula underlying cue-devaluation effects might also be non-drug specific rather than drug-specific. Consistent with this idea, some recent studies from behavioural science suggest that Go/No-Go training did not change alcohol-specific cue-devaluation (Schenkel et al., 2023; Stein et al., 2023), as mentioned, but more research across addictions is needed.

EEG or fMRI studies question the mechanism of Go/No-Go training in targeting top-down cue-related inhibitory control (Aulbach et al., 2020; Carbine et al., 2021; Grieder et al., 2022; Veling et al., 2022; Yang et al., 2023). Specifically, a food Go/No-Go training did not affect the amplitude of the N2 ERP component (an indicator of inhibitory control) during the completion of the Go/No-Go task in a within-subject laboratory study (Aulbach et al., 2020). These null results regarding N2 ERP were further supported in a relatively large randomized controlled trial where individuals with overweight or obesity were assigned to complete generic or food-specific Go/No-Go training four times per week for four weeks (Carbine et al., 2021). In addition, one fMRI study specifically tested alcohol-specific Go/No-Go training changes in activation of the right inferior frontal gyrus, characterized as ‘a brake’, (Aron et al., 2014) and found no evidence for such training changes among patients with alcohol use disorder (Grieder et al., 2022), while another fMRI study even found evidence for decreased, rather than increased, activation in inhibitory control regions to high-calorie food images after a food-specific Go/No-Go training (Yang et al., 2023). It is possible that increased explicit cue-devaluation reduces the need for top-down control (Yang et al., 2023). Interestingly, one EEG study found that, during passively viewing food pictures, theta power at frontal midline electrodes was larger for food stimuli that were previously paired with ‘no-go’ as compared to ‘go’ responses (van de Vijver et al., 2018). As higher frontal midline theta activity may be indicative of more brain plasticity and effortless control (Tang et al., 2019), we might speculate that a Go/No-Go training increases effortless control partly through enhanced cue-devaluation. Future work is needed to test this hypothesis.

Overall, these first neural studies provide support for down-regulation mechanisms. Their findings suggest that Go/No-Go non-drug specific tasks may result in cue devaluation, while ApBM tasks may change attentional and/or approach biases rather than ‘liking’ or cue-devaluation across addictions. However, another fMRI study among cannabis users suggest that ApBM did not modify neural (bias-related) cue-reactivity (Karoly et al., 2019), and, an alcohol-specific EEG study also found no neural or behavioural effects of ApBM training in a hazardous drinking population (den Uyl et al., 2016). As such, neural downregulation mechanisms of CBM trainings might differ based on the addiction or target group under consideration.

Besides these neural CBM studies, a recent review (Agarwal et al., 2021) identified two cue exposure treatment fMRI studies in the field of obesity and alcohol (Becker et al., 2018; Vollstädt-Klein et al., 2011). Below, we will discuss the findings of these studies, in combination with an EEG study (Lee et al., 2009) and two studies employing fMRI that presented first results of single prolonged cue-exposure sessions (Ekhtiari et al., 2021; Frankort et al., 2014). Similar to the first neural effects of CBM trainings concerning alcohol and eating, a study in the treatment of alcoholism found that cue-exposure therapy in addition to care-as-usual led to a relatively larger decrease of fMRI cue reactivity in the bilateral anterior cingulate gyrus, the left precentral gyrus, the left insula, the bilateral inferior parietal lobule, the left superior frontal gyrus, the right middle frontal gyrus, and the left ventral and the left dorsal striatum than sole care-as-usual (Vollstädt-Klein et al., 2011). These relative decreases were the result of reduced brain activation in

the anterior cingulate and frontal regions (middle frontal gyrus and superior frontal gyrus) after cue exposure therapy, but increases in cue-induced activation in the insula, the precentral gyrus, and several frontal regions in the care-as-usual group. Meta-analytic evidence shows that alcohol cues generally evoke greater cue-reactivity than neutral cues in the anterior cingulate cortex, the middle cingulate, and the right medial prefrontal cortex in alcohol use disorder patients compared to healthy controls (Zeng et al., 2021). As such, cue-exposure therapy seems to reduce neural cue-reactivity to alcohol cues.

Decreases in ‘cue-reactive’ brain areas are also observed in some other addiction-specific prolonged single session cue-exposure studies (Ekhtiari et al., 2021; Frankort et al., 2014). Specifically, a recent single within-subject cue-exposure session among individuals with methamphetamine and opioid use disorder who were abstinent during early treatment showed ventral-medium-prefrontal-cortex, right amygdala and bilateral ventral striatum habituation (i.e., decreased activation) to repeated drug cue, but not neutral cue, presentation, also a few days later (Ekhtiari et al., 2021). Although these habituation effects were replicated in different samples, participants received treatment in between test and retest time points, which could have contributed to the habituation effects (Ekhtiari et al., 2021). Moreover, another fMRI study found that, compared to exposure to a control stimulus, a single prolonged chocolate cue-exposure session resulted in lower brain activation in areas that have been mostly implicated in food reward, including the left and right caudate, left striate cortex, and bilateral extrastriate cortex, and on the border of the right parahippocampal gyrus with the lingual and posterior cingulate gyrus, while in the beginning of the exposure session the pattern was reversed (Frankort et al., 2014). Of note, these neural studies found no direct significant effects of (prolonged) cue-exposure on reductions in self-reported craving (Ekhtiari et al., 2021; Frankort et al., 2014; Vollstädt-Klein et al., 2011). However, one study observed that craving started to decrease, suggesting that the decline in brain reward activation in the cue-exposure group might be a precursor of a decrease in follow-up craving (Frankort et al., 2014). Future research is needed to examine future (follow-up) craving effects, as well as different cue-reactive down-regulation mechanisms (e.g., cue-devaluation).

In an EEG study, cognitive therapy combined with cue exposure therapy and aversive counterconditioning resulted in increased alpha waves in prefrontal cortex areas (i.e., Fp2-A2 and F8-A2) in patients with alcohol dependence, while cognitive therapy alone did not result in such changes (Lee et al., 2009). Although the exact mechanistic role of increases in alpha power remains unclear, recent reviews suggest that it reflects different facets of top-down cognitive control and possible decreases in task demands and cognitive workload (Chikhi et al., 2022; Clayton et al., 2018; Sadaghiani and Kleinschmidt, 2016). A final fMRI study among alcohol use disorder patients provides some further support for the idea that cue-exposure therapy may also impact the way some patients learn to regulate their alcohol consumption (Becker et al., 2018). This study investigated non-drug reward sensitivity and found that higher baseline reward sensitivity in the ventral striatum during the anticipation of monetary (compared to verbal feedback) reward was linked to increased activation in the superior frontal gyrus and the anterior cingulate cortex after cue-exposure treatment for alcohol use disorder (Becker et al., 2018). As this increased activation was positively associated with self-efficacy to abstain from alcohol, non-drug reward enhanced striatal sensitivity may determine effects of cue-exposure treatment on prefrontal cortex processes related to self-regulation (Becker et al., 2018). Nevertheless, meta-analytic data of individuals with substance addictions, compared to healthy controls, showed decreased, rather than increased, striatal activation during non-drug momentary reward anticipation (Luijten et al., 2017). However, a previous study (Becker et al., 2017), using the same task as used in the cue-exposure treatment study (Becker et al., 2018), found increased activation of the ventral striatum during anticipation of monetary gain in individuals with alcohol use disorder compared to healthy controls

(Becker et al., 2017). These findings are most likely explained by differences in task design (Becker et al., 2017). Specifically, the reward task used in the cue-exposure study may have elicited a more precise prediction of the rewarded task and, as such, may have elicited more similarities with the reward outcome phase, where individuals with substance use addiction similarly showed increased activation in the ventral striatum (Luijten et al., 2017). Although these findings may suggest that individuals with enhanced striatal sensitivity to non-drug rewards may profit most from cue-exposure therapy, more research examining differential effects of non-drug and drug-specific cues is needed.

2.2. Mindfulness-based intervention strategies

As mentioned, mindfulness-based interventions (MBIs) aim to increase a state of meta-awareness in which people learn to monitor their present moment experiences with non-reactivity and acceptance (Creswell, 2017). There are many forms of mindfulness-based interventions with different durations, ranging from 3-month retreats to very brief mindfulness interventions with a duration of 30 min or less on any occasion and ranging 4–8 weeks (Creswell et al., 2019; Hogarth et al., 2019). Mindfulness practices are integrated with other practices such as targeting stress/coping reactions in Mindfulness-based Stress Reduction (MBSR) or mindfulness-based cognitive therapy (MBCT) integrating mindfulness practice with cognitive behavioural therapy (Kabat-Zinn, 2003; Sipe and Eisendrath, 2012). These mindfulness-based interventions (MBIs) have also been used for many addictive behaviours, including MBIs for binge eating, Mindfulness-based Relapse Prevention (MBRP) and Mindfulness Training (MT) for Smokers specifically (MTS), and Mindfulness-Oriented Recovery Enhancement (MORE) for addiction (Garland, 2016; Garland et al., 2019; Godfrey et al., 2015; Oikonomou et al., 2017; Parisi et al., 2022). Moreover, “third wave cognitive and behavioural” interventions that use mindfulness as a smaller component within a larger set of techniques (Schuman-Olivier et al., 2020; Tapper, 2022) have also been used in similar addiction contexts (Sancho et al., 2018).

Although large and rigorous randomized controlled trials of specific mindfulness therapies (e.g., MORE, MBRP) as a treatment for addiction have been conducted (Bowen et al., 2014; Garland et al., 2022), reviews have often investigated a range of MBIs and “third wave” interventions, impeding conclusions regarding the specific effects of mindfulness on for instance binge eating disorder (Mercado et al., 2021). Nevertheless, a growing body of review and meta-analytic evidence suggests that MBIs are effective in reducing addictive behaviours, including smoking, alcohol use and addictive-like eating, although more highly powered mechanistic studies with long-term follow-ups are needed to further understand these effects (Goldberg et al., 2021; Korecki et al., 2020; Li et al., 2017; Mercado et al., 2021; Parisi et al., 2022; Roche et al., 2019; Schuman-Olivier et al., 2020; Tapper, 2022). Although the working mechanisms of MBIs for addiction are understudied, as mentioned, Rosenthal and colleagues have recently distinguished three principal ways in which MBIs may impact the course of addictive disorders, including increased top-down cognitive control and decreased cue-reactivity and stress perception (Rosenthal et al., 2021).

2.2.1. Neural effects of mindfulness-based interventions

Rosenthal and colleagues have recently discussed (neuroimaging) studies that support these three principal ways in which MBIs may impact the course of addictive disorders (Rosenthal et al., 2021). We now briefly summarise the findings of Rosenthal and colleagues (see Rosenthal et al., 2021, 2022 for a further discussion on the specific studies) and add further insights from other reviews and recent studies. Regarding decreases in cue-reactivity, Rosenthal and colleagues (Rosenthal et al., 2022; Rosenthal et al., 2021) discuss several studies showing that MBIs reduced (neuronal) cue-induced craving (Froeliger et al., 2017; Garland et al., 2023; Garland et al., 2014, 2015; Hanley and

Garland, 2020; Janes et al., 2019; Westbrook et al., 2013), addiction-related attentional bias (Garland et al., 2017; Garland et al., 2010; Garland et al., in press) and (neuronal) stress reactivity attenuating addictive responses (Davis et al., 2018; Garland et al., 2017; Garland, Hanley et al., 2019; Kober et al., 2017). Regarding top-down cognitive control, they cite several studies showing that MBIs lead to increases in reflective decision-making, decreased efforts to inhibit responses or increases in brain prefrontal cognitive control networks (Andreu et al., 2018; Garland et al., 2019; Garland and Howard, 2018; Rosenthal et al., 2021; Tang et al., 2013; Valls-Serrano et al., 2016).

In contrast, there are also studies showing that mindfully accepting craving (smoking sample) and pain or negative emotion (normative sample) do not recruit prefrontal regions (Kober et al., 2019; Westbrook et al., 2013). A recent systematic review of fMRI studies in people with substance dependence, principally concerning tobacco, supports the idea that MBIs are not only associated with changes in the function of brain pathways implicated in reward processing (e.g., anterior cingulate cortex and the striatum), but also in additional higher order cognitive regions (precuneus, inferior frontal gyrus) (Lorenzetti et al., 2023). However, this fMRI evidence is still limited, as studies had relatively small samples sizes, and some also lacked pre-post fMRI measurement, control groups or randomized allocation to groups (Lorenzetti et al., 2023). In the field of addictive-like eating, fMRI evidence is even more limited. We found only one recent fMRI study that fulfilled our search criteria (Janssen et al., 2023). This study found reduced reward midbrain food reward anticipation after an intensive mindful eating intervention compared to an active control intervention, but these effects were not anticipated, and were not significant in the whole-brain corrected analysis (Janssen et al., 2023). Of note, recent meta-analyses of behavioural data generally support the effects of MBIs on increasing self-regulation and executive control (Cásedas et al., 2020; Leyland et al., 2019), although further investigation in the field of addiction is needed (Brandtner et al., 2022). Moreover, a recent meta-analysis of resting-state fMRI frontoparietal functional connectivity of brain networks suggests that functional connectivity is related to mindfulness (i.e., operationalized as both a trait and MBIs) (Sezer et al., 2023). Specifically, the cingulate cortex played a major role in this connectivity across multiple (prefrontal) modalities, with increased connectivity of different parts of the cingulate cortex with dorsolateral prefrontal cortex (‘attention control’) and dorsomedial prefrontal cortex (‘emotion regulation’) (Sezer et al., 2023). Furthermore, systematic reviews and/or meta-analyses of EEG studies have shown that mindfulness meditation mostly increases amplitude in the frontal midline alpha and/or theta bandwidths (Lee et al., 2018; Lomas et al., 2015). These increases are associated with decreases in cognitive workload, but increases in self-regulation, working memory functioning, conflict modulations, sustained attention and, specifically for frontal midline theta bandwidths, probably also with more effortless control, as mentioned (Chikhi et al., 2022; Hsieh and Ranganath, 2014; Jo et al., 2017; Mitchell et al., 2008; Tang et al., 2019).

