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Neurocognitive Treatments for Eating Disorders and Obesity

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Abstract
Purpose of Review Recent research has highlighted executive function and neurocognitive deficits among individuals with eating and weight disorders, identifying a potential target for treatment. Treatments targeting executive function for eating and weight disorders are emerging. This review aims to summarize the recent literature evaluating neurocognitive/executive function-oriented treatments for eating and weight disorders and highlights additional work needed in this area.
Recent Findings Cognitive remediation therapy (CRT) for anorexia nervosa has been the most extensively studied neurocognitive treatment for eating disorders. Results demonstrate that CRT improves executive function and may aid in the reduction of eating disorder symptomatology. Computer training programs targeting modifying attention and increasing inhibition are targeting reduction of binge eating and weight loss with modest success.
Summary Neurocognitive treatments are emerging and show initial promise for eating and weight disorders. Further research is necessary to determine whether these treatments can be used as stand-alone treatments or whether they need to be used as an adjunct to or in conjunction with other evidence-based treatments to improve outcomes.

This article is part of the Topical Collection on *Eating Disorders*

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Introduction

In the USA, roughly 4.4% of adults have some form of eating disorder [1], and two thirds of adults have obesity or are overweight [2]. Although evidence-based treatments exist for these disorders, remission is not achieved for nearly half of individuals in treatment [3, 4], recidivism is common [5, 6], and treatment dropout rates are high [6, 7]. There is a pressing need to identify and target underlying mechanisms to improve treatment outcomes.

Growing research suggests executive function deficits exist across eating and weight disorders; however, evidence-based treatments do not currently target these mechanisms. Neurocognitive and executive function-oriented treatments are emerging for eating and weight disorders and show initial promise. This area is still in its nascent stages but this review aims to (1) briefly review the neurocognitive deficits among eating and weight disorders, (2) summarize the research evaluating the efficacy of neurocognitive treatments of eating and weight disorders, and (3) discuss future steps needed for research in this area. Together, this review will serve to evaluate the state of neurocognitive treatments for eating and weight disorders and will highlight the importance of targeting these mechanisms in treatment. To assist readers, this review is organized by diagnosis and the evidence describing neurocognitive deficits and neurocognitive treatments are presented separately for each diagnosis.

Brief Overview of Neurocognitive Deficits in Eating and Weight Disorders

Research suggests that individuals with eating and weight disorders display executive function impairments compared to individuals without these disorders [8, 9]. Executive function or cognitive control broadly refers to top-down mental processes that enable effortful control over behavior. Executive functions include inhibitory control (i.e., attention control, self control), working memory, and cognitive flexibility that feed into higher level executive functions such as reasoning and problem-solving [10]. Executive function plays a strong role in regulating eating behavior and related thoughts and impairments in these areas are associated with dysfunction found in eating and weight disorders. A good framework for understanding these neurobiological differences is the "core eating network" proposed by Chen et al. [11•]. This neural model outlines a dorsal control pathway and a ventral reward pathway in the brain that modulate food consumption [11•]. The imbalance of these networks presents as impairment in executive function ranging from over-controlled/rigidity (i.e., low reward, high inhibition) to under-controlled/disinhibited (i.e., high reward, low inhibition). The range of executive function impairments maps onto the spectrum of eating and weight disorders, with individuals with anorexia nervosa (AN) exhibiting more over-controlled tendencies whereas individuals with binge-eating disorder (BED) or overweight/obesity (OW/OB) exhibiting more under-controlled tendencies. Details regarding the specific neurocognitive impairments exhibited by each disorder are described below.

Anorexia Nervosa

Typically, individuals with AN show impairment in the areas of cognitive flexibility and decision-making [12]. Individuals with AN exhibit imbalance in the ventral limbic and dorsal executive circuits which are implicated in inhibition, decision-making, and reward response [13]. This imbalance may lead individuals with AN to modulate their responses to hedonically appealing foods based on pre-defined rules rather than reward drive or hunger state. For example, these neurobiological-based differences may allow individuals with AN to maintain low caloric intake through strict adherence to a system of rules about what to eat and what not to eat, even in the presence of highly palatable, energy-dense foods. Behavioral research findings support these differences in decision-making, as individuals with AN make poorer decisions than healthy controls (HCs; i.e., individuals within the normal body weight BMI range and do not have an eating disorder) on the Iowa Gambling Task, a task in which individuals incorporate past experience into future decision-making [14]. Similarly, research also suggests that individuals with AN demonstrate the ability to delay rewards, as measured by delay discounting tasks, compared to HCs in tasks involving non-food rewards [15, 16]. A study utilizing fMRI compared performance on a delay discounting task for women in recovery from AN to HCs across metabolic states (fasted versus sated), finding increased activation in cognitive control brain regions for HCs when sated but no differences in these areas for women in recovery from AN in either state [17]. Taken together, these findings suggest that individuals with AN may be particularly good at delaying short-term rewards in favor of long-term gains, regardless of hunger status, which could have implications for eating and exercise behaviors.

