

Effectiveness of dialectical behavior therapy as a transdiagnostic treatment for improving cognitive functions: a systematic review

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Contributions: CV developed the idea and designed the overall structure of the systematic review. She conducted the literature search, risk of bias assessment, and analysis of results for the systematic review and drafted the complete article. She also refined the final version using the APA format, before submitting the manuscript. RT provided constant modifications and inputs in fine-tuning the design of the systematic review and contributed to the risk of bias assessment. He provided the contextual understanding and interpretation of the analysis. He also critically revised the manuscript and approved the final version to be published.

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ABSTRACT

Dialectical behavior therapy (DBT) has been found to be an efficacious treatment for disorders characterized by high levels of emotional instability. In view of the multifaceted applications of DBT and the extent to which mental disorders can incapacitate cognitive functions, the current systematic review aimed to investigate the effect of DBT in strengthening cognitive functions across various mental health conditions. Original research studies employing both experimental and quasi-experimental designs were included in the review. The literature search was done using different electronic databases, from the first available literature until June 2022, that covered an approximate period of ten years. Joanna Briggs Institute checklist was used to assess the methodological rigor of the studies. Twelve studies conducted on adolescents with emotional dysregulation, and adults with borderline personality disorder, bipolar disorder, attention deficit hyperactivity disorder, and multiple sclerosis were selected. Results indicate that DBT has the potential to improve key cognitive functions such as attention, memory, fluency, response inhibition, planning, set shifting, tolerance for delayed rewards and time perception, as assessed by neuropsychological tests, self-report of cognitive functions, and neuroimaging techniques. Considering the review's findings that showcase the effectiveness of DBT in fostering improvements in cognitive functions, DBT may possibly be chosen as a preferred treatment to ensure that patients reach optimal levels of cognitive functioning. Limitations include lack of sufficient studies encompassing all the common mental health conditions, usage of neuroimaging techniques as only an indirect measure of cognitive functioning and nuances related to the quality of individual studies.

Key words: dialectical behavior therapy, cognitive changes, mental disorders, transdiagnostic, functioning.

Introduction

The influence of emotions on cognitive processes is far-reaching, as evidenced by a wide range of literature (Okon-Singer *et al.*, 2015). For example, anxiety can have negative effects on executive functions such as interpretation, attention, judgment, and decision making. Emotions also interact with basic attentional effects, priming of concepts and knowledge structures, computational capacity and reflective processes (Blanchette & Richards, 2010). Likewise, emotion regulation also plays a vital role in academic performance. A study conducted by Fabre and Lemaire (2019) on graduate students, showed that emotions influence arithmetic performance in terms of which strategy is used and how each strategy is executed for solving a problem. Given the strong influence of emotions on cognition, it would be worthwhile to understand if psychological

treatments such as dialectical behavior therapy (DBT) that primarily target emotion regulation skills (McMain *et al.*, 2001) can also enhance cognitive functioning.

DBT adopts a highly eclectic method, which includes concepts from psychodynamic, supportive, cognitive, and behavioral therapies. The highlighting feature of this form of psychotherapy is that it borrows features from the eastern Zen philosophy. DBT is also highly versatile, as it uses techniques such as metaphors, storytelling, confrontation, etc. The techniques in DBT primarily alternate between the philosophical concepts of acceptance and change (Linehan, 1993). The concept of acceptance was adopted from eastern Zen principles and the change strategies, influenced by behavioral principles, were adopted from Western contemporary practices (Robins, 2002). It is this combination of acceptance and change that marks this therapy as *dialectical*. The concept of *dialectical* refers to a set of attention and thinking approaches or strategies aimed at decreasing dichotomous or polarized thought patterns (Fruzzetti, 2022) by the synthesis of two conflicting and extreme positions or ideas. The uniqueness of DBT has influenced researchers to further investigate the gripping facets that underlie this form of therapy.