As such, it is not surprising that recent randomized controlled EEG studies among opioid users found that effects of MBIs (i.e., MORE) on decreasing opioid use and misuse were mediated by increased frontal midline theta activity (Garland et al., 2022; Hudak et al., 2021). In a recent study, which is to our knowledge the largest neuroscientific study of mindfulness as a treatment for addiction, MORE, compared to a supportive psychotherapy control condition, produced significantly greater increases in frontal midline theta spectral power and coherence during a laboratory-based mindfulness meditation session. These increases in both power and coherence mediated the effect of MORE on reduced opioid use at 9 months follow-up (Garland et al., 2022). Similar mediation by changes in frontal theta power was found in a previous MORE pilot study that had a modest sample size (Hudak et al., 2021). MORE integrates traditional mindfulness meditation techniques with reappraisal and savoring strategies to strengthen top-down cognitive control functions as a means of restructuring bottom-up reward learning

from valuation of drug-related rewards (i.e., decrease drug cue-reactivity) back to valuation of natural rewards (i.e., increase natural reward responsiveness) (Garland, 2016). Indeed, prior autonomic, EEG, and fMRI studies have also shown MORE to decrease reactivity to drug cues while increasing responsiveness to natural rewards (Froeliger et al., 2017; Garland et al., 2019a; Garland et al., 2014; Garland, Howard et al., 2017). However, MORE and many other MBIs are multicomponent interventions, and the studies discussed so far did not compare effects between different mindfulness strategies.

2.2.2. Mindfulness dismantling studies

As MBIs are quite heterogeneous, consisting of different mindfulness strategies, it is not surprising that there are a growing number of recent high-quality behavioural mindfulness ‘dismantling’ intervention studies in the field of mental health, where mindfulness has been studied more extensively during the past decades. These studies are discussed below as they provide further insights into specific MBI mechanisms (e.g., stress reactivity) relevant for response-focused addictive outcomes. To date, these mindfulness intervention studies often compare awareness or monitoring, this concerning attending to present moment experiences, with acceptance skills training to stimulate the acceptance of thoughts and emotions without judging them. This comparison follows from the monitor and acceptance theory, suggesting that only attention/awareness combined with an accepting stance diminishes negative affect reactivity (Lindsay and Creswell, 2017). Such dismantling studies support this component of monitor and acceptance theory, suggesting that awareness (i.e., monitoring) is particularly effective when combined with acceptance skills training, for regulating affect, decreasing emotional reactivity, stress ratings and objective stress measures, and boosting positive emotions (Chin et al., 2019; Lindsay et al., 2018; Lindsay et al., 2018; Stein and Witkiewitz, 2020). As concluded by a recent systematic review, acceptance coupled with awareness holds promise as an important active ‘stress-reducing’ ingredient of mindfulness-based interventions (Stein and Witkiewitz, 2020). Although these dismantling studies from mental health research may yield promise for the field of addiction, where the ability to ‘sit with discomfort’ may have high applicability to craving and negative affect or distress, acceptance strategies alone do not appear to be promising in targeting addictive-like eating (Tapper, 2022). Future research is needed to examine the neural substrates of the effects of acceptance coupled with awareness.

Moreover, monitor and acceptance theory also suggests that the training of attention monitoring skills mainly underlies effects on attention-related mechanisms (Lindsay and Creswell, 2017). Although this has been examined less often, a recent high-quality dismantling study has shown evidence for this idea (Chin et al., 2021). Specifically, relative to a no treatment control condition, both monitor and accept training during a standard 8-week MBSR intervention and a well-matched modified 8-week MBSR-adapted intervention that focused on monitoring skills only resulted in equivalent improvements in momentary and trait attentional control (Chin et al., 2021). In addition, recent meta-analytic results suggest that attentional improvements can be achieved by teaching focused attention meditation, to encourage shifting attention towards a specific attentional target, such as breathing, and away from thoughts, and/or teaching open monitoring meditation, to direct attention towards any thought or emotion in an open-minded way (Sumantry and Stewart, 2021). Although both types of meditation practices might thus be possible ways to target awareness/monitoring, some other recent dismantling studies comparing focused attention and open monitoring meditation trainings suggest that focused attention practices are more important for improving emotion regulatory skills and mental health compared to open monitoring practices (Brown et al., 2022; Lohani et al., 2020). Of note, EEG oscillation contrasts also suggest distinct differences in neural activity among these different meditation practices (Lee et al., 2018) and specific longitudinal data in non-meditators suggests that the changes in neural

activity caused by focused attention meditation practices modulated attention (Yoshida et al., 2020). Further neurocognitive research is needed to deepen understanding of how these different meditation training practices can be fueled by specific awareness and/or acceptance skills training, included in both meditation instructions and other didactic mindful content.

Besides these present moment awareness and acceptance strategies more intensively investigated in the field of mental health, another key feature strategy of mindfulness is decentering (Tapper, 2022). Decentering has been defined as the metacognitive process of creating distance and distinguishing oneself as separate from the experiences, such as thoughts, emotions or physical sensations (Bernstein et al., 2015). The specific strategy of mindful decentering has mainly been examined in the field of addiction. To date, a recent review concludes that decentering strategies may be helpful for craving management (Tapper, 2022). Specifically, there is a growing body of psychological experiments suggesting that decentering is a promising mindful strategy to deal directly with food cravings (Keesman et al., 2017, 2020; Papies et al., 2016; Tapper and Turner, 2018; Wilson et al., 2021). These experiments included a food-exposure craving induction, after which participants were instructed to focus on the high-calorie palatable food while they received general (e.g., imagine placing any thoughts or feelings into a leaf and watch it float down the stream) or food-specific (e.g., observe reactions to the high calorie foods as passing mental events) decentering instructions. Theoretically, decentering strategies may reduce craving by preventing craving-related thoughts, specifically through reducing the believability of intrusive craving-related thoughts (Papies et al., 2020) and increasing the accessibility of other thoughts and goals that are important to the individual (Tapper and Ahmed, 2018). However, although these psychological experiments can be informative, they also carry the risks of oversimplifying mindfulness interventions to specific techniques in a toolbox (Powell, 2014; Schuman-Olivier et al., 2020). Notably, decentering has also been regarded as a key mechanism explaining mental health improvements stimulated through more intensive MBIs that focus on combined present moment awareness and acceptance (meditation) training (Bennett et al., 2021; Hanley et al., 2021; Hanley et al., 2020; Levi et al., 2021; Moore et al., 2022). As such, we suggest that a clear distinction should be made between targeting decentering as a separate mindful strategy and changing decentering mechanisms in MBIs. Combined present moment awareness and acceptance training, as is cultivated in MBIs like MBSR and MORE, aims to provide longer-term insights that one’s thoughts and experiences are transient and fleeting mental events that are separate from oneself and not necessarily a true reflection of reality. This contributes to a state of decentering in which thoughts and experiences can be observed from a real metacognitive perspective. In contrast, a simple decentering strategy in a cue-food exposure craving induction will probably not lead to these insights. Nevertheless, the mindful eating literature suggests that decentering strategies may be helpful for craving management even without further mindfulness training (Tapper, 2022).

2.3. Combined response-focused and mindfulness strategies

There are only a few studies that have combined mindfulness-based with response-focused intervention strategies. In the field of anxiety and chronic pain disorders, combined cue-exposure and mindfulness-based (awareness) interventions have been developed (Hedman-Lagerlöf et al., 2019; Hesser et al., 2018). However, little is known about combined effects, as the designs of these intervention studies did not allow the investigation of interaction effects (Hedman-Lagerlöf et al., 2019; Hesser et al., 2018). In the field of addiction, however, there is some initial evidence from psychological experiments for combined effects of response-focused (i.e., cue-exposure or CBM techniques) and mindfulness meditation and awareness strategies with regard to reductions in addictive-like eating and smoking (Andreu et al., 2018; Bowen and Marlatt, 2009; Fisher et al., 2016; Forman et al., 2016). This evidence

should be regarded as highly preliminary, given the generally small sample sizes, limited follow-up measures, or absence of control condition(s). Future high-quality research is needed to increase insight into the combined effects of response-focused and mindfulness techniques on addictive outcomes. Specifically, adequately powered and rigorous studies comparing single and combined effects are needed across different addictions. Examples of what these experiments and interventions may look like are presented in part 4.1 (directions for future research). This research can benefit from insights regarding specific underlying (combined) working mechanisms.

3. Conceptual model (Fig. 1)

In Fig. 1 we present a model that differentiates mindfulness strategies according to whether they may i) facilitate or add to the induced response-focused mechanisms decreasing cue-induced craving (paths 1a-1c) and ii) further weaken the link between craving and addictive responses (path 1d). With regard to paths 1a, downregulation mechanisms (e.g., explicit cue devaluation, a reduction in cognitive biases and ‘expectancy violation’) may be amplified by mindfulness present moment awareness strategies. We suggest that present moment awareness might particularly stimulate downregulation mechanisms, as the training of present moment awareness/open monitoring/focused attention (meditation) skills mainly underlies effects on improvements in attentional mechanisms, as mentioned (Chin et al., 2021; Sumantry and Stewart, 2021). These attentional improvements may particularly benefit response-focused downregulating mechanisms, as the attention/awareness of stimulus-response contingencies has shown to stimulate effects of CBM trainings (Hofmann et al., 2010; Van Dessel et al., 2016),

and, specifically, attention paid to stimuli during a Go/No-Go training seems to elicit stronger cue devaluation effects (Quandt et al., 2019). In addition, Go/No-Go trainings within fMRI context may also increase attentional focus, by performing tasks in a scanner without further distracting information, and provide further neural support for this cue-devaluation mechanism, as mentioned (Stice et al., 2017; Yang et al., 2023), although attention was not manipulated in these studies. Moreover, attention during cue-exposure is similarly considered important, as it highlights ‘expectancy violation’, a crucial mechanism to effective food-cue exposures, as mentioned (Magson et al., 2021). In a combined cue-exposure-mindful awareness intervention in the context of anxiety and chronic pain disorders, exposure effects were importantly generated through reduced avoidance (Hedman-Lagerlöf et al., 2019; Hesser et al., 2018). This might suggest that mindful attention during exposure has played a role in facilitating these exposure mechanisms. However, the designs of these studies did not allow the investigation of specific effects, as mentioned (Hedman-Lagerlöf et al., 2019; Hesser et al., 2018). Future research is needed to examine whether present moment awareness strategies *during* response-focused strategies may be particularly helpful in facilitating downregulating mechanisms through increased attention, in line with an inferential account (Hogarth, 2020; Hogarth et al., 2019; Van Dessel et al., 2018).

Moreover, we suggest that decentering strategies utilized *after* response-focused techniques (paths 1b, Fig. 1) may further prevent later cue-induced craving reactions. This would likely be attributable to added effects due to an increased ‘dose’. Theoretically, it might be easier to resist cues in daily life if experienced cue-induced craving is further lowered by decentering techniques that are theorized to reduce craving-related thoughts, as mentioned (Papies et al., 2020; Tapper and Ahmed,

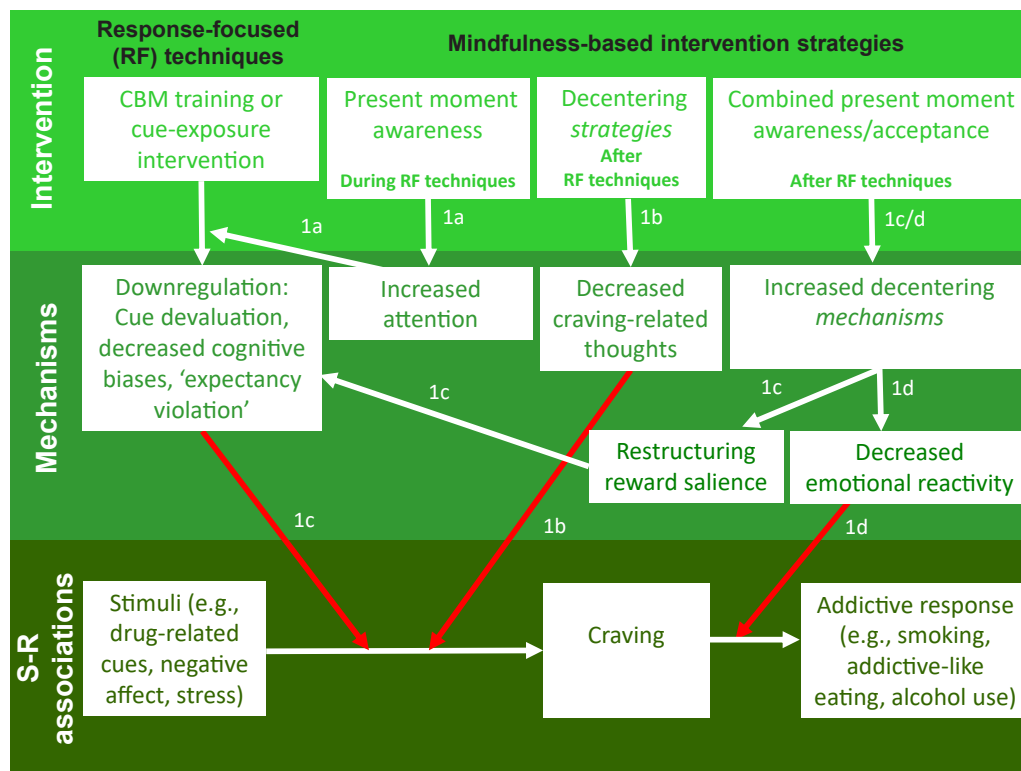


Fig. 1. A conceptual model of how mindfulness strategies may influence response-focused (RF) mechanisms and addictive responses (paths 1a-1d). Note. S-R associations = Stimulus-Response associations. Red arrows represent decreasing effects; White arrows represent increasing effects. CBM = Cognitive Bias Modification. Our model proposes that awareness/monitoring may facilitate (paths 1a), and decentering may add to (paths 1b), the induced response-focused effects decreasing cue-induced craving. Combined awareness acceptance strategies may also add to response-focused effects decreasing cue-induced craving (paths 1c), but may weaken the link between craving and addictive responses as well (paths 1d). Of note, a clear distinction has been made between targeting decentering as a separate mindful strategy and changing decentering mechanisms.