Furthermore, individuals with AN perform worse on set-shifting tasks such as the Wisconsin Card Sorting Test or the Trail Making Test compared to HCs. This can translate into rigidity, making it difficult for them to change the rules and rituals related to food consumption that maintain AN [18]. Central coherence—or difficulty seeing the forest through the trees—refers to the ability to consolidate individual objects or pieces of information into a larger, holistic picture or construct. A meta-analysis shows that individuals with AN perform poorly on tests of central coherence such as the Group/Embedded Figures Test or Rey-Osterrieth Complex Figure Test compared to HCs [19]. Weak central coherence could help maintain AN symptomatology as it may cause individuals with AN to focus more on the details of their weight or shape and not on the bigger picture of their overall health [18].

Bulimia Nervosa

Impairments in inhibitory control are found among individuals with bulimia nervosa (BN), particularly when examining stimuli related to the disorder (e.g., food, body shape) [20]. Moreover, impairments in decision-making are associated with BN compared to HCs. For example, a study investigating temporal discounting found that adults with BN placed less value on future rewards than HCs, a characteristic which may make them more susceptible to binge eating [21]. Another study examined executive function (composite Z score combining measures of set-shifting, problem-solving, and inhibition) in those diagnosed with BN or AN and compared them to HCs. This study found that although both the BN and AN groups showed impaired executive function compared to HCs, individuals with AN performed significantly worse than those with BN [22]. These results are consistent with those of another study that compared patients with BN alone and patients with BN and a previous AN diagnosis to HCs. The former study found that patients with a dual diagnosis performed worse on set-shifting and on decision-making tasks than those diagnosed only with BN. A meta-

analysis on central coherence suggests that individuals with BN show significantly weaker central coherence on some measures [19]. These results suggest that although some executive functioning deficits are similar in these two disorders, AN can result in more severe impairment in some domains [23]. However, individuals with BN may be more impulsive—particularly in regard to eating behaviors—such that deficits in inhibitory control processes may be contributing to the maintenance of disordered eating behaviors/binge episodes. Individuals with BN show hypoactivity in the anterior cingulate region and parahippocampal regions when compared to HCs during a task examining reorienting attention and executive control of attention [24]. This hypoactivity during reorienting may explain why individuals with BN have difficulties with preoccupations about thoughts about food and body image while the hypoactivity during executive control is related to impairments in inhibition [24]. A review of the neurobiological mechanisms of individuals with AN and BN shows altered activity of dorsal circuits [25] which could lead to the higher inhibition in those with AN and lower inhibition in those with BN that has been demonstrated in behavioral tasks.

Binge-Eating Disorder

Unlike those with BN, individuals with BED perform worse than individuals with AN on decision-making, cognitive flexibility, and central coherence [12]. While many individuals with BED have comorbid OW/OB which also influences neurocognitive functioning (see the next paragraph), their neurocognitive profile differs from that of people with OW/OB who do not binge eat. It is possible that OW/OB compounds the neurocognitive changes seen with BED. Specifically, people with OW/OB and BED perform worse on tasks that measure self-regulatory control, planning, and working memory than do people with OW/OB without BED [26]. With regard to inhibitory control, both of these groups show deficits in general inhibitory control when compared to HCs, but do not differ from each other [27•]. However, individuals with BED and obesity exhibit more food-related impulsivity than do those with obesity without BED [27•]. Although fewer neuroimaging studies exist for BED, a review of the research suggests that individuals with BED exhibit altered responses found in corticostriatal circuitry which are related to processing motivation/reward and impulsivity [28]. Specifically, individuals with BED show increased activity in the dorsal anterior cingulate cortex in response to high-calorie food cues compared to those without BED [29], suggesting or contributing to loss of control over the consumption of these foods. Adults with OW/OB and BED show less activity in the prefrontal cortex (i.e., area implicated in inhibitory control) than do those with obesity alone [27•].