Several randomized controlled trials (RCTs) provide mounting evidence on the effectiveness and efficacy of DBT in the treatment of borderline personality disorder (BPD; Bohus *et al.*, 2004; Linehan *et al.*, 2006). Though DBT was originally developed for chronically suicidal patients (Linehan, 1993), the treatment is designed such that it can target multiple chief complaints across a wide range of diagnoses like bipolar affective disorder (BPAD), depression, anxiety disorders, substance use disorders, post-traumatic stress disorder (PTSD), etc. (Ritschel *et al.*, 2018). DBT Skills Training (DBT-ST; Linehan, 2014) as a stand-alone treatment has also been exhaustively researched across many populations. For example, according to a study conducted by Neacsiu *et al.* (2014), DBT-ST can be used as a promising intervention for depressed and anxious transdiagnostic adults in the treatment of emotional dysregulation. Another study done by Flynn *et al.* (2018) on adolescents, showed that a 22-week DBT-ST program that targeted emotional problem solving, can contribute to significant reductions in depression, anxiety, and social stress among this population. DBT-ST has also been found to show improvements among adults with alcohol dependence syndrome in decreasing alcohol-related behaviors and improving emotion regulation (Maffei *et al.*, 2018). Therefore, a tremendous amount of evidence conveys that DBT can be used as a mode of treatment across a wide scale of mental disorders. Apart from the apparent emotional symptoms, many mental disorders can cognitively incapacitate an individual by adding to deficits varying from reduced attention and working memory to disruptions in social cognition and language (Millan *et al.*, 2012). Due to this, it is essential for psychotherapies to also promote direct cognitive enhancement along with relief from emotional symptoms.

In the last ten years, two systematic reviews have reviewed DBT's effectiveness on cognitive functions to a considerable extent. Poissant *et al.* (2019) aimed at studying the effect of mindfulness-based interventions on symptoms of attention deficit hyperactivity disorder (ADHD) and other outcome measures such as executive/cognitive functioning, emotional disturbances, quality of life, mindfulness, and grade point average in school. Across all of the studies included in this review, the mindfulness-based interventions were based on different forms of psychotherapies such as DBT, mindful awareness program (MAP), and mindfulness-based cognitive therapy (MBCT). The included studies used

both objective and subjective measures to assess improvements in cognitive functioning. The objective measures included tests such as the *Connors' Continuous Performance Test*, the *Stroop Test*, *Wechsler Adult Intelligence Scale - Revised* (WAIS-R), etc. and the subjective measure included the *Behavior Rating Inventory of Executive Functions* (BRIEF-A). All the studies (100%) included in the review, not only showed improvement in ADHD symptoms but also demonstrated significant improvement in cognitive task performance, compared to treatment as usual or with pre-treatment measures. This review concluded that a mindfulness-based intervention not only improves ADHD behavioral symptoms but also some facets of executive functions and emotion dysregulation.

Another review article authored by Iskrac and Barkley-Levenson (2021) attempted to understand how the neural changes in BPD can be influenced by DBT. Out of the nine articles selected for their review, seven studies used functional magnetic resonance imaging (fMRI) and two studies used functional near-infrared spectroscopy (fNIRS) to study the brain-related changes following DBT. The results of this study showed significant deactivation of amygdala activity and anterior cingulate cortex (ACC) among patients with BPD after DBT. Considering the involvement of amygdala in the perception and processing of emotions as well as the hyperactivity of the amygdala in patients with BPD and non-suicidal self-injury, this finding has crucial implications in the treatment of BPD. The dorsal ACC plays a significant role in attention and executive function, and the rostral ACC is concerned with the assessment and regulation of emotional information. The study also showed the impact of DBT on the inferior frontal gyrus as evidenced by an increase in gray matter, increased activity in response to inhibitory control and decreased activity in response to arousing stimuli. In view of the role of inferior frontal gyrus in language production, risk aversion, and empathetic response to facial expressions (American Psychological Association, n.d.), this finding suggests that DBT can promote changes in the structure and the function of the inferior frontal gyrus among patients with BPD. This review indicated major brain-related changes following DBT. Therefore, a large body of research has shown that the human brain comprises a pronounced learning-dependent structural plasticity which is involved in the acquisition of all types of skills, capacities, and learnings, as assimilated in psychotherapy (Mehlum, 2021).

The current review article seeks to provide leeway for an improved understanding of DBT's effectiveness in the management of cognitive symptoms across different mental disorders. Heightened emotionality in certain mental disorders can cognitively challenge patients in a complex manner. For example, individuals with obsessive compulsive disorder (OCD) and post-traumatic stress disorder (PTSD), frequently experience deficits in inhibition due to difficulties in managing intrusive thoughts. While deficits in attention, working memory, social cognition and language are common in schizophrenia, similar deficits are indicated in bipolar disorder but with lesser severity. Individuals with ADHD tend to experience difficulties in attention, working memory and processing speed. Moreover, deficits in attention and executive functions are common across different psychiatric diagnoses (Millan *et al.*, 2012). This can contribute to difficulties in efficiently performing day-to-day tasks, thereby resulting in a lack of productivity. Keeping this in mind, it would be logical to presume that as one's emotional symptoms improve, their cognitive capacity may be amplified, resulting in improved cognitive functioning and productivity. Based on this premise, it would be valuable to evaluate through the existing body of evidence, if a treatment such as DBT

that primarily targets emotion regulation, can also have additional effects on cognitive functions post-treatment.