2018). Nevertheless, we propose that the temporal order in which mindfulness decentering and response-focused strategies are presented is important for its combined effectiveness. Decentering strategies that decrease cue-induced craving *during* response-focused techniques may actually impede the therapeutic potential of response-focused interventions in which people need to engage with the challenge by exerting high attention in order to modulate it. There is no direct empirical evidence yet to support this hypothesis, but given the effects of specific decentering strategies on cue-induced craving (Keesman et al., 2017, 2020; Papies et al., 2016; Tapper, 2022; Tapper and Turner, 2018; Wilson et al., 2021), we identify this as an important future research avenue. Also, the time course of these processes remains largely unknown. Studies are needed to determine how long a patient should be exposed to a drug cue before engaging in decentering strategies.

Finally, we suggest that specifically combined mindful (meditation) awareness and acceptance strategies, often forming the core component of MBIs, may target downregulation mechanisms, such as attentional bias (Garland, Baker et al., 2017; Garland et al., 2010; Garland et al., *in press*), and subsequent cue-induced craving (Froeliger et al., 2017; Garland et al., 2023; Garland et al., 2014, 2015; Hanley and Garland, 2020; Janes et al., 2019; Westbrook et al., 2013), as mentioned (paths 1c). Moreover, these combined strategies may particularly be important for further generalization of response-focused mechanisms to (longer-term) addictive responses (paths 1d). Longer-term MBIs may facilitate the integration of combined aspects of awareness and acceptance in daily life, stimulating decentering *mechanisms* that may explain mental health outcomes, as mentioned (Bennett et al., 2021; Hanley et al., 2021; Hanley et al., 2020; Levi et al., 2021; Moore et al., 2022). Specifically, combined awareness and acceptance strategies generally reduce emotional reactivity (path 1d), including reduced stress-reactivity, negative affect and increased self-control (Blanck et al., 2018; Im et al., 2021; Stein and Witkiewitz, 2020; Yakobi et al., 2021). Further, as Garland proposes in his *restructuring reward hypothesis*, mindfulness might amplify savoring of non-drug rewards and thereby facilitate cue devaluation and downregulation (paths 1c) by restructuring reward salience mechanisms from valuing drug rewards back to valuing natural rewards (Garland, 2021); in that regard, MORE has been shown to increase neurophysiological responses to natural reward cues while decreasing cue-reactivity toward drug cues, as mentioned (Froeliger et al., 2017; Garland et al., 2019; Garland et al., 2014; Garland, Howard et al., 2017). As such, these combined mindful strategies may prevent important triggers for relapse (Bresin et al., 2018; Heckman et al., 2017).

Some behavioural and neuroimaging studies indeed support the idea that MBIs, consisting of combined awareness and acceptance strategies, may reduce addictive responses and relapse through building resilience to stress and negative affective triggers, as mentioned (Davis et al., 2018; Garland, Bryan et al., 2017; Garland, Hanley et al., 2019; Kober et al., 2017). Moreover, mindfulness leads to enhanced frontal theta oscillations (Lee et al., 2018; Lomas et al., 2015) and the addiction reducing effects of MBIs appear to be mediated by such increases in theta oscillations (Garland et al., 2022; Hudak et al., 2021), possibly decreasing drug cue-reactivity through more effortless self-regulation (Tang et al., 2019). Although response-focused treatments may also enhance theta power at frontal midline electrodes (van de Vijver et al., 2018), most studies provide evidence for reduced cue-reactive activation in attentional and reward-related brain areas after treatment, as mentioned. As such, we only include a path from response-focused treatments to downregulation mechanisms, but not to reduced emotional reactivity. Moreover, although resilience regarding stress reactivity may also attenuate stress-induced craving, such ‘stress-craving’ effects were not specific to mindfulness interventions (Carroll and Lustyk, 2018) and null results were found as well (Davis et al., 2018). As such, we only include a moderating link from ‘decreased emotional reactivity’ to the ‘craving-addictive response’ link (path 1d), while no such moderating path has been added to the ‘stimuli-craving’ link in Fig. 1. To conclude, our model proposes that mindful awareness/monitoring may facilitate

(paths 1a), and decentering may add to (paths 1b), the induced response-focused effects decreasing cue-induced craving. Combined awareness and acceptance strategies may also add to response-focused effects decreasing cue-induced craving (paths 1c), but may weaken the link between craving and addictive responses as well (paths 1d). Our model is necessarily a simplification (e.g., downregulation mechanisms may impact addictive stimuli). Moreover, given the limited empirical studies performed, the pathways in Fig. 1 represent working hypotheses that require corroboration in future research.

4. Discussion

4.1. Directions for future research

We propose some suggestions for future research. First, future experiments are needed that focus on investigating and comparing underlying shorter-term neural mechanisms of single response-focused or mindfulness and combined techniques. We encourage researchers to include multiple downregulation mechanisms in their experiments. This may provide insights for further optimizing and tailoring treatment, including in combination with mindfulness strategies. Future experiments may for instance compare effects of response-focused trainings with or without mindful attention on addictive (brain) responses as mediated by ‘downregulation’ mechanisms. Second, future randomized controlled trials in both clinical and non-clinical samples are needed to examine longer-term effects of combined response-focused and mindfulness-based intervention treatments, while also paying attention to underlying neural and behavioural mechanisms of these longer-term treatment effects. These interventions may compare effects of prolonged response-focused training in daily life with MBIs in 2×2 randomized controlled designs. According to our model, and if supported by experiments, such a combined intervention would start with mindful momentary awareness meditation training to support response-focused trainings and then elaborate training further with specific decentering strategies and combined present moment awareness and acceptance training, as is cultivated in MBIs like MBSR and MORE. Ecological momentary assessment measures of mindfulness, stress-regulation, affect, craving and further addictive responses should be measured during different stages of the intervention. Neuroimaging data should be measured at least before and after intervention, but we encourage researchers to include additional in-between neural measures as this may reveal further insight into the question whether changes in brain function may drive, or be driven by, reduction in addiction outcomes. Although fMRI studies examining effects of MBIs in people with substance use dependence mostly used drug cue reactivity tasks (Lorenzetti et al., 2023), and recommendations for such studies have been reported (Ekhtiari et al., 2022), future neuroimaging studies should also examine the other principal ways in which MBIs may impact the course of addictive disorders, including decreasing stress perception, as mentioned (Rosenthal et al., 2021).

Neural studies are also required to examine if and how trait mindfulness moderates how MBIs affect brain function in substance use disorders (Lorenzetti et al., 2023) and other addiction-related behaviours, including in combination with response-focused strategies. Moreover, neural mediation studies should not only focus on differences in specific brain areas after (combined) response-focused and mindfulness treatments, as mostly been the case thus far. They should also focus on dynamic neural connectivity between areas, as addiction is often conceptualized as impacting individual differences in reward sensitivity and cue-reactivity along with weakened cognitive control or self-regulation (Volkow et al., 2019). Moreover, these studies should examine stress-related and drug-cue related dopamine release in mesolimbic brain areas (Baik, 2020; Cofresí et al., 2019) to further increase insights into specific underlying differential neural mechanisms based on genetic differences. Finally, they should further examine specific links with the proposed mechanisms of change (i.e., attention, different

downregulation and emotional reactivity mechanisms). This is considered crucial, as it can further increase insights into addiction-specific, task-specific and target-group specific effects and ultimately pave the way for more tailored treatment approaches. In addition, it may reveal further insights into functions of specific brain areas, and, as such, provides important implications for the field of neuroscience.

4.2. Concluding remarks

This review adds to the existing literature by providing a recent overview of the most prominent neurocognitive effects of CBM trainings, cue-exposure therapy and mindfulness interventions for targeting addictive responses. It highlights the key insights that have stemmed from cognitive neuroscience and brain imaging research and combines these with insights from behavioural science in building an innovative conceptual model integrating mindfulness with cognitive bias modification or cue-exposure interventions. This model furthers our understanding of whether and how mindfulness strategies may i) facilitate or add to the induced response-focused effects decreasing cue-induced craving, and ii) further weaken the link between craving and addictive responses. The conceptual model presented in this review is necessarily a simplification, however, it provides a specific theoretical framework to deepen our understanding of how mindfulness strategies and CBM or cue-exposure interventions can be combined to greatest effect. This is important in both suggesting a roadmap for future research, and for the further development of clinical interventions, including among disadvantaged populations who may display enhanced procedural learning but lower executive control (Ellis et al., 2022; Ellis et al., 2017; Frankenhuis and Nettle, 2020) and might particularly profit from interventions targeting stimulus-response associations.

Declarations of interest

None.

Funding

No external funding was received by any authors for this study.