Overweight/Obesity

Interestingly, OW/OB in the absence of EDs is also associated with neurocognitive deficits. [19, 30•, 31•] Increased BMI is associated with higher levels of impulsivity, although debate exists as to whether the impulsivity is primarily food-related or generally impaired [32]. Individuals with OW/OB exhibit impaired decision-making and central coherence compared to HCs, but evidence for reduced cognitive flexibility is mixed [33]. It should be noted that in studies that demonstrate a relationship between OW/OB and impaired decision-making and central coherence do not all control for comorbidities to obesity, such as cardiovascular disease or depression, that could potentially explain the relationship [33]. To date, there does not appear to be a relationship between the level of executive function impairment and degree of obesity [34]. Individuals with OW/OB without BED show more activation in the orbitofrontal cortex, amygdala, ventral striatum, and the anterior cingulate cortex or "reward pathway" than HCs in response to food cues [11•]. Moreover, increased weight is associated with decreased activation in the inhibitory control regions (e.g., prefrontal cortex) while completing a behavioral impulsivity task with food stimuli [11•]. Taken together, overeating and subsequent weight gain may result from impaired reward processing that leads to greater consumption of calorically dense, hedonically pleasing food coupled with decreased inhibition to resist consumption [11•].

Treatments Targeting Neurocognitive or Executive Function in Eating and Weight Disorders

Despite evidence suggesting that executive function deficits exist across a range of eating and weight disorder diagnoses [9, 19, 30•, 35], current evidence-based treatments do not specifically target these processes. For example, cognitive behavioral therapy targets normalizing eating patterns and addressing cognitive distortions, dialectical behavior therapy targets underlying emotion dysregulation, and behavioral weight loss targets reducing calories consumed and increasing physical activity. Altogether, an understanding of the neurocognitive differences across eating and weight disorders can be leveraged to form the basis of treatments specifically targeted to a particular disorder. Further development of treatments targeting these underlying mechanisms, which can improve neurocognitive functioning for individuals with eating and weight disorders is needed [36, 37•, 38••]. With low remission and high recidivism rates in current treatment modalities [3–7], it is important to investigate adjunctive or alternative treatments that target these underlying mechanisms.

Anorexia Nervosa

Cognitive Remediation Therapy

Cognitive remediation therapy consists of in-session cognitive exercises that encourage individuals to reflect upon their own cognitive style to gain awareness of their thinking processes to encourage more adaptive thinking styles and the application of these skills to real-life situations. CRT targets the development of a more holistic and flexible thinking style and encourages more flexibility in every day behaviors. CRT is thought to target cognitive processes such as set-shifting and central coherence that are known to be deficits associated with AN symptomatology [39]. Instead of focusing on eating disorder symptoms directly, CRT works on increasing overall cognitive flexibility through a series of exercises designed to present alternative thinking styles and reduce cognitive rigidity [37•]. CRT is most commonly delivered in person over 8–10 weekly sessions, though studies report that CRT is acceptable and feasible in individual, group, and computerized formats [40–44]. CRT has been applied to improve cognitive functioning in populations such as traumatic brain injury and schizophrenia and has also been adapted for depression [45–48]. In AN, CRT is typically used as an adjunctive intervention to supplement evidence-based treatment in order to bolster retention while simultaneously improving cognitive flexibility to maximize treatment outcomes [37•, 43, 49].

Systematic reviews indicate that CRT improves set-shifting and central coherence for patients with AN [43, 50••]. Across studies, analyses reveal medium to large effect sizes in terms of improved neurocognitive performance following CRT across a variety of standardized neuropsychological assessments [37•]. To date, four randomized controlled clinical trials on CRT for adults with AN have been completed, with promising results of not only improved set-shifting but also reduced eating disorder symptoms [40, 50••, 51, 52, 53]. However, it can be hard to compare results across RCTs as the methodological designs, patient populations, and CRT treatment formats vary across studies.