The past systematic reviews on this subject are prone to certain contextual limitations. In the study conducted by Poissant *et al.* (2019), there was substantial variability among the mindfulness-based interventions, even though mindfulness based on DBT was carried out in few studies. Furthermore, while ADHD symptoms were the primary outcome of interest in this study, executive functions were only an additional outcome measure. This review only included studies using standard neuropsychological tests and self-report measures of executive functions and excluded studies using neuroimaging techniques. In the study done by Iskrac and Barkley-Levenson (2021) only the articles that used neuroimaging measures of brain changes such as fMRI and fNIRS were included in the study and articles that used neuropsychological measures of changes in brain functions and self-report measures of executive functions were excluded. While neuroimaging techniques provide rich and in-depth information regarding the structure and the function of the brain, standard neuropsychological tests provide objective ways to collect diagnostic and differential diagnostic information, assess treatment response, and predict functional potential and functional recovery (Harvey, 2012). On the other hand, self-report measures attempt to understand the practical effectiveness of a treatment by obtaining first-hand information regarding the perceived improvements, from the person actually experiencing the improvement following a treatment. The apparent benefits of all the three methods of assessing cognitive functions, assert the need for systematic reviews that comprehensively include studies using standard neuropsychological tests, self-report measures and neuroimaging techniques.

The two systematic reviews conducted in the past (Poissant *et al.*, 2019; Iskrac & Barkley-Levenson, 2021) were highly specific to a single disorder such that the entire sample consisted exclusively of individuals with only ADHD and BPD respectively. A transdiagnostic approach was adopted for the current review as emotional difficulties are not just specific to BPD but are also prevalent in several other mental health conditions (Sadock *et al.*, 2011). The term *transdiagnostic* not only refers to psychological constructs that are observed across a range of disorders, but also elucidates functionally causal mechanisms that inform the development of classes of disorders and can be targeted in treatment (Harvey *et al.*, 2011, as cited in Sauer-Zavala *et al.*, 2017). Therefore, the current review is the first of its kind to understand the effects of DBT on cognitive functions across several mental disorders, using a transdiagnostic approach.

Given the enormous applications of DBT, the current systematic review aims to provide more evidence for the use of DBT across various mental health conditions by investigating the effect of DBT in strengthening cognitive functions among adolescents and adults with different mental health conditions. Despite the salient differences between adolescents and adults in terms of their cognitive, neurological, psychosocial and developmental characteristics, the rationale for including studies with both adolescents and adults, hinges on the common underlying dysfunction in emotion regulation that crosses the age barrier among various psychiatric disorders and problem behaviors. For example, even at the diagnostic level, a diagnosis of BPD in adolescents can be comparable to that of adult samples with respect to symptom constellation, functional impairment and temporal stability. Emotional dysregulation and problematic behaviors may also be linked to the development of several other forms of psychopathology that may be relatively stable during adolescence and adulthood. Since DBT is flexible and comprehensive in a way that allows for use

with individuals presenting with different diagnoses, in diverse settings and across a relatively larger age range (MacPherson *et al.*, 2012), studies with both adolescents and adults with varied mental health conditions have been included in the review. It is important to review the research done in this area to holistically understand the objective and subjective outcomes of cognitive change caused by DBT. This evidence can have significant implications in the clinical practice of DBT.

Methods

Eligibility criteria

The present review only included Randomized Controlled Trials (RCTs), non-RCTs (n-RCTs) and studies using single-arm pre-post study designs, published in English. Gray literature including master's and doctoral dissertations were also eligible for being included in the review. Studies that conducted DBT were included only if they met the following criteria: i) The general principles underlying DBT as applied through the dialectical approach, acceptance *versus* change strategies, problem-solving strategies, validation, and communication strategies formed the backbone of the intervention, ii) at least one component of DBT (*e.g.*, mindfulness module from DBT-ST) was included in the intervention, iii) at least one mode of DBT (*e.g.* DBT individual therapy or DBT-ST) was adopted in the intervention, iv) at least one standard adaptation of DBT (*e.g.* original DBT-ST protocol or a DBT version specific to bipolar disorder) was rigorously followed. Studies administering DBT both on in-patient and out-patient bases were included. Studies conducting DBT in both individual and group settings were eligible for selection. Studies conducted on adolescents and adults aged between 12 and 60 years, diagnosed with different kinds of mental health conditions, both with and without comorbidities met the review's inclusion criteria. The review also included participants who were under the influence of psychiatric medications. Studies using either subjective measures or objective measures of cognitive functions (outcome variable) as well as studies using neuroimaging techniques to measure the structural and functional changes in the brain were selected for the review. Only studies in which cognitive/neuropsychological/neurocognitive changes were one of the primary outcomes of interest were included.