References

- Adams, R.C., Button, K.S., Hickey, L., Morrison, S., Smith, A., Bolus, W., Coombs, E., Randolph, S., Hunt, R., Kim, D., 2021. Food-related inhibitory control training reduces food liking but not snacking frequency or weight in a large healthy adult sample. *Appetite* 167, 105601. <https://doi.org/10.1016/j.appet.2021.105601>.
- Agarwal, K., Manza, P., Leggio, L., Livinski, A.A., Volkow, N.D., Joseph, P.V., 2021. Sensory cue reactivity: sensitization in alcohol use disorder and obesity. *Neurosci. Biobehav. Rev.* 124, 326–357. <https://doi.org/10.1016/j.neubiorev.2021.02.014>.
- Andreu, C.I., Cosmelli, D., Slagter, H.A., Franken, I.H.J.P., 2018. Effects of a brief mindfulness-meditation intervention on neural measures of response inhibition in cigarette smokers. *PLoS ONE* 13 (1), e0191661. <https://doi.org/10.1371/journal.pone.0191661>.
- Aron, A.R., Robbins, T.W., Poldrack, R.A., 2014. Inhibition and the right inferior frontal cortex: one decade on. *Trends Cogn. Sci.* 18 (4), 177–185. <https://doi.org/10.1016/j.tics.2013.12.003>.
- Aulbach, M.B., Knittle, K., Haukka, A., 2019. Implicit process interventions in eating behaviour: a meta-analysis examining mediators and moderators. *Health Psychol. Rev.* 13 (2), 179–208. <https://doi.org/10.1080/17437199.2019.1571933>.
- Aulbach, M.B., Harjunen, V.J., Spapé, M., Knittle, K., Haukka, A., Ravaja, N., 2020. No evidence of calorie-related modulation of N2 in food-related Go/No-Go training: A preregistered ERP study. *Psychophysiology* 57 (4), e13518. <https://doi.org/10.1111/psyp.13518>.
- Baik, J.-H., 2020. Stress and the dopaminergic reward system. *Exp. Mol. Med.* 52 (12), 1879–1890. <https://doi.org/10.1038/s12276-020-00532-4>.
- Becker, A., Kirsch, M., Gerchen, M.F., Kiefer, F., Kirsch, P., 2017. Striatal activation and frontostriatal connectivity during non-drug reward anticipation in alcohol dependence. *Addict. Biol.* 22 (3), 833–843. <https://doi.org/10.1111/adb.12352>.
- Becker, A., Gerchen, M.F., Kirsch, M., Hoffmann, S., Kiefer, F., Kirsch, P., 2018. Striatal reward sensitivity predicts therapy-related neural changes in alcohol addiction. *Eur. Arch. Psychiatry Clin. Neurosci.* 268, 231–242. <https://doi.org/10.1007/s00406-017-0805-y>.
- Bennett, M.P., Knight, R., Patel, S., So, T., Dunning, D., Barnhofer, T., Smith, P., Kuyken, W., Ford, T., Dalgleish, T., 2021. Decentering as a core component in the psychological treatment and prevention of youth anxiety and depression: a narrative review and insight report. *Transl. Psychiatry* 11 (1), 1–14. <https://doi.org/10.1038/s41398-021-01397-5>.
- Bernard, L., Cyr, L., Bonnet-Suard, A., Cutarella, C., Bréjard, V., 2021. Drawing alcohol craving process: a systematic review of its association with thought suppression, inhibition and impulsivity. *Heliyon* 7 (1), e05868. <https://doi.org/10.1016/j.heliyon.2020.e05868>.
- Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., Fresco, D.M., 2015. Decentering and related constructs: a critical review and metacognitive processes model. *Perspect. Psychol. Sci.* 10 (5), 599–617. <https://doi.org/10.1177/1745691615594577>.
- Blanck, P., Perleth, S., Heidenreich, T., Kröger, P., Ditzén, B., Bents, H., Mander, J., 2018. Effects of mindfulness exercises as stand-alone intervention on symptoms of anxiety and depression: systematic review and meta-analysis. *Behav. Res. Ther.* 102, 25–35. <https://doi.org/10.1016/j.brat.2017.12.002>.
- Bodell, L.P., Racine, S.E., 2023. A mechanistic staging model of reward processing alterations in individuals with binge-type eating disorders. *Int. J. Eat. Disord.* 56 (3), 516–522. <https://doi.org/10.1002/eat.23875>.
- Boffo, M., Zerhouni, O., Gronau, Q.F., van Beek, R.J., Nikolaou, K., Marsman, M., Wiers, R.W., 2019. Cognitive bias modification for behavior change in alcohol and smoking addiction: Bayesian meta-analysis of individual participant data. *Neuropsychol. Rev.* 29 (1), 52–78. <https://doi.org/10.1007/s11065-018-9386-4>.
- Bos, J., Staiger, P.K., Hayden, M.J., Hughes, L.K., Youssef, G., Lawrence, N.S., 2019. A randomized controlled trial of inhibitory control training for smoking cessation and reduction. *J. Consult. Clin. Psychol.* 87 (9), 831. <https://doi.org/10.1037/ccp0000424>.
- Boswell, R.G., Kober, H., 2016. Food cue reactivity and craving predict eating and weight gain: a meta-analytic review. *Obes. Rev.* 17 (2), 159–177. <https://doi.org/10.1111/obr.12354>.
- Bowen, S., Marlatt, A., 2009. Surfing the urge: brief mindfulness-based intervention for college student smokers. *Psychol. Addict. Behav.* 23 (4), 666. <https://doi.org/10.1037/a0017127>.
- Bowen, S., Witkiewitz, K., Clifasefi, S.L., Grow, J., Chawla, N., Hsu, S.H., Carroll, H.A., Harrop, E., Collins, S.E., Lustyk, M.K., 2014. Relative efficacy of mindfulness-based relapse prevention, standard relapse prevention, and treatment as usual for substance use disorders: a randomized clinical trial. *JAMA Psychiatry* 71 (5), 547–556. <https://doi.org/10.1001/jamapsychiatry.2013.4546>.
- Bradizza, C.M., Stasiewicz, P.R., Paas, N.D., 2006. Relapse to alcohol and drug use among individuals diagnosed with co-occurring mental health and substance use disorders: a review. *Clin. Psychol. Rev.* 26 (2), 162–178. <https://doi.org/10.1016/j.cpr.2005.11.005>.
- 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. *Clin. Psychol.: Sci. Pract.* <https://doi.org/10.1037/cps0000075>.
- Bresin, K., Mekawi, Y., Verona, E., 2018. The effect of laboratory manipulations of negative affect on alcohol craving and use: a meta-analysis. *Psychol. Addict. Behav.* 32 (6), 617. <https://doi.org/10.1037/adb0000383>.
- Brown, K.W., Berry, D., Eichel, K., Beloborodova, P., Rahrig, H., Britton, W.B., 2022. Comparing impacts of meditation training in focused attention, open monitoring, and mindfulness-based cognitive therapy on emotion reactivity and regulation: Neural and subjective evidence from a dismantling study. *Psychophysiology*, e14024. <https://doi.org/10.1111/psyp.14024>.
- Byrne, S.P., Haber, P., Baillie, A., Giannopolous, V., Morley, K., 2019. Cue exposure therapy for alcohol use disorders: what can be learned from exposure therapy for anxiety disorders? *Subst. Use Misuse* 54 (12), 2053–2063. <https://doi.org/10.1080/10826084.2019.1618328>.
- Cabrera, E.A., Wiers, C.E., Lindgren, E., Miller, G., Volkow, N.D., Wang, G.-J., 2016. Neuroimaging the effectiveness of substance use disorder treatments. *J. Neuroimmune Pharmacol.* 11, 408–433. <https://doi.org/10.1007/s11481-016-9680-y>.
- Carbine, K.A., Muir, A.M., Allen, W.D., LeCheminant, J.D., Baldwin, S.A., Jensen, C.D., Kirwan, C.B., Larson, M.J., 2021. Does inhibitory control training reduce weight and caloric intake in adults with overweight and obesity? a pre-registered, randomized controlled event-related potential (ERP) study. *Behav. Res. Ther.* 136, 103784. <https://doi.org/10.1016/j.brat.2020.103784>.
- Carroll, H., Lustyk, M.K.B., 2018. Mindfulness-based relapse prevention for substance use disorders: effects on cardiac vagal control and craving under stress. *Mindfulness* 9 (2), 488–499. <https://doi.org/10.1007/s12671-017-0791-1>.
- Cáscas, L., Pirruccio, V., Vadillo, M.A., Lupiáñez, J., 2020. Does mindfulness meditation training enhance executive control? a systematic review and meta-analysis of randomized controlled trials in adults. *Mindfulness* 11 (2), 411–424. <https://doi.org/10.1007/s12671-019-01279-4>.
- Cavichioni, M., Vassena, G., Movalli, M., Maffei, C., 2020. Is craving a risk factor for substance use among treatment-seeking individuals with alcohol and other drugs use disorders? a meta-analytic review. *Drug Alcohol Depend.* 212, 108002. <https://doi.org/10.1016/j.drugalcdep.2020.108002>.
- Chen, Z., Veling, H., Dijksterhuis, A., Holland, R.W., 2016. How does not responding to appetitive stimuli cause devaluation: evaluative conditioning or response inhibition? *J. Exp. Psychol.: Gen.* 145 (12), 1687. <https://doi.org/10.1037/xge0000236>.
- Chen, Z., Veling, H., de Vries, S.P., Bijvank, B.O., Janssen, I., Dijksterhuis, A., Holland, R.W., 2018. Go/no-go training changes food evaluation in both morbidly obese and normal-weight individuals. *J. Consult. Clin. Psychol.* 86 (12), 980. <https://doi.org/10.1037/ccp0000320>.

- Cheval, B., Finckh, A., Maltagliati, S., Fessler, L., Cullati, S., Sander, D., Friese, M., Wiers, R.W., Boisgontier, M.P., Courvoisier, D.S., 2021. Cognitive-bias modification intervention to improve physical activity in patients following a rehabilitation programme: protocol for the randomised controlled IMPACT trial. *BMJ Open* 11 (9), e053845. <https://doi.org/10.1136/bmjopen-2021-053845>.
- Chikhi, S., Matton, N., Blanchet, S., 2022. EEG power spectral measures of cognitive workload: a meta-analysis. *Psychophysiology* 59 (6), e14009. <https://doi.org/10.1111/psyp.14009>.
- Chin, B., Lindsay, E.K., Greco, C.M., Brown, K.W., Smyth, J.M., Wright, A.G., Creswell, J. D., 2019. Psychological mechanisms driving stress resilience in mindfulness training: a randomized controlled trial. *Health Psychol.* 38 (8), 759. <https://doi.org/10.1037/hea0000763>.
- Chin, B., Lindsay, E.K., Greco, C.M., Brown, K.W., Smyth, J.M., Wright, A.G., Creswell, J. D., 2021. Mindfulness interventions improve momentary and trait measures of attentional control: evidence from a randomized controlled trial. *J. Exp. Psychol.: Gen.* 150 (4), 686. <https://doi.org/10.1037/xge0000969>.
- Chowdhury, N., Khandoker, A.H., 2023. The gold-standard treatment for social anxiety disorder: a roadmap for the future. *Front. Psychol.* 13, 1070975. <https://doi.org/10.3389/fpsyg.2022.1070975>.
- Clayton, M.S., Yeung, N., Cohen Kadosh, R., 2018. The many characters of visual alpha oscillations. *Eur. J. Neurosci.* 48 (7), 2498–2508. <https://doi.org/10.1111/ejn.13747>.
- Cofresí, R.U., Bartholow, B.D., Piasecki, T.M., 2019. Evidence for incentive salience sensitization as a pathway to alcohol use disorder. *Neurosci. Biobehav. Rev.* 107, 897–926. <https://doi.org/10.1016/j.neubiorev.2019.10.009>.
- Conklin, C.A., Tiffany, S.T., 2002. Applying extinction research and theory to cue-exposure addiction treatments. *Addiction* 97 (2), 155–167. <https://doi.org/10.1046/j.1360-0443.2002.00014.x>.
- Craske, M.G., Treanor, M., Conway, C.C., Zbozinek, T., Vervliet, B., 2014. Maximizing exposure therapy: An inhibitory learning approach. *Behav. Res. Ther.* 58, 10–23. <https://doi.org/10.1016/j.brat.2014.04.006>.
- Creswell, J.D., 2017. Mindfulness interventions. *Annu. Rev. Psychol.* 68, 491–516. <https://doi.org/10.1146/annurev-psych-042716-051139>.
- Cristea, I.A., Kok, R.N., Cuijpers, P., 2016. The effectiveness of cognitive bias modification interventions for substance addictions: a meta-analysis. *PLoS One* 11 (9). <https://doi.org/10.1371/journal.pone.0162226>.
- Davis, J.P., Berry, D., Dumas, T.M., Ritter, E., Smith, D.C., Menard, C., Roberts, B.W., 2018. Substance use outcomes for mindfulness based relapse prevention are partially mediated by reductions in stress: results from a randomized trial. *J. Subst. Abuse. Treat.* 91, 37–48. <https://doi.org/10.1016/j.jsat.2018.05.002>.
- van de Vijver, I., van Schie, H.T., Veling, H., van Dooren, R., Holland, R.W., 2018. Go/no-go training affects frontal midline theta and mu oscillations to passively observed food stimuli. *Neuropsychologia* 119, 280–291. <https://doi.org/10.1016/j.neuropsychologia.2018.08.023>.
- Di Lemma, L.C., Field, M., 2017. Cue avoidance training and inhibitory control training for the reduction of alcohol consumption: a comparison of effectiveness and investigation of their mechanisms of action. *Psychopharmacology* 234, 2489–2498. <https://doi.org/10.1007/s00213-017-4639-0>.
- Droutman, V., Read, S.J., Bechara, A., 2015. Revisiting the role of the insula in addiction. *Trends Cogn. Sci.* 19 (7), 414–420. <https://doi.org/10.1016/j.tics.2015.05.005>.
- Effertz, T., Mann, K., 2013. The burden and cost of disorders of the brain in Europe with the inclusion of harmful alcohol use and nicotine addiction. *Eur. Neuropsychopharmacol.* 23 (7), 742–748. <https://doi.org/10.1016/j.euroneuro.2012.07.010>.
- Ekhtiari, H., Kuplicki, R., Aupperle, R.L., Paulus, M.P., 2021. It is never as good the second time around: Brain areas involved in salience processing habituate during repeated drug cue exposure in treatment engaged abstinent methamphetamine and opioid users. *Neuroimage* 238, 118180. <https://doi.org/10.1016/j.neuroimage.2021.118180>.
- Ekhtiari, H., Zare-Bidoky, M., Sangchooli, A., Janes, A.C., Kaufman, M.J., Oliver, J.A., Prisciandaro, J.J., Wüstenberg, T., Anton, R.F., Bach, P., 2022. A methodological checklist for fMRI drug cue reactivity studies: development and expert consensus. *Nat. Protoc.* 17 (3), 567–595.
- Ellis, B.J., Bianchi, J., Griskevicius, V., Frankenhuis, W.E., 2017. Beyond risk and protective factors: an adaptation-based approach to resilience. *Perspect. Psychol. Sci.* 12 (4), 561–587.
- Ellis, B.J., Abrams, L.S., Masten, A.S., Sternberg, R.J., Tottenham, N., Frankenhuis, W.E., 2022. Hidden talents in harsh environments. *Dev. Psychopathol.* 34 (1), 95–113. <https://doi.org/10.1017/S0954579420000887>.
- Fisher, N., Lattimore, P., Malinowski, P.J.A., 2016. Attention with a mindful attitude attenuates subjective appetitive reactions and food intake following food-cue exposure. *Appetite* 99, 10–16. <https://doi.org/10.1016/j.appet.2015.12.009>.
- Flagel, S.B., Akil, H., Robinson, T.E., 2009. Individual differences in the attribution of incentive salience to reward-related cues: implications for addiction. *Neuropharmacology* 56, 139–148. <https://doi.org/10.1016/j.neuropharm.2008.06.027>.
- Foa, E.B., McLean, C.P., 2016. The efficacy of exposure therapy for anxiety-related disorders and its underlying mechanisms: the case of OCD and PTSD. *Annu. Rev. Clin. Psychol.* 12, 1–28. <https://doi.org/10.1146/annurev-clinpsy-021815-093533>.
- Forman, E.M., Shaw, J.A., Goldstein, S.P., Butryn, M.L., Martin, L.M., Meiran, N., Crosby, R.D., Manasse, S.M., 2016. Mindful decision making and inhibitory control training as complementary means to decrease snack consumption. *Appetite* 103, 176–183. <https://doi.org/10.1016/j.appet.2016.04.014>.
- Frankenhuis, W.E., Nettle, D., 2020. The strengths of people in poverty. *Curr. Dir. Psychol. Sci.* 29 (1), 16–21. <https://doi.org/10.1177/0963721419881>.
- Frankort, A., Roefs, A., Siep, N., Roebroek, A., Havermans, R., Jansen, A., 2014. The craving stops before you feel it: neural correlates of chocolate craving during cue exposure with response prevention. *Cereb. Cortex* 24 (6), 1589–1600. <https://doi.org/10.1093/cercor/bht016>.
- Froeliger, B., Mathew, A.R., McConnell, P.A., Eichberg, C., Saladin, M.E., Carpenter, M. J., Garland, E.L., 2017. Restructuring reward mechanisms in nicotine addiction: a pilot fMRI study of mindfulness-oriented recovery enhancement for cigarette smokers. *Evid.-Based Complement. Altern. Med.* 2017. <https://doi.org/10.1155/2017/7018014>.
- Garland, E.L., 2016. Restructuring reward processing with mindfulness-oriented recovery enhancement: novel therapeutic mechanisms to remediate hedonic dysregulation in addiction, stress, and pain. *Ann. N. Y. Acad. Sci.* 1373 (1), 25–37. <https://doi.org/10.1111/nyas.13034>.
- Garland, E.L., 2021. Mindful positive emotion regulation as a treatment for addiction: from hedonic pleasure to self-transcendent meaning. *Curr. Opin. Behav. Sci.* 39, 168–177. <https://doi.org/10.1016/j.cobeha.2021.03.019>.
- Garland, E.L., Howard, M.O., 2018. Mindfulness-based treatment of addiction: current state of the field and envisioning the next wave of research. *Addict. Sci. Clin. Pract.* 13 (1), 1–14. <https://doi.org/10.1186/s13722-018-0115-3>.
- Garland, E.L., Nakamura, Y., Bryan, C.J., Hanley, A.W., Parisi, A., Froeliger, B., Marchand, W.R., & Donaldson, G.W. (in press). Mindfulness-Oriented Recovery Enhancement for Veterans and Military Personnel on Long-Term Opioid Therapy for Chronic Pain: A Randomized Clinical Trial. *American Journal of Psychiatry*.
- Garland, E.L., Gaylord, S.A., Boettiger, C.A., Howard, M.O., 2010. Mindfulness training modifies cognitive, affective, and physiological mechanisms implicated in alcohol dependence: results of a randomized controlled pilot trial. *J. Psychoact. Drugs* 42 (2), 177–192. <https://doi.org/10.1080/02791072.2010.10400690>.
- Garland, E.L., Froeliger, B., Howard, M.O., 2014. Effects of mindfulness-oriented recovery enhancement on reward responsiveness and opioid cue-reactivity. *Psychopharmacology* 231, 3229–3238. <https://doi.org/10.1007/s00213-014-3504-7>.
- Garland, E.L., Froeliger, B., Howard, M.O., 2015. Neurophysiological evidence for remediation of reward processing deficits in chronic pain and opioid misuse following treatment with mindfulness-oriented recovery enhancement: exploratory ERP findings from a pilot RCT. *J. Behav. Med.* 38, 327–336. <https://doi.org/10.1007/s10865-014-9607-0>.
- Garland, E.L., Howard, M.O., Zubieta, J.-K., Froeliger, B., 2017. Restructuring hedonic dysregulation in chronic pain and prescription opioid misuse: effects of mindfulness-oriented recovery enhancement on responsiveness to drug cues and natural rewards. *Psychother. Psychosom.* 86 (2), 111–112. <https://doi.org/10.1159/000453400>.
- Garland, E.L., Bryan, C.J., Finan, P.H., Thomas, E.A., Priddy, S.E., Riquino, M.R., Howard, M.O., 2017. Pain, hedonic regulation, and opioid misuse: modulation of momentary experience by Mindfulness-Oriented Recovery Enhancement in opioid-treated chronic pain patients. *Drug Alcohol Depend.* 173, S65–S72. <https://doi.org/10.1016/j.drugalcdep.2016.07.033>.
- Garland, E.L., Baker, A.K., Howard, M.O., 2017. Mindfulness-oriented recovery enhancement reduces opioid attentional bias among prescription opioid-treated chronic pain patients. *J. Soc. Soc. Work Res.* 8 (4), 493–509. <https://doi.org/10.1086/694324>.
- Garland, E.L., Hanley, A.W., Riquino, M.R., Reese, S.E., Baker, A.K., Salas, K., Yack, B.P., Bedford, C.E., Bryan, M.A., Atchley, R., 2019. Mindfulness-oriented recovery enhancement reduces opioid misuse risk via analgesic and positive psychological mechanisms: a randomized controlled trial. *J. Consult. Clin. Psychol.* 87 (10), 927. <https://doi.org/10.1037/ccp0000390>.
- Garland, E.L., Atchley, R.M., Hanley, A.W., Zubieta, J.-K., Froeliger, B., 2019. Mindfulness-oriented recovery enhancement mediates hedonic dysregulation in opioid users: neural and affective evidence of target engagement. *eaa1569 Sci. Adv.* 5 (10). <https://doi.org/10.1126/sciadv.aax156>.
- Garland, E.L., Bryan, M.A., Priddy, S.E., Riquino, M.R., Froeliger, B., Howard, M.O., 2019. Effects of mindfulness-oriented recovery enhancement versus social support on negative affective interference during inhibitory control among opioid-treated chronic pain patients: a pilot mechanistic study. *Ann. Behav. Med.* 53 (10), 865–876. <https://doi.org/10.1093/abm/kay096>.
- Garland, E.L., Baker, A.K., Riquino, M.R., Priddy, S.E., 2019. Mindfulness-oriented recovery enhancement. *Handb. mindfulness-based program mindfulness Interv from Educ to heal Ther.* Routledge, Abingdon.
- Garland, E.L., Hanley, A.W., Hudak, J., Nakamura, Y., Froeliger, B., 2022. Mindfulness-induced endogenous theta stimulation occasions self-transcendence and inhibits addictive behavior. *eabo4455 Sci. Adv.* 8 (41). <https://doi.org/10.1126/sciadv.abo4455>.
- Garland, E.L., Hanley, A.W., Nakamura, Y., Barrett, J.W., Baker, A.K., Reese, S.E., Riquino, M.R., Froeliger, B., Donaldson, G.W., 2022. Mindfulness-oriented recovery enhancement vs supportive group therapy for co-occurring opioid misuse and chronic pain in primary care: a randomized clinical trial. *JAMA Intern. Med.* 182 (4), 407–417. <https://doi.org/10.1001/jamainternmed.2022.0033>.
- Garland, E.L., Fix, S.T., Hudak, J.P., Bernat, E.M., Nakamura, Y., Hanley, A.W., Donaldson, G.W., Marchand, W.R., Froeliger, B., 2023. Mindfulness-oriented recovery enhancement remediates anhedonia in chronic opioid use by enhancing neurophysiological responses during savoring of natural rewards. *Psychol. Med.* 53 (5), 2085–2094. <https://doi.org/10.1017/S0033291721003834>.
- Gearhardt, A.N., Hebebrand, J., 2021. The concept of “food addiction” helps inform the understanding of overeating and obesity: Debate Consensus. *Am. J. Clin. Nutr.* 113 (2), 274–276. <https://doi.org/10.1093/ajcn/nqaa345>.
- Gearhardt, A.N., Schulte, E.M., 2021. Is food addictive? a review of the science. *Annu. Rev. Nutr.* 41, 387–410. <https://doi.org/10.1146/annurev-nutr-110420-111710>.