CRT has also been applied among children and adolescents with AN, with somewhat more mixed results than adult samples. A within-subjects design showed that significant improvements on neurocognitive measures were found in a child and adolescent inpatient population with AN after undergoing an eight-session CRT program [54]. Compared to HCs, adolescents with AN (n = 20) demonstrated improved cognitive flexibility on neuropsychological measures following CRT, although improvements in self-reported flexibility (as measured by the Cognitive Shift and Behavioral Shift subscales of the Behavioral Rating Inventory for Executive Functioning, BRIEF-SR) and central coherence (as measured by copy condition of the Rey-Osterrieth Complex Figure Test) did not differ between the two groups [55]. Although no empirical data were reported, a small sample of inpatient adolescents with AN found a group-based CRT program to be fun, playful, and engaging [56]. Adolescents in a day treatment program reported some improvement in self-reported cognitive flexibility following a group-based CRT program [57]. However, a recent meta-analysis found limited support for set-shifting difficulties in children and adolescents with AN compared to HCs [58]. The lack of set-shifting difficulties in children with AN compared to HCs may be due to these mechanisms not being as well-developed in normal children at this age or perhaps that the difficulties found in adults with AN may be the result of chronic starvation and illness duration. Thus, it is important to explore whether CRT for children and adolescents with AN may have less utility than for adults or if perhaps it can be advantageous and aid in the development of adaptive cognitive functioning.

While CRT offers many potential benefits as an adjunctive treatment with adults, the current state of the literature presents several limitations. As noted by others, CRT is often conducted in inpatient populations, with small samples and limited statistical power, which severely limits the generalizability of the results [36, 43]. Despite these limitations, CRT has many potential benefits, including increased motivation and treatment adherence [50••]. In particular, high treatment dropout rates in outpatient treatments are observed in eating disorder populations [6], likely due to both the intensive nature of treatment and the ego-syntonic symptomatology that characterizes the disorder, in particular AN. Thus, CRT may offer additional benefits in terms of treatment outcomes above and beyond any improvements in executive functioning. Overall, the current state of the evidence suggests that CRT may be acceptable and effective as an adjunctive treatment for AN, though more research with a greater emphasis on longitudinal outcomes in this area is warranted.

Bulimia Nervosa

Computerized Video Games

Compared to AN, much less is known about the utility of executive function treatments for BN. BN is thought to be a disorder of under-regulated impulse control [25]. Thus, executive function treatments designed to target inhibition, impulsivity, and emotional regulation may be especially beneficial for improving these areas within this population. One study utilized a computerized video game to train emotion regulation and impulse control as an adjunct to traditional cognitive behavioral therapy for individuals with a bulimic-type of eating disorder (defined as BN, BED, or ED-NOS) [59]. This study noted improvements in emotion regulation (as measured via psychophysiological and self-reported reductions in anxiety) as well as reductions in both binge and vomiting episodes [59]. However, the study sample was extremely small (nine

individuals) and had varying diagnoses and symptom presentation; thus, the study's findings may not be generalizable and further replication in larger treatment samples is warranted before meaningful conclusions can be drawn. A single case study also utilized a computerized videogame to enhance inhibitory control prior to engaging in CBT for one patient with BN and reported within-subject decreases in impulsivity as well as binge episodes [60]. Despite small sample sizes, these studies provide initial evidence for the potential efficacy of a computerized training program aimed at targeted core components of executive functioning and cognitive control which may supplement existing evidence-based treatments for eating disorders.

Binge-Eating Disorder

Attention Modification and Inhibitory Control

Neurocognitive treatments may also play an important role in BED. The imbalance between salient, bottom-up reward processes that promote overeating and top-down inhibitory control processes that seek to limit food consumption may be one contributing factor in overeating and binge eating [61, 62]. More recently, treatments targeting overeating and weight gain have started to include components aimed at neurocognitive processes related to inhibition, impulsivity, and attentional bias. Attention bias modification programs, originally developed for use in anxiety disorders [63], may be a promising intervention to treat disordered eating [64]. By training one's automatic attention away from food, the need to utilize impaired top-down inhibitory control processes over eating behavior is limited; thus, in theory, attention modification training may help prevent disinhibited eating. An initial, open-label, pilot study of an 8-week attention bias modification program for overweight adults with binge eating appears to be effective in decreasing binge episode frequency as well as producing modest weight loss outcomes within subjects [65]. Food-specific anti-saccade training may also provide added benefit in decreasing impulsivity as well as training attentional bias away from highly salient food cues in populations with BED [66, 67]. A small proof of concept RCT that randomized 22 females with DSM-5 BED to either a 3-session anti-saccade training condition (look away from high-calorie food picture shown) or a control (gaze wherever you would like) showed that both conditions reduced self-reported binges in the 4 weeks following the training [68]. RCTs are currently underway that specifically focus on decreasing impulsivity among individuals with BED [69]. Additional studies that investigate the use of attention bias modification and inhibitory control training programs should be conducted in eating disorder populations in order to determine the utility of this implicit, computerized treatment in reducing eating disorder symptomatology.