The exclusion criteria for the review excluded: i) studies conducted with children below 12 years, ii) studies in which the mindfulness module administered was not a part of the DBT-ST, iii) studies that did not evaluate the treatment effects, iv) studies in which the outcome variables did not include cognitive/executive/neuropsychological functions, v) studies that failed to report the treatment outcomes, and vi) studies in which DBT was provided as an adjunct therapy along with other psychotherapies. Based on the inclusion and exclusion criteria, twelve studies that attempted to understand the effectiveness of DBT in improving cognitive functions among adolescents and adults were finally selected for the review. The full electronic process search strategy for databases is described in Figure 1.

Information sources and search strategy

The literature search was done using APAPsycNet, National Digital Library of India, Proquest, PubMed, Sage, Science Direct, Springer, and Taylor & Francis databases, from the first literature that was available until June 2022 (including reference lists of previous reviews). The initial and final searches were done in June

2022. The search terms included *DBT and cognitive changes*, *DBT and neuropsychological changes*, *DBT and executive functions*, and *DBT and neurocognitive changes*.

Data extraction

A Google Sheet compliant with the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) 2020 checklist (Page *et al.*, 2021) was designed, which comprised of the information extracted from each article based on the article's title, names of authors, year of publication, name of the journal, type of research, aims of the study, nature of the sample (including the sample size, characteristics of the sample, diagnoses), features of the control group (control group size, characteristics of the control group, diagnoses, details on the allocation/assignment process for the control group and details of whether there was no treatment/wait-list treatment/alternative treatment for the control group), methodology (including study design, tools used and procedures), nature of the treatment received for the experimental group (including the mode of DBT, the adaptation of DBT and number of sessions), results (including details on the outcome measures), conclusion and limitations of each research. The search was limited to quantitative research designs that examined the effect of DBT on cognitive functions. All the selected articles were published in English. Books, single case studies, cross-sectional studies, pure qualitative studies, systematic reviews, and duplicates were excluded from the review. Data extraction and the final selection of studies based on an eligibility assessment were done by both the review authors independently, and any disagreement in the process was resolved through discussion.

Assessment of risk of bias

Quality assessment/risk of bias among the studies was performed in detail, using the Joanna Briggs Institute (JBI) checklist for randomized controlled trials (Barker *et al.*, 2023) and quasi-experimental studies (Joanna Briggs Institute, 2020), similar to the study conducted by Xiao *et al.* (2019). The JBI critical appraisal checklists contain items that assess the selection, performance, detection and attrition biases, as well as trial designs. Items in each of the checklists have four possible responses: yes, no, unclear and not applicable (Xiao *et al.*, 2019). Studies were included only if they received at least five yes ratings in RCT and n-RCT checklists. Assessment of the risk of bias was performed independently by the two authors of the study and the process for resolving disagreements involved discussion. Duplicating the risk of bias assessment decreased the risk of making mistakes and the possibility that assessments could be influenced by a single person's biases. Both the authors assessing the risk of bias have content and methodological expertise, as well as a sufficient understanding of the concerned methodological issues assessed by the risk of bias tool.

Data synthesis and summary of findings

Results based on a comprehensive review of all the twelve studies and the risk of bias assessment have been presented in a narrative manner as well as through tables. The risk of bias of each study was distinctly considered to understand the validity of studies. Data related to the risk of bias analysis of individual studies has been securely stored by the primary researcher in a specific repository.