- Geller, K., Lippke, S., Nigg, C.R., 2017. Future directions of multiple behavior change research. *J. Behav. Med.* 40 (1), 194–202. <https://doi.org/10.1007/s10865-016-9809-8>.
- Ghaffari, A., Mousavi-Nasab, S., Fazilat-Pour, M., 2021. Comparison of the effectiveness of attentional bias modification, approach bias modification and their combination on cognitive bias and relapse in methamphetamine abusers. *Int. J. Behav. Sci.* 14 (4), 217–224. <https://doi.org/10.30491/ijbs.2020.224250.1230>.
- Ghiță, A., Teixidor, L., Monras, M., Ortega, L., Mondon, S., Gual, A., Paredes, S.M., Villares Urgell, L., Porras-García, B., Ferrer-García, M., 2019. Identifying triggers of alcohol craving to develop effective virtual environments for cue exposure therapy. *Front. Psychol.* 10, 74. <https://doi.org/10.3389/fpsyg.2019.00074>.
- Glanz, K., Bishop, D.B., 2010. The role of behavioral science theory in development and implementation of public health interventions. *Annu. Rev. Public Health* 31, 399–418. <https://doi.org/10.1146/annurev.publhealth.012809.103604>.
- Godfrey, K.M., Gallo, L.C., Afari, N., 2015. Mindfulness-based interventions for binge eating: a systematic review and meta-analysis. *J. Behav. Med.* 38, 348–362. <https://doi.org/10.1007/s10865-014-9610-5>.
- Goldberg, S.B., Riordan, K.M., Sun, S., Davidson, R.J., 2021. The empirical status of mindfulness-based interventions: a systematic review of 44 meta-analyses of randomized controlled trials. *Perspect. Psychol. Sci.*, 1745691620968771. <https://doi.org/10.1177/1745691620968771>.
- Grieder, M., Soravia, L.M., Tschuempferlin, R.M., Batschelet, H.M., Federspiel, A., Schwab, S., Morishima, Y., Moggi, F., Stein, M., 2022. Right inferior frontal activation during alcohol-specific inhibition increases with craving and predicts drinking outcome in alcohol use disorder. *Front. Psychiatry* 13. <https://doi.org/10.3389/fpsyg.2022.909992>.
- Gullo, M.J., Loxton, N.J., Dawe, S., 2014. Impulsivity: four ways five factors are not basic to addiction. *Addict. Behav.* 39 (11), 1547–1556. <https://doi.org/10.1016/j.addbeh.2014.01.002>.
- Hanley, A.W., Garland, E.L., 2020. Salivary measurement and mindfulness-based modulation of prescription opioid cue-reactivity. *Drug Alcohol Depend.* 217, 108351. <https://doi.org/10.1016/j.drugalcdep.2020.108351>.
- Hanley, A.W., Dorjee, D., Garland, E.L., 2020. Mindfulness training encourages self-transcendent states via decentering. *Psychol. Conscious.: Theory, Res., Pract.* <https://doi.org/10.1002/smi.3035>.
- Hanley, A.W., de Vibe, M., Solhaug, I., Farb, N., Goldin, P.R., Gross, J.J., Garland, E.L., 2021. Modeling the mindfulness-to-meaning theory's mindful reappraisal hypothesis: Replication with longitudinal data from a randomized controlled study. *Stress Health* 37 (4), 778–789. <https://doi.org/10.1002/smi.3035>.
- Hanna, E.Z., Yi, H.-y., Dufour, M.C., Whitmore, C.C., 2001. The relationship of early-onset regular smoking to alcohol use, depression, illicit drug use, and other risky behaviors during early adolescence: results from the youth supplement to the third national health and nutrition examination survey. *J. Subst. Abuse* 13 (3), 265–282. [https://doi.org/10.1016/S0899-3289\(01\)00077-3](https://doi.org/10.1016/S0899-3289(01)00077-3).
- Heckman, B.W., MacQueen, D.A., Marquinez, N.S., MacKillop, J., Bickel, W.K., Brandon, T.H., 2017. Self-control depletion and nicotine deprivation as precipitants of smoking cessation failure: A human laboratory model. *J. Consult. Clin. Psychol.* 85 (4), 381. <https://doi.org/10.1037/ccp0000197>.
- Hedman-Lagerlöf, M., Andersson, E., Hedman-Lagerlöf, E., Wicksell, R.K., Flück, I., Ljótsson, B., 2019. Approach as a key for success: reduced avoidance behaviour mediates the effect of exposure therapy for fibromyalgia. *Behav. Res. Ther.* 122, 103478. <https://doi.org/10.1016/j.brat.2019.103478>.
- Heitmann, J., Bennis, E.C., van Hemel-Ruiter, M.E., de Jong, P.J., 2018. The effectiveness of attentional bias modification for substance use disorder symptoms in adults: a systematic review. *Syst. Rev.* 7 (1), 1–21. <https://doi.org/10.1186/s13643-018-0822-6>.
- Hesser, H., Hedman-Lagerlöf, E., Andersson, E., Lindfors, P., Ljótsson, B., 2018. How does exposure therapy work? a comparison between generic and gastrointestinal anxiety-specific mediators in a dismantling study of exposure therapy for irritable bowel syndrome. *J. Consult. Clin. Psychol.* 86 (3), 254. <https://doi.org/10.1037/ccp0000273>.
- Hill-Bowen, L.D., Riedel, M.C., Poudel, R., Salo, T., Flannery, J.S., Camilleri, J.A., Eickhoff, S.B., Laird, A.R., Sutherland, M.T., 2021. The cue-reactivity paradigm: an ensemble of networks driving attention and cognition when viewing drug and natural reward-related stimuli. *Neurosci. Biobehav. Rev.* 130, 201–213. <https://doi.org/10.1016/j.neubiorev.2021.08.010>.
- Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., Crombez, G., 2010. Evaluative conditioning in humans: a meta-analysis. *Psychol. Bull.* 136 (3), 390. <https://doi.org/10.1037/a0018916>.
- Hogarth, L., 2020. Addiction is driven by excessive goal-directed drug choice under negative affect: translational critique of habit and compulsion theory. *Neuropsychopharmacology* 45 (5), 720–735. <https://doi.org/10.1038/s41386-020-0600-8>.
- Hogarth, L., Balleine, B.W., Corbit, L.H., Killcross, S., 2013. Associative learning mechanisms underpinning the transition from recreational drug use to addiction. *Ann. N. Y. Acad. Sci.* 1282 (1), 12–24. <https://doi.org/10.1111/j.1749-6632.2012.06768.x>.
- Hogarth, L., Lam-Cassettari, C., Pacitti, H., Currah, T., Mählberg, J., Hartley, L., Moustafa, A., 2019. Intact goal-directed control in treatment-seeking drug users indexed by outcome-devaluation and Pavlovian to instrumental transfer: critique of habit theory. *Eur. J. Neurosci.* 50 (3), 2513–2525. <https://doi.org/10.1111/ejn.13961>.
- Hollands, G.J., Prestwich, A., Marteau, T.M., 2011. Using aversive images to enhance healthy food choices and implicit attitudes: an experimental test of evaluative conditioning. *Health Psychol.* 30 (2), 195. <https://doi.org/10.1037/a0022261>.
- Houben, K., Aulbach, M., 2023. Is there a difference between stopping and avoiding? a review of the mechanisms underlying Go/No-Go and approach-avoidance training for food choice. *Curr. Opin. Behav. Sci.* 49, 101245. <https://doi.org/10.1016/j.cobeha.2022.101245>.
- Houben, K., Havermans, R.C., Nederkoorn, C., Jansen, A.J.A., 2012. Beer à No-Go: learning to stop responding to alcohol cues reduces alcohol intake via reduced affective associations rather than increased response inhibition. *Addiction* 107 (7), 1280–1287. <https://doi.org/10.1111/j.1360-0443.2012.03827.x>.
- Hsieh, L.-T., Ranganath, C., 2014. Frontal midline theta oscillations during working memory maintenance and episodic encoding and retrieval. *Neuroimage* 85, 721–729. <https://doi.org/10.1016/j.neuroimage.2013.08.003>.
- Hudak, J., Hanley, A.W., Marchand, W.R., Nakamura, Y., Yabko, B., Garland, E.L., 2021. Endogenous theta stimulation during meditation predicts reduced opioid dosing following treatment with mindfulness-oriented recovery enhancement. *Neuropsychopharmacology* 46 (4), 836–843. <https://doi.org/10.1038/s41386-020-00831-4>.
- Iceta, S., Rodrigue, C., Legendre, M., Daoust, J., Flaudias, V., Michaud, A., Begin, C., 2021. Cognitive function in binge eating disorder and food addiction: a systematic review and three-level meta-analysis. *Prog. Neuro-Psychopharmacol. Biol. Psychiatry* 111, 110400.
- Im, S., Stavas, J., Lee, J., Mir, Z., Hazlett-Stevens, H., Caplovitz, G., 2021. Does mindfulness-based intervention improve cognitive function? a meta-analysis of controlled studies. *Clin. Psychol. Rev.*, 101972. <https://doi.org/10.1016/j.cpr.2021.101972>.
- Jacobus, J., Taylor, C.T., Gray, K.M., Meredith, L.R., Porter, A.M., Li, I., Castro, N., Squeglia, L.M., 2018. A multi-site proof-of-concept investigation of computerized approach-avoidance training in adolescent cannabis users. *Drug Alcohol Depend.* 187, 195–204. <https://doi.org/10.1016/j.drugalcdep.2018.03.007>.
- Janes, A.C., Datko, M., Roy, A., Barton, B., Druker, S., Neal, C., Ohashi, K., Benoit, H., van Lutterveld, R., Brewer, J.A., 2019. Quitting starts in the brain: a randomized controlled trial of app-based mindfulness shows decreases in neural responses to smoking cues that predict reductions in smoking. *Neuropsychopharmacology* 44 (9), 1631–1638. <https://doi.org/10.1038/s41386-019-0403-y>.
- Janssen, L.K., Duif, I., Speckens, A., Van Loon, I., Wegman, J., De Vries, J.H., Cools, R., Aarts, E., 2023. The effects of an 8-week mindful eating intervention on anticipatory reward responses in striatum and midbrain. *Front. Nutr.* 10, 1115727. <https://doi.org/10.3389/fnut.2023.1115727>.
- Jo, H.-G., Malinowski, P., Schmidt, S., 2017. Frontal theta dynamics during response conflict in long-term mindfulness meditators. *Front. Hum. Neurosci.* 11, 299. <https://doi.org/10.3389/fnhum.2017.00299>.
- Kabat-Zinn, J., 2003. Mindfulness-based stress reduction (MBSR). *Constr. Hum. Sci.* 8 (2), 73.
- Kakoschke, N., Kemps, E., Tiggemann, M., 2017. The effect of combined avoidance and control training on implicit food evaluation and choice. *J. Behav. Ther. Exp. Psychiatry* 55, 99–105. <https://doi.org/10.1016/j.jbtep.2017.01.002>.
- Karoly, H.C., Schacht, J.P., Jacobus, J., Meredith, L.R., Taylor, C.T., Tapert, S.F., Gray, K.M., Squeglia, L.M., 2019. Preliminary evidence that computerized approach avoidance training is not associated with changes in fMRI cannabis cue reactivity in non-treatment-seeking adolescent cannabis users. *Drug Alcohol Depend.* 200, 145–152. <https://doi.org/10.1016/j.drugalcdep.2019.04.007>.
- Keeler, J.L., Chami, R., Cardi, V., Hodsoll, J., Bonin, E., MacDonald, P., Treasure, J., Lawrence, N., 2022. App-based food-specific inhibitory control training as an adjunct to treatment as usual in binge-type eating disorders: A feasibility trial. *Appetite* 168, 105788. <https://doi.org/10.1016/j.appet.2021.105788>.
- Keesman, M., Aarts, H., Häfner, M., Papies, E.K., 2017. Mindfulness reduces reactivity to food cues: underlying mechanisms and applications in daily life. *Curr. Addict. Rep.* 4 (2), 151–157. <https://doi.org/10.1007/s40429-017-0134-2>.
- Keesman, M., Aarts, H., Häfner, M., Papies, E.K., 2020. The decentering component of mindfulness reduces reactions to mental imagery. *Motiv. Sci.* 6 (1), 34. <https://doi.org/10.1037/mot0000137>.
- Kiyak, C., Simonetti, M.E., Norton, S., Deluca, P., 2022. The efficacy of cue exposure therapy on alcohol use disorders: a quantitative meta-analysis and systematic review. *Addict. Behav.*, 107578. <https://doi.org/10.1016/j.addbeh.2022.107578>.
- Kober, H., Brewer, J.A., Height, K.L., Sinha, R., 2017. Neural stress reactivity relates to smoking outcomes and differentiates between mindfulness and cognitive-behavioral treatments. *Neuroimage* 151, 4–13. <https://doi.org/10.1016/j.neuroimage.2016.09.042>.
- Kober, H., Buhle, J., Weber, J., Ochsner, K.N., Wager, T.D., 2019. Let it be: mindful acceptance down-regulates pain and negative emotion. *Soc. Cogn. Affect. Neurosci.* 14 (11), 1147–1158. <https://doi.org/10.1093/scan/nsz104>.
- Kopetz, C., MacPherson, L., Mitchell, A.D., Houston-Ludlam, A.N., Wiers, R.W., 2017. A novel training approach to activate alternative behaviors for smoking in depressed smokers. *Exp. Clin. Psychopharmacol.* 25 (1), 50. <https://doi.org/10.1037/pha0000108>.
- Korecki, J.R., Schwebel, F.J., Votaw, V.R., Witkiewitz, K., 2020. Mindfulness-based programs for substance use disorders: a systematic review of manualized treatments. *Subst. Abuse. Treat., Prev., Policy* 15 (1), 1–37. <https://doi.org/10.1186/s13011-020-00293-3>.
- Kotov, R., Gamez, W., Schmidt, F., Watson, D., 2010. Linking “big” personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. *Psychol. Bull.* 136 (5), 768. <https://doi.org/10.1037/a0020327>.
- LaFata, E.M., 2022. A commentary on the progress towards recognizing food addiction as a psychological diagnosis. *Curr. Addict. Rep.* 1–4. <https://doi.org/10.1007/s40429-022-00436-5>.
- Langener, S., Van Der Nagel, J., van Manen, J., Markus, W., Dijkstra, B., Fuentes-Merillas, D., Klaassen, R., Heitmann, J., Heylen, D., Schellekens, A., 2021. Clinical