Overweight and Obesity

The relation between OW/OB and cognitive function is still being explored. As stated above, significant evidence shows that neurocognitive deficits are related to OW/OB. However, a recent meta-analysis demonstrated improvements in neurocognitive function following weight loss among adults [70••]. Further, baseline executive function levels may moderate treatment response. Specifically, executive function was found to moderate treatment response in a weight loss trial for African American adolescents, such that adolescents with higher executive function lost more weight than those with lower executive function [71]. Taken together, it is possible that a bi-directional relationship may exist such that poor executive function can lead to increased weight and decreases in weight can improve executive function. Given this, several studies have begun to examine whether targeting executive function as part of treatment can be effective for weight loss. A RCT utilizing self-regulation strategies effectively reduced weight gain in a large sample (n = 599) of young adults [72]. Several RCTs utilizing executive function training for obesity are currently underway, including a RCT comparing computerized self-regulation training for obese adolescents (compared to a placebo condition) [73] as well as RCTs using manualized CRT for adult weight loss [74, 75]. While the field has recognized the potential of targeting EF in the context of weight loss interventions [30•, 31•, 76••], additional research is needed to better understand the relationship between EF and the short- and long-term maintenance of weight loss.

Physical Activity Interventions

Research suggests that OW/OB are related to executive function deficits in children and adults [30•, 31•]. Physical activity, which has been related to executive function, is an important component of weight loss treatments. A systematic review highlighted that physical activity interventions may promote greater cognitive benefits among OW/OB children and adolescents compared to normal weight peers while acknowledging some limitations with the current research [77]. OW/OB adolescents randomized to a competitive physically active videogame not only improved in executive functioning skills significantly more than adolescents in either the cooperative videogame and control group conditions but this improvement in executive functioning was also positively correlated with weight loss following the 10-week intervention [78].

Computerized Inhibitory Training

Research suggests that training inhibitory control processes while reducing attentional and salient reward responses to food cues may provide an effective treatment target to reduce overeating and weight gain [38••, 79]. Obese children in an

inpatient treatment program randomized to a 6-week executive function computerized training condition targeting inhibition and working memory showed greater improvements in working memory and maintained their weight loss compared to children in the treatment as usual condition [80]. OW/OB adults that were assigned to an active response inhibition training (Go/No-Go computer task) lost more weight and rated liking and attractiveness of food lower than adults assigned to a control condition [81]. Adult dieters who participated in four brief Go/No-Go computer trainings with the No-Go trials associated 100% for high-calorie food and beverage images lost more weight than those trained with non-food images with stronger effects found for those with a greater BMI [82] signifying the potential for this intervention to aid weight loss. Several laboratory studies have examined a variety of tasks (dot-probe, Go/No-Go, Stop Signal) and have shown that brief computerized trainings may have an impact on cognitive function and immediate food consumption in the laboratory [83–85]. A recent meta-analysis examined inhibitory control trainings for appetitive behaviors (food and alcohol) found a small but significant effect compared to control treatments [86]. Although typically these studies have used university or non-overweight adults, they highlight the need to better explore these trainings for the potential to aid weight loss and reduce binge eating.

Another proposed avenue for reducing overeating and weight gain is to target learned responses to highly salient food cues that promote eating in the absence of hunger [87–89]. These programs have shown preliminary efficacy and are thought to strengthen motor inhibition. Overall, preliminary work in targeting executive function in overweight and obesity appears to offer promising results in terms of improved neurocognitive functioning as well as modest weight loss outcomes that deserve further attention and research.

Directions for Future Research

There is sufficient evidence to suggest that neurocognitive impairments exist among individuals with eating and weight disorders. Research examining the potential of targeting these deficits in the treatment of eating and weight disorders is nascent. However, it is important to evaluate these alternative mechanisms to target treatment due to the necessity to improve dismal treatment outcomes for these conditions.