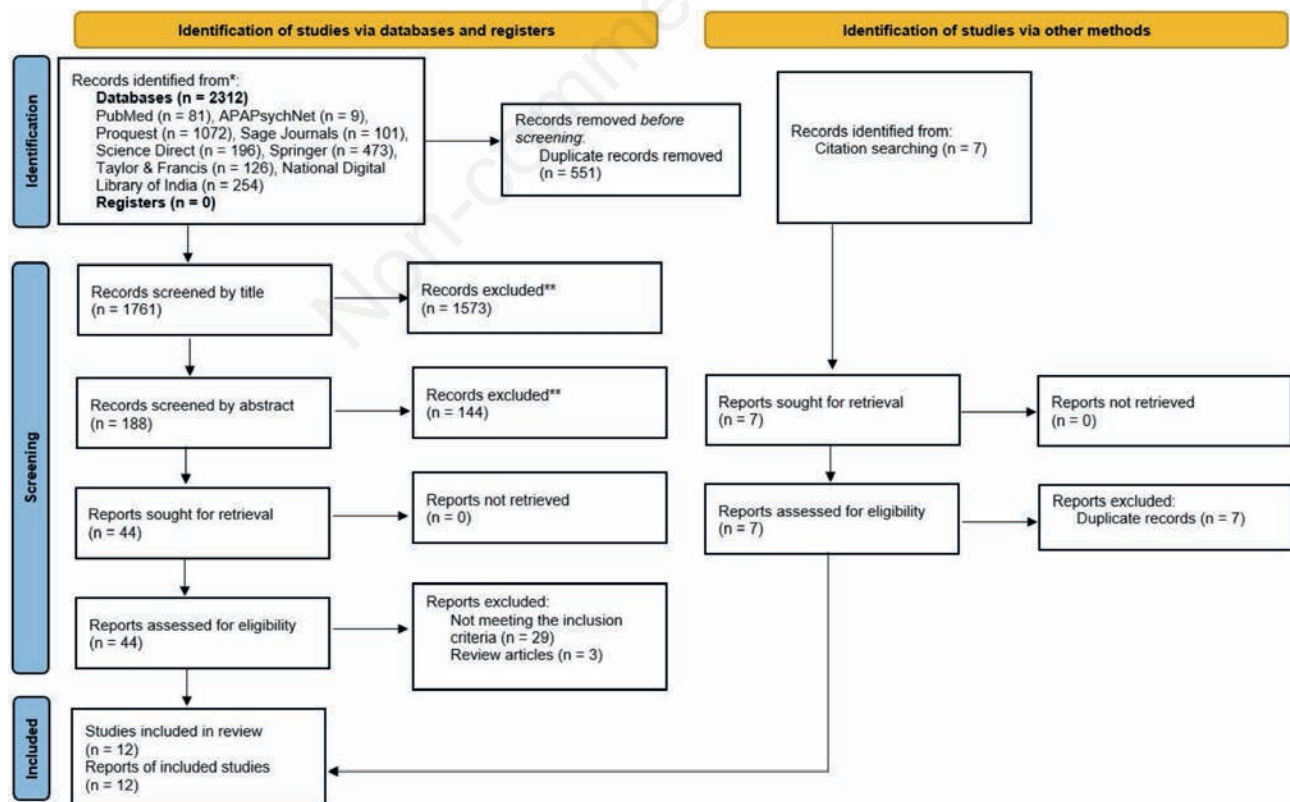


Figure 1. Selection process of studies as per the PRISMA 2020 flowchart.

Results

Study selection

The final list of studies selected for synthesis covered an approximate period of ten years (2012 to 2022). The final literature search yielded results consisting of a total of 2312 studies: PubMed (n=81), APA PsychNet (n=9), Proquest (n=1072), Sage Journals (n=101), Science Direct (n=196), Springer (n=473), Taylor & Francis (n=126), National Digital Library of India (n=254). The first step involved the elimination of 551 duplicate articles. After reviewing the titles of 1761 studies, 1573 studies were classified as irrelevant based on the context of the study/mode. The abstracts of the remaining 188 studies were reviewed, and only 44 studies were relevant to the scope of the current review. Out of the remaining 44 studies, 29 studies were then eliminated as they did not meet the inclusion criteria (due to studies in different languages, theoretical papers, pure qualitative studies, case studies, not using DBT as one of the primary treatments, outcomes not measuring cognitive functions) and 3 studies were eliminated as they were systematic reviews (but reference lists of systematic reviews were examined). On examining the reference lists of systematic reviews, 7 studies were identified. However, all the 7 studies from the reference lists were duplicate records of the studies already identified in the databases, and hence had to be eliminated. Finally, twelve studies conducted with adolescents and adults, corresponding to each of the selection criteria were included in the review. A detailed illustration of the process of study selection is provided in Figure 1.