- relevance of immersive virtual reality in the assessment and treatment of addictive disorders: a systematic review and future perspective. *J. Clin. Med.* 10 (16), 3658. <https://doi.org/10.3390/jcm10163658>.
- Larsen, J.K., Hollands, G.J., 2022. Targeting automatic processes to reduce unhealthy behaviours: a process framework. *Health Psychol. Rev.* 16 (2), 204–219. <https://doi.org/10.1080/17437199.2021.1876572>.
- Lee, D.J., Kulubya, E., Goldin, P., Goodarzi, A., Girgis, F., 2018. Review of the neural oscillations underlying meditation. *Front. Neurosci.* 12, 178 <https://doi.org/10.3389/fnins.2018.00178>.
- Lee, S.H., Han, D.H., Oh, S., Lyoo, I.K., Lee, Y.S., Renshaw, P.F., Lukas, S.E., 2009. Quantitative electroencephalographic (qEEG) correlates of craving during virtual reality therapy in alcohol-dependent patients. *Pharmacol. Biochem. Behav.* 91 (3), 393–397. <https://doi.org/10.1016/j.pbb.2008.08.014>.
- Levallius, J., Monell, E., Birgegård, A., Clinton, D., Forsen Mantilla, E., 2022. Binge eating and addictive-like behaviours in males and females. *Psychol. Rep.* 125 (1), 148–166.
- Levi, K., Shoham, A., Amir, I., Bernstein, A., 2021. The daily dose-response hypothesis of mindfulness meditation practice: an experience sampling study. *Psychosom. Med.* 83 (6), 624–630. <https://doi.org/10.1097/PSY.0000000000000912>.
- Leyland, A., Rowse, G., Emerson, L.-M., 2019. Experimental effects of mindfulness inductions on self-regulation: a systematic review and meta-analysis. *Emotion* 19 (1), 108. <https://doi.org/10.1037/emo0000425>.
- Li, W., Howard, M.O., Garland, E.L., McGovern, P., Lazar, M., 2017. Mindfulness treatment for substance misuse: a systematic review and meta-analysis. *J. Subst. Abuse Treat.* 75, 62–96. <https://doi.org/10.1016/j.jsat.2017.01.008>.
- Lindsay, E.K., Creswell, J.D., 2017. Mechanisms of mindfulness training: monitor and acceptance theory (MAT). *Clin. Psychol. Rev.* 51, 48–59. <https://doi.org/10.1016/j.cpr.2016.10.011>.
- Lindsay, E.K., Chin, B., Greco, C.M., Young, S., Brown, K.W., Wright, A.G., Smyth, J.M., Burkett, D., Creswell, J.D., 2018. How mindfulness training promotes positive emotions: Dismantling acceptance skills training in two randomized controlled trials. *J. Personal. Soc. Psychol.* 115 (6), 944. <https://doi.org/10.1037/pspa0000134>.
- Lindsay, E.K., Young, S., Smyth, J.M., Brown, K.W., Creswell, J.D., 2018. Acceptance lowers stress reactivity: dismantling mindfulness training in a randomized controlled trial. *Psychoneuroendocrinology* 87, 63–73. <https://doi.org/10.1016/j.psyneuen.2017.09.015>.
- Liu, X., Hairston, J., Schrier, M., Fan, J., 2011. Common and distinct networks underlying reward valence and processing stages: a meta-analysis of functional neuroimaging studies. *Neurosci. Biobehav. Rev.* 35 (5), 1219–1236. <https://doi.org/10.1016/j.neubiorev.2010.12.012>.
- Lohani, M., McElvaine, K., Payne, B., Mitcheom, K., Britton, W., 2020. A longitudinal training study to delineate the specific causal effects of open monitoring versus focused attention techniques on emotional health. *Complement. Ther. Med.* 53, 102525 <https://doi.org/10.1016/j.ctim.2020.102525>.
- Lomas, T., Ivtzan, I., Fu, C.H., 2015. A systematic review of the neurophysiology of mindfulness on EEG oscillations. *Neurosci. Biobehav. Rev.* 57, 401–410. <https://doi.org/10.1016/j.neubiorev.2015.09.018>.
- Lorenzetti, V., Gaillard, A., Beyer, E., Kowalczyk, M., Kamboj, S.K., Manning, V., Gleeson, J., 2023. Do mindfulness-based interventions change brain function in people with substance dependence? a systematic review of the fMRI evidence. *BMC Psychiatry* 23 (1), 407. <https://doi.org/10.1186/s12888-023-04789-7>.
- Luijten, M., Schellekens, A.F., Kühn, S., Machielse, M.W., Sescousse, G., 2017. Disruption of reward processing in addiction: an image-based meta-analysis of functional magnetic resonance imaging studies. *JAMA Psychiatry* 74 (4), 387–398. <https://doi.org/10.1001/jamapsychiatry.2016.3084>.
- Lüscher, C., Robbins, T.W., Everitt, B.J., 2020. The transition to compulsion in addiction. *Nat. Rev. Neurosci.* 21 (5), 247–263. <https://doi.org/10.1038/s41583-020-0289-z>.
- Machulska, A., Rinck, M., Klucken, T., Kleinke, K., Wunder, J.-C., Remeniuk, O., Margraf, J., 2022. “Push it!” or “Hold it!”? A comparison of nicotine-avoidance training and nicotine-inhibition training in smokers motivated to quit. *Psychopharmacology* 17 (1). <https://doi.org/10.1007/s00213-021-06058-5>.
- MacLean, R.R., 2023. Integrating cognitive bias modification for pain and opioid cues into medication for opioid use disorder clinical care: feasibility, acceptability, and preliminary results. *Drug Alcohol Depend.* 246, 109857 <https://doi.org/10.1016/j.drugalcdep.2023.109857>.
- Magson, N.R., Handford, C.M., Norberg, M.M., 2021. The empirical status of cue exposure and response prevention treatment for binge eating: a systematic review. *Behav. Ther.* 52 (2), 442–454. <https://doi.org/10.1016/j.beth.2020.06.005>.
- Malbos, E., Borwell, B., Einig-Iscain, M., Korchia, T., Cantalupi, R., Boyer, L., Lancon, C., 2022. Virtual reality cue exposure therapy for tobacco relapse prevention: a comparative study with standard intervention. *Psychol. Med.* 53 (11), 1–11. <https://doi.org/10.1017/S0033291722002070>.
- Manning, V., Garfield, J.B., Mroz, K., Campbell, S.C., Piercy, H., Staiger, P.K., Lum, J.A., Lubman, D.I., Verdejo-García, A., 2019. Feasibility and acceptability of approach bias modification during methamphetamine withdrawal and related methamphetamine use outcomes. *J. Subst. Abuse Treat.* 106, 12–18. <https://doi.org/10.1016/j.jsat.2019.07.008>.
- Marissen, M.A., Franken, I.H., Blanken, P., van den Brink, W., Hendriks, V.M., 2007. Cue exposure therapy for the treatment of opiate addiction: results of a randomized controlled clinical trial. *Psychother. Psychosom.* 76 (2), 97–105. <https://doi.org/10.1159/000097968>.
- Masterton, S., Hardman, C.A., Halford, J.C., Jones, A., 2020. Examining cognitive bias modification interventions for reducing food value and choice: Two pre-registered, online studies. *Appetite* 159, 105063. <https://doi.org/10.1016/j.appet.2020.105063>.
- Mayer, A.R., Dodd, A.B., Wilcox, C.E., Klimaj, S.D., Claus, E.D., Bryan, A.D., 2020. Effects of attentional bias modification therapy on the cue reactivity and cognitive control networks in participants with cocaine use disorders. *Am. J. Drug Alcohol Abuse* 46 (3), 357–367. <https://doi.org/10.1080/00952990.2019.1671437>.
- Mehl, N., Morys, F., Villringer, A., Horstmann, A., 2019. Unhealthy yet avoidable—How cognitive bias modification alters behavioral and brain responses to food cues in individuals with obesity. *Nutrients* 11 (4), 874. <https://doi.org/10.3390/n11040874>.
- Mellentin, A.I., Skøt, L., Nielsen, B., Schippers, G.M., Nielsen, A.S., Stenager, E., Juhl, C.J. C.P.R., 2017. Cue exposure therapy for the treatment of alcohol use disorders: a meta-analytic review. *Clin. Psychol. Rev.* 57, 195–207. <https://doi.org/10.1016/j.cpr.2017.07.006>.
- Mercado, D., Robinson, L., Gordon, G., Werthmann, J., Campbell, I.C., Schmidt, U., 2021. The outcomes of mindfulness-based interventions for obesity and binge eating disorder: a meta-analysis of randomised controlled trials. *Appetite* 166, 105464. <https://doi.org/10.1016/j.appet.2021.105464>.
- Mitchell, D.J., McNaughton, N., Flanagan, D., Kirk, I.J., 2008. Frontal-midline theta from the perspective of hippocampal “theta”. *Prog. Neurobiol.* 86 (3), 156–185. <https://doi.org/10.1016/j.pneurobio.2008.09.005>.
- Moore, M.T., Lau, M.A., Haigh, E.A., Willett, B.R., Bosma, C.M., Fresco, D.M., 2022. Association between decentering and reductions in relapse/recurrence in mindfulness-based cognitive therapy for depression in adults: a randomized controlled trial. *J. Consult. Clin. Psychol.* 90 (2), 137. <https://doi.org/10.1037/ccp0000718>.
- Najberg, H., Rigamonti, M., Mouthon, M., Spierer, L., 2021. Modifying food items valuation and weight with gamified experience control training. *R. Soc. Open Sci.* 8 (5), 191288 <https://doi.org/10.1098/rsos.191288>.
- Naqvi, N.H., Bechara, A., 2009. The hidden island of addiction: the insula. *Trends Neurosci.* 32 (1), 56–67. <https://doi.org/10.1016/j.tins.2008.09.009>.
- Naqvi, N.H., Rudrauf, D., Damasio, H., Bechara, A., 2007. Damage to the insula disrupts addiction to cigarette smoking. *Science* 315 (5811), 531–534. <https://doi.org/10.1126/science.1135926>.
- Noël, X., Brevers, D., Bechara, A., 2013. A neurocognitive approach to understanding the neurobiology of addiction. *Curr. Opin. Neurobiol.* 23 (4), 632–638. <https://doi.org/10.1016/j.conb.2013.01.018>.
- Oikonomou, M.T., Arvanitis, M., Sokolove, R.L., 2017. Mindfulness training for smoking cessation: a meta-analysis of randomized-controlled trials. *J. Health Psychol.* 22 (14), 1841–1850. <https://doi.org/10.1177/1359105316637>.
- Papies, E.K., van Winckel, M., Keesman, M., 2016. Food-specific decentering experiences are associated with reduced food cravings in meditators: a preliminary investigation. *Mindfulness* 7 (5), 1123–1131. <https://doi.org/10.1007/s12671-016-0554-4>.
- Papies, E.K., Barsalou, L.W., Rusz, D., 2020. Understanding desire for food and drink: a grounded-cognition approach. *Curr. Dir. Psychol. Sci.* 29 (2), 193–198. <https://doi.org/10.1177/0963721420904>.
- Parisi, A., Roberts, R.L., Hanley, A.W., Garland, E.L., 2022. Mindfulness-oriented recovery enhancement for addictive behavior, psychiatric distress, and chronic pain: a multilevel meta-analysis of randomized controlled trials. *Mindfulness* 13 (10), 2396–2412. <https://doi.org/10.1007/s12671-022-01964-x>.
- Pepe, M., Di Nicola, M., Panaccione, I., Franza, R., De Berardis, D., Cibin, M., Janiri, L., Sani, G., 2023. Impulsivity and alexithymia predict early versus subsequent relapse in patients with alcohol use disorder: A 1-year longitudinal study. *Drug Alcohol Rev.* 42 (2), 367–372. <https://doi.org/10.1111/dar.13568>.
- Perales, J.C., King, D.L., Navas, J.F., Schimmenti, A., Sescousse, G., Starcevic, V., van Holst, R.J., Billieux, J., 2020. Learning to lose control: A process-based account of behavioral addiction. *Neurosci. Biobehav. Rev.* 108, 771–780. <https://doi.org/10.1016/j.neubiorev.2019.12.025>.
- Pericot-Valverde, I., Secades-Villa, R., Gutiérrez-Maldonado, J., 2019. A randomized clinical trial of cue exposure treatment through virtual reality for smoking cessation. *J. Subst. Abuse Treat.* 96, 26–32. <https://doi.org/10.1016/j.jsat.2018.10.003>.
- Pittig, A., van den Berg, L., Vervliet, B., 2016. The key role of extinction learning in anxiety disorders: behavioral strategies to enhance exposure-based treatments. *Curr. Opin. Psychiatry* 29 (1), 39–47. <https://doi.org/10.1097/YCO.0000000000000220>.
- Powell, S.K., 2014. Mindfulness: another tool in the case managers’ toolbox. *Prof. Case Manag.* 19 (4), 159–160. <https://doi.org/10.1097/NCM.0000000000000041>.
- Quandt, J., Holland, R.W., Chen, Z., Veling, H.J.J., 2019. The role of attention in explaining the no-go devaluation effect: Effects on appetitive food items. *J. Exp. Psychol.: Hum. Percept. Perform.* <https://doi.org/10.1037/xhp0000659>.
- Rief, W., Sperl, M.F., Braun-Koch, K., Khosrowtaj, Z., Kirchner, L., Schäfer, L., Schwarting, R.K., Teige-Mocigemba, S., Panitz, C., 2022. Using expectation violation models to improve the outcome of psychological treatments. *Clin. Psychol. Rev.* 102212 <https://doi.org/10.1016/j.cpr.2022.102212>.
- Rinck, M., Wiers, R.W., Becker, E.S., Lindenmeyer, J., 2018. Relapse prevention in abstinent alcoholics by cognitive bias modification: clinical effects of combining approach bias modification and attention bias modification. *J. Consult. Clin. Psychol.* 86 (12), 1005. <https://doi.org/10.1037/ccp0000321>.
- Robinson, J.D., Cui, Y., Linares Abrego, P., Engelmann, J.M., Prokhorov, A.V., Vidrine, D. J., Shete, S., Cinciripini, P.M., 2022. Sustained reduction of attentional bias to smoking cues by smartphone-delivered attentional bias modification training for smokers. *Psychol. Addict. Behav.* <https://doi.org/10.1037/adb0000805>.
- Robinson, T.E., Berridge, K.C., 1993. The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Res. Rev.* 18 (3), 247–291. [https://doi.org/10.1016/0165-0173\(93\)90013-P](https://doi.org/10.1016/0165-0173(93)90013-P).
- Roche, A.I., Kroska, E.B., Denburg, N.L., 2019. Acceptance- and mindfulness-based interventions for health behavior change: systematic reviews and meta-analyses. *J. Context. Behav. Sci.* 13, 74–93. <https://doi.org/10.1016/j.jcbs.2019.06.002>.