Anecdotally, when treating patients with eating and weight disorders, it is apparent how these neurocognitive deficits interfere with treatment outcome. Patients with AN are rigid and cannot fathom giving up their specific food and eating rules. Utilizing a treatment that does not directly target the eating behaviors such as CRT may be particularly useful in helping to reduce treatment dropout by allowing the patient to engage in treatment without having to directly address eating disorder pathology. As cognitive flexibility improves, it may be easier to engage the patient in directly addressing the eating disorder symptoms through other evidence-based approaches for AN. Further, computerized training should be explored to see whether training implicit mechanisms could be useful in targeting eating disorder pathology. For example, computerized trainings that use implicit mechanisms to target deficits in executive functions may be able to improve these areas in order to influence behaviors and indirectly promote treatment success. Moreover, patients may be more willing to comply with treatments that do not explicitly target eating disorder symptoms. If these programs can boost the effects of treatment, they could be a cost-effective way to do so.

Patients who experience loss of control (i.e., BN, BED) over eating report substantial distress over this loss of control. Weight loss treatments require high amounts of effortful control and patients with low inhibition struggle. If inhibitory training could aid in reducing this loss of control or need for effortful control, or if attentional training can strengthen automatic processes and reduce the need to utilize inhibitory control, this could drastically reduce loss of control or overeating. Further, unlike the current evidence-based treatments which largely require in-person meetings for a significant amount of time, computerized trainings would be a less expensive alternative or adjunct, are easily disseminable, and can be completed at home at any time of day without needing a professional to administer it. Moreover, utilizing hand-held technology, such as smartphone or internet-based applications, may provide greater dissemination of these resources, allowing individuals to access training and support from a mobile device in real time.

Although initial evidence is promising for neurocognitive treatments, significant limitations exist with the current research reviewed. The majority of research examining treatments targeting neurocognitive function is preliminary efficacy/proof of concept pilot studies. As such, they have small sample sizes and have often utilized specific populations (e.g., inpatient, predominantly female) which may impact generalizability. Thus, while promising, these findings must be interpreted with caution and should inspire more rigorous trials. Further, it is important to explore whether any of these treatments, like CRT could be applied transdiagnostically. One study included a few patients with BN, while exploring the impact of adding CRT to treatment as usual for patients with severe and enduring eating disorders [53]. This study found no moderating effects as to whether patients had restrictive vs binge-purge symptomatology, suggesting there may be transdiagnostic applications. Further, studies are undergoing that have modified CRT to apply to the neurocognitive deficits found among OW/OB and are currently testing its effects [74, 75]. Computerized trainings produce favorable effects, particularly when comparing the limited amount of time they have typically been deployed to time-intensive behavioral interventions [38••]; however, it is

unknown whether these interventions could succeed long-term as stand-alone treatments and this must be evaluated in future research. Relatedly, rigorous research examining the dose of treatment needed for withstanding effects to help tease apart whether computerized trainings need to be consistently utilized or perhaps if booster sessions could be deployed when effects begin to disappear is needed. Further, research examining the mechanisms by which these neurocognitive treatments are effective can help increase potency of the treatment. Lastly, exploration as to whether these treatments should be targeted at individuals who may benefit the most (i.e., demonstrate greatest deficits) would be informative.

To date, more research has examined neurocognitive treatments in adults. In CRT, the effects need to be better understood in children and adolescents as developmental considerations are needed. Areas of the brain implicated in executive function develop into young adulthood [90]. Thus, it is important to understand whether treatments targeting these areas can help shape the development of executive function in children adolescents or whether these treatments are more effective once the brain is developed and target rewiring the already developed brain. It is possible that one explanation for the limited effectiveness of CRT in children and adolescents is that these areas have not yet been developed and the treatment may not be as effective. Alternatively, it may be important to utilize these treatments to help encourage positive neurocognitive development. Regardless, when targeting children, it may be necessary to consider age and cognitive development. Further, it is important to not only consider whether change in cognitive function is seen following these treatments, but it is necessary to understand how the measured cognitive change is related to neurobiological changes measured through techniques like neuroimaging (e.g., activation, network connectivity). Research should continue examine and utilize neurobiological evidence to help identify additional treatment targets for eating and weight disorders. In addition to other behavioral treatments that can be developed to address these neurocognitive deficits, this research could potentially illuminate future pharmacological targets.

Conclusion

In conclusion, neurocognitive deficits occur across eating and weight disorders. Targeting these deficits has strong potential at enhancing existing treatments and could potentially reduce recidivism rates. Additional research is needed to better understand their utility and to help maximize the impact they can have. Further, as we move away from a "one size fits all" approach to treatment, these treatments may allow for us to characterize neurocognitive profiles and individualize treatments to target the specific neurocognitive deficits seen. This field is advancing rapidly and it will be exciting to see the advancement over the next 5–10 years.

Compliance with Ethical Standards

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