- Rosenthal, A., Levin, M.E., Garland, E.L., Romanczuk-Seiferth, N., 2021. Mindfulness in treatment approaches for addiction—underlying mechanisms and future directions. *Curr. Addict. Rep.* 8 (2), 282–297. <https://doi.org/10.1007/s40429-021-00372-w>.
- Rosenthal, A., Ebrahimi, C., Wedemeyer, F., Romanczuk-Seiferth, N., Beck, A., 2022. The treatment of substance use disorders: recent developments and new perspectives. *Neuropsychobiology* 81 (5), 451–472. <https://doi.org/10.1159/000525268>.
- Sadaghiani, S., Kleinschmidt, A., 2016. Brain networks and α -oscillations: structural and functional foundations of cognitive control. *Trends Cogn. Sci.* 20 (11), 805–817. <https://doi.org/10.1016/j.tics.2016.09.004>.
- Sancho, M., De Gracia, M., Rodríguez, R.C., Mallorquí-Bagué, N., Sánchez-González, J., Trujols, J., Sánchez, I., Jiménez-Murcia, S., Menchón, J.M., 2018. Mindfulness-based interventions for the treatment of substance and behavioral addictions: a systematic review. *Front. Psychiatry* 9, 95. <https://doi.org/10.3389/fpsy.2018.00095>.
- Schemer, L., Körfer, K., Glombiewski, J.A., 2020. Evaluation of exposure instructions to pain: does therapist focus on fear reduction or expectation violation? *Cogn. Ther. Res.* 44, 697–708. <https://doi.org/10.1007/s10608-019-10070-7>.
- Schenkel, E.J., Schöneck, R., Wiers, R.W., Veling, H., Becker, E.S., Lindenmeyer, J., Rinck, M., 2023. Does selective inhibition training reduce relapse rates when added to standard treatment of alcohol use disorder? a randomized controlled trial. *Alcohol. Clin. Exp. Res.* <https://doi.org/10.1111/acer.15055>.
- Scholten, H., Granic, I., Chen, Z., Veling, H., Luijten, M., 2019. Do smokers devalue smoking cues after go/no-go training? *Psychol. Health* 34 (5), 609–625. <https://doi.org/10.1080/08870446.2018.1554184>.
- Schuman-Olivier, Z., Trombka, M., Lovas, D.A., Brewer, J.A., Vago, D.R., Gawande, R., Dunne, J.P., Lazar, S.W., Loucks, E.B., Fulwiler, C., 2020. Mindfulness and behavior change. *Harv. Rev. Psychiatry*. <https://doi.org/10.1097/HRP.0000000000000277>.
- Schyns, G., van den Akker, K., Roefs, A., Houben, K., Jansen, A., 2020. Exposure therapy vs lifestyle intervention to reduce food cue reactivity and binge eating in obesity: A pilot study. *J. Behav. Ther. Exp. Psychiatry* 67, 101453. <https://doi.org/10.1016/j.jbtep.2019.01.005>.
- Schyns, G., Roefs, A., Jansen, A., 2020. Tackling sabotaging cognitive processes to reduce overeating: expectancy violation during food cue exposure. *Physiol. Behav.*, 112924. <https://doi.org/10.1016/j.physbeh.2020.112924>.
- Seghier, M.L., 2023. Multiple functions of the angular gyrus at high temporal resolution. *Brain Struct. Funct.* 228 (1), 7–46. <https://doi.org/10.1007/s00429-022-02512-y>.
- Sezer, I., Pizzagalli, D.A., Sacchet, M.D., 2023. Resting-state fMRI functional connectivity and mindfulness in clinical and non-clinical contexts: a review and synthesis. *Neurosci. Biobehav. Rev.*, 104583. <https://doi.org/10.1016/j.neubiorev.2022.104583>.
- Sherman, B.J., Baker, N.L., Squeglia, L.M., McRae-Clark, A.L., 2018. Approach bias modification for cannabis use disorder: a proof-of-principle study. *J. Subst. Abuse Treat.* 87, 16–22. <https://doi.org/10.1016/j.jsat.2018.01.012>.
- Sipe, W.E., Eisendrath, S.J., 2012. Mindfulness-based cognitive therapy: theory and practice. *Can. J. Psychiatry* 57 (2), 63–69.
- Stein, E., Witkiewitz, K., 2020. Dismantling mindfulness-based programs: a systematic review to identify active components of treatment. *Mindfulness* 11 (11), 2470–2485. <https://doi.org/10.1007/s12671-020-01444-0>.
- Stein, M., Soravia, L.M., Tschuempelin, R.M., Batschelet, H.M., Jaeger, J., Roesner, S., Keller, A., Gomez Penedo, J.M., Wiers, R.W., Moggi, F., 2023. Alcohol-specific inhibition training in patients with alcohol use disorder: a multicenter, double-blind, randomized clinical trial examining drinking outcome and working mechanisms. *Addiction* 118 (4), 646–657. <https://doi.org/10.1111/add.16104>.
- Stice, E., Yokum, S., Veling, H., Kemps, E., Lawrence, N.S., 2017. Pilot test of a novel food response and attention training treatment for obesity: Brain imaging data suggest actions shape valuation. *Behav. Res. Ther.* 94, 60–70. <https://doi.org/10.1016/j.brat.2017.04.007>.
- Stice, E., Yokum, S., Gau, J., Veling, H., Lawrence, N., Kemps, E., 2022. Efficacy of a food response and attention training treatment for obesity: a randomized placebo controlled trial. *Behav. Res. Ther.* 158, 104183. <https://doi.org/10.1016/j.brat.2022.104183>.
- Sumantry, D., Stewart, K.E., 2021. Meditation, mindfulness, and attention: a meta-analysis. *Mindfulness* 12 (6), 1332–1349. <https://doi.org/10.1007/s12671-021-01593-w>.
- Sun, W., Kober, H., 2020. Regulating food craving: from mechanisms to interventions. *Physiol. Behav.* 222, 112878. <https://doi.org/10.1016/j.physbeh.2020.112878>.
- Sussman, S., Lisha, N., Griffiths, M., 2011. Prevalence of the addictions: a problem of the majority or the minority? *Eval. Health Prof.* 34 (1), 3–56. <https://doi.org/10.1177/0163278710380124>.
- Tang, Y.-Y., Tang, R., Posner, M.I., 2013. Brief meditation training induces smoking reduction. *Proc. Natl. Acad. Sci.* 110 (34), 13971–13975. <https://doi.org/10.1073/pnas.1311887110>.
- Tang, Y.-Y., Tang, R., Rothbart, M.K., Posner, M.I., 2019. Frontal theta activity and white matter plasticity following mindfulness meditation. *Curr. Opin. Psychol.* 28, 294–297. <https://doi.org/10.1016/j.copsyc.2019.04.004>.
- Tappe, K., 2022. Mindful eating: what we know so far. *Nutr. Bull.* <https://doi.org/10.1111/nu.12559>.
- Tappe, K., Ahmed, Z., 2018. A mindfulness-based decentering technique increases the cognitive accessibility of health and weight loss related goals. *Front. Psychol.* 9, 587.
- Tappe, K., Turner, A., 2018. The effect of a mindfulness-based decentering strategy on chocolate craving. *Appetite* 130, 157–162. <https://doi.org/10.1016/j.appet.2018.08.011>.
- Trahan, M.H., Maynard, B.R., Smith, K.S., Farina, A.S., Khoo, Y.M., 2019. Virtual reality exposure therapy on alcohol and nicotine: a systematic review. *Res. Soc. Work Pract.* 29 (8), 876–891. <https://doi.org/10.1177/1049731518823073>.
- Treanor, M., 2011. The potential impact of mindfulness on exposure and extinction learning in anxiety disorders. *Clin. Psychol. Rev.* 31 (4), 617–625. <https://doi.org/10.1016/j.cpr.2011.02.003>.
- den Uyl, T.E., Gladwin, T.E., Wiers, R.W., 2016. Electrophysiological and behavioral effects of combined transcranial direct current stimulation and alcohol approach bias retraining in hazardous drinkers. *Alcohol. Clin. Exp. Res.* 40 (10), 2124–2133. <https://doi.org/10.1111/acer.13171>.
- Vafaie, N., Kober, H., 2022. Association of drug cues and craving with drug use and relapse: a systematic review and meta-analysis. *JAMA Psychiatry*. <https://doi.org/10.1001/jamapsychiatry.2022.1240>.
- Valls-Serrano, C., Caracul, A., Verdejo-Garcia, A., 2016. Goal management training and mindfulness meditation improve executive functions and transfer to ecological tasks of daily life in polysubstance users enrolled in therapeutic community treatment. *Drug Alcohol Depend.* 165, 9–14. <https://doi.org/10.1016/j.drugalcdep.2016.04.040>.
- Van Dessel, P., De Houwer, J., Gast, A., 2016. Approach–avoidance training effects are moderated by awareness of stimulus–action contingencies. *Personal. Soc. Psychol. Bull.* 42 (1), 81–93. <https://doi.org/10.1177/0146167215615335>.
- Van Dessel, P., Eder, A.B., Hughes, S., 2018. Mechanisms underlying effects of approach–avoidance training on stimulus evaluation. *J. Exp. Psychol.: Learn., Mem., Cogn.* 44 (8), 1224. <https://doi.org/10.1037/xlm0000514>.
- Veling, H., Holland, R.W., van Knippenberg, A., 2008. When approach motivation and behavioral inhibition collide: Behavior regulation through stimulus devaluation. *J. Exp. Soc. Psychol.* 44 (4), 1013–1019. <https://doi.org/10.1016/j.jesp.2008.03.004>.
- Veling, H., Lawrence, N.S., Chen, Z., van Koningsbruggen, G.M., Holland, R.W., 2017. What is trained during food go/no-go training? a review focusing on mechanisms and a research agenda. *Curr. Addict. Rep.* 4 (1), 35–41. <https://doi.org/10.1007/s40429-017-0131-5>.
- Veling, H., Verpaalen, I.A., Liu, H., Mosannenzadeh, F., Becker, D., Holland, R.W., 2021. How can food choice best be trained? approach–avoidance versus go/no-go training. *Appetite* 163, 105226. <https://doi.org/10.1016/j.appet.2021.105226>.
- Veling, H., Becker, D., Liu, H., Quandt, J., Holland, R.W., 2022. How go/no-go training changes behavior: a value-based decision-making perspective. *Curr. Opin. Behav. Sci.* 47, 101206. <https://doi.org/10.1016/j.cobeha.2022.101206>.
- Verdejo-Garcia, A., 2016. Cognitive training for substance use disorders: neuroscientific mechanisms. *Neurosci. Biobehav. Rev.* 68, 270–281. <https://doi.org/10.1016/j.neubiorev.2016.05.018>.
- Verdejo-Garcia, A., Rezapour, T., Giddens, E., Khojasteh Zonoozi, A., Rafei, P., Berry, J., Caracul, A., Copersino, M.L., Field, M., Garland, E.L., 2023. Cognitive training and remediation interventions for substance use disorders: a Delphi consensus study. *Addiction* 118 (5), 935–951. <https://doi.org/10.1111/add.16109>.
- Vinci, C., Sawyer, L., Yang, M.-J., 2021. Minding the gap: leveraging mindfulness to inform cue exposure treatment for substance use disorders. *Front. Psychol.* 12, 649409. <https://doi.org/10.3389/fpsyg.2021.649409>.
- Volkow, N.D., Michaelides, M., Baler, R., 2019. The neuroscience of drug reward and addiction. *Physiol. Rev.* 99 (4), 2115–2140. <https://doi.org/10.1152/physrev.00014.2018>.
- Vollstädt-Klein, S., Loeber, S., Kirsch, M., Bach, P., Richter, A., Bühler, M., von der Goltz, C., Hermann, D., Mann, K., Kiefer, F., 2011. Effects of cue-exposure treatment on neural cue reactivity in alcohol dependence: a randomized trial. *Biol. Psychiatry* 69 (11), 1060–1066. <https://doi.org/10.1016/j.biopsych.2010.12.016>.
- Walitzer, K.S., Dearing, R.L., 2006. Gender differences in alcohol and substance use relapse. *Clin. Psychol. Rev.* 26 (2), 128–148. <https://doi.org/10.1016/j.cpr.2005.11.003>.
- Wang, Y.-g., Liu, M.-h., Shen, Z.-h., 2019. A virtual reality counterconditioning procedure to reduce methamphetamine cue-induced craving. *J. Psychiatr. Res.* 116, 88–94. <https://doi.org/10.1016/j.jpsychires.2019.06.007>.
- Warlow, S.M., Berridge, K.C., 2021. Incentive motivation: ‘wanting’ roles of central amygdala circuitry. *Behav. Brain Res.* 411, 113376. <https://doi.org/10.1016/j.bbr.2021.113376>.
- Webb, T.L., Sniedhota, F.F., Michie, S., 2010. Using theories of behaviour change to inform interventions for addictive behaviours. *Addiction* 105 (11), 1879–1892. <https://doi.org/10.1111/j.1360-0443.2010.03028.x>.
- Weisman, J.S., Rodebaugh, T.L., 2018. Exposure therapy augmentation: a review and extension of techniques informed by an inhibitory learning approach. *Clin. Psychol. Rev.* 59, 41–51. <https://doi.org/10.1016/j.cpr.2017.10.010>.
- Wen, S., Larsen, H., Wiers, R.W., 2021. A pilot study on approach bias modification in smoking cessation: activating personalized alternative activities for smoking in the context of increased craving. *Int. J. Behav. Med.* 1–14. <https://doi.org/10.1007/s12529-021-10033-x>.
- Westbrook, C., Creswell, J.D., Tabibnia, G., Julson, E., Kober, H., Tindle, H.A., 2013. Mindful attention reduces neural and self-reported cue-induced craving in smokers. *Soc. Cogn. Affect. Neurosci.* 8 (1), 73–84. <https://doi.org/10.1093/scan/nsr076>.
- Wiers, C.E., Wiers, R.W., 2017. Imaging the neural effects of cognitive bias modification training. *Neuroimage* 151, 81–91. <https://doi.org/10.1016/j.neuroimage.2016.07.041>.
- Wiers, C.E., Ludwig, V.U., Gladwin, T.E., Park, S.Q., Heinz, A., Wiers, R.W., Rinck, M., Lindenmeyer, J., Walter, H., Bermppohl, F., 2015. Effects of cognitive bias modification training on neural signatures of alcohol approach tendencies in male alcohol-dependent patients. *Addict. Biol.* 20 (5), 990–999. <https://doi.org/10.1111/adb.12221>.
- Wiers, C.E., Stelzel, C., Gladwin, T.E., Park, S.Q., Pawelczack, S., Gawron, C.K., Stuke, H., Heinz, A., Wiers, R.W., Rinck, M., 2015. Effects of cognitive bias modification training on neural alcohol cue reactivity in alcohol dependence. *Am. J. Psychiatry* 172 (4), 335–343. <https://doi.org/10.1176/appi.ajp.2014.13111495>.

- Wiers, R.W., 2018. Cognitive training in addiction: does it have clinical potential? *Biol. Psychiatry Cogn. Neurosci. Neuroimaging* 3. <https://doi.org/10.1016/j.bpsc.2017.12.008>.
- Wiers, R.W., Gladwin, T.E., Hofmann, W., Salemink, E., Ridderinkhof, K.R., 2013. Cognitive bias modification and cognitive control training in addiction and related psychopathology: Mechanisms, clinical perspectives, and ways forward. *Clin. Psychol. Sci.* 1 (2), 192–212. <https://doi.org/10.1177/2167702612466547>.
- Wiers, R.W., Boffo, M., Field, M., 2018. What's in a trial? On the importance of distinguishing between experimental lab studies and randomized controlled trials: The case of cognitive bias modification and alcohol use disorders. *J. Stud. Alcohol Drugs* 79 (3), 333–343. <https://doi.org/10.15288/jsad.2018.79.333>.
- Wiers, R.W., Van Dessel, P., Köpetz, C., 2020. ABC training: a new theory-based form of cognitive-bias modification to foster automatization of alternative choices in the treatment of addiction and related disorders. *Curr. Dir. Psychol. Sci.* 29 (5), 499–505. <https://doi.org/10.1177/0963721420949500>.
- Wiers, R.W., Pan, T., van Dessel, P., Rinck, M., Lindenmeyer, J., 2023. Approach-bias retraining and other training interventions as add-on in the treatment of AUD patients. In *Current Topics in Behavioral Neurosciences*. Springer. https://doi.org/10.1007/7854_2023_421.
- Wilson, E., Senior, V., Tapper, K., 2021. The effect of visualisation and mindfulness-based decentering on chocolate craving. *Appetite* 164, 105278. <https://doi.org/10.1016/j.appet.2021.105278>.
- Yakobi, O., Smilek, D., Danckert, J., 2021. The effects of mindfulness meditation on attention, executive control and working memory in healthy adults: a meta-analysis of randomized controlled trials. *Cogn. Ther. Res.* 1–18. <https://doi.org/10.1007/s10608-020-10177-2>.
- Yang, Y., Shields, G.S., Wu, Q., Liu, Y., Chen, H., Guo, C., 2019. Cognitive training on eating behaviour and weight loss: a meta-analysis and systematic review. *Obes. Rev.* 20 (11), 1628–1641. <https://doi.org/10.1111/obr.12916>.
- Yang, Y., Qi, L., Morys, F., Wu, Q., Chen, H., 2022. Food-specific inhibition training for food devaluation: a meta-analysis. *Nutrients* 14 (7), 1363. <https://doi.org/10.3390/nu14071363>.
- Yang, Y., Morys, F., Wu, Q., Li, J., Chen, H., 2023. Pilot study of food-specific go/no-go training for overweight individuals: brain imaging data suggest inhibition shapes food evaluation. *Soc. Cogn. Affect. Neurosci.* 18 (1), nsab137 <https://doi.org/10.1093/scan/nsab137>.
- Yau, M.Y.H., Potenza, M.N., 2015. Gambling disorder and other behavioral addictions: recognition and treatment. *Harv. Rev. Psychiatry* 23 (2), 134. <https://doi.org/10.1097/HRP.0000000000000051>.
- Yoshida, K., Takeda, K., Kasai, T., Makinae, S., Murakami, Y., Hasegawa, A., Sakai, S., 2020. Focused attention meditation training modifies neural activity and attention: longitudinal EEG data in non-meditators. *Soc. Cogn. Affect. Neurosci.* 15 (2), 215–224. <https://doi.org/10.1093/scan/nsaa020>.
- Zeng, J., Yu, S., Cao, H., Su, Y., Dong, Z., Yang, X., 2021. Neurobiological correlates of cue-reactivity in alcohol-use disorders: a voxel-wise meta-analysis of fMRI studies. *Neurosci. Biobehav. Rev.* 128, 294–310. <https://doi.org/10.1016/j.neubiorev.2021.06.031>.
- Zhang, M., Ying, J., Wing, T., Song, G., Fung, D.S., Smith, H., 2018. A systematic review of attention biases in opioid, cannabis, stimulant use disorders. *Int. J. Environ. Res. Public Health* 15 (6), 1138. <https://doi.org/10.3390/ijerph15061138>.