Synthesis of studies

A synthesis of the systematic review is presented in a narrative manner that begins with an overview of the study designs, comparison groups, participants, interventions and outcomes pertinent to the selected studies. The synthesis also includes a disorder-wise presentation of DBT's effectiveness on cognitive functions.

Study designs

In the current systematic review, six of the selected studies were RCTs (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Secrist, 2014; Soler *et al.*, 2016; Zargar *et al.*, 2019). Abdolghaddri *et al.* (2019) carried out a randomized controlled trial with pre-test and post-test measures on 257 patients having multiple sclerosis. The study conducted by Afshari *et al.* (2019) was a pilot study in which 30 patients with bipolar disorder were randomly assigned to a treatment condition or a wait-list condition, and were assessed at pre-test, post-test and follow-up. In the study carried out by Fleming *et al.* (2015), 33 undergraduate students with ADHD were randomly assigned to different treatment conditions and assessments took place at pre-treatment, post-treatment and 3-month follow-up. The study done by Secrist (2014) was based on data previously collected in a one-year randomized control trial that randomly allocated 101 female participants with BPD to the treatment and the control group. The study conducted by Soler *et al.* (2016) was a pilot randomized study on 64 BPD patients, consisting of two-arms. Zargar *et al.* (2019) carried out a randomized controlled clinical trial with 50 patients having bipolar disorder.

Out of the twelve studies included in the review, three of the selected studies were n-RCTs (Mancke *et al.*, 2018; Schmitt *et al.*,

2016; Soler *et al.*, 2012). The study conducted by Mancke *et al.* (2018) was a part of a bigger project concerned with the neural correlates of BPD, in which the treatment assignment was based on the preferences of the patient. The study carried out by Schmitt *et al.* (2016) was also a part of a bigger project concerned with the neural correlates of emotion regulation in BPD following DBT, in which DBT patients were recruited from in-patient treatment facilities, and the healthy participants as well as the BPD control group were selected through advertisements. Soler *et al.* (2012) conducted a single-center, non-randomized controlled trial with two treatment arms whose assignment was based on consecutive referrals.

Three studies used within group study designs (Rodrigo, 2015; Smith *et al.*, 2018; Wayne, 2018) with tests administered at least during two-time points (pre-tests and post-tests). Rodrigo (2015) adopted a single group pre-test and post-test design on 29 patients with BPD. Smith *et al.* (2018) selected participants from a de-identified dataset of 93 adolescents with deliberate self-harm, emotion dysregulation or behavioral problems, attending an intensive outpatient program, and compiled a single group pre-post study. The study conducted by Wayne (2018) was based on an archival data collected in the course of a school-based intervention and used a single group design on 48 educators and 20 high school students with emotional dysregulation, difficulty coping with frustration, poor interpersonal relationships, and the inability to be calm and maintain attentiveness. These participants were assessed at baseline, during treatment and post treatment. Table 1 shows the research design used in each study.

Comparison groups

Out of the twelve studies, nine studies followed a between-subjects design that had one or more comparison groups of participants (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Mancke *et al.*, 2018; Schmitt *et al.*, 2016; Secrist, 2014; Soler *et al.*, 2012; Soler *et al.*, 2016; Zargar *et al.*, 2019). Most of the studies had only one comparison group. The control group interventions included community treatment by experts (Secrist, 2014), general psychiatric management (Soler *et al.*, 2012), self-guided skills handouts for ADHD (Fleming *et al.*, 2015) by Tuckman (2007), and DBT Interpersonal Effectiveness Module (Soler *et al.*, 2016) by Linehan (2014). One study had a waitlist control group (Afshari *et al.*, 2019) while another study had a control group that did not receive any other form of psychotherapy other than routine medications (Zargar *et al.*, 2019). Two studies had two comparison groups with which the experimental group was compared (Abdolghaddri *et al.*, 2019; Schmitt *et al.*, 2016). The study conducted by Abdolghaddri *et al.* (2019) had two comparison groups in which one group received positive psychotherapy and another group did not receive any treatment. The study carried out by Schmitt *et al.* (2016) also had two comparison groups that included one group with healthy participants and another group receiving an unspecific form of treatment across both outpatient and residential care setups. Table 2 shows the details of the conditions for the comparison group across all the studies.

Participants

The sum of participants in all the studies was 703 with a mean age of 26.6 years (12-50 y/o). In three studies (Mancke *et al.*, 2018; Schmitt *et al.*, 2016; Secrist, 2014), all the participants were females. In eight other studies (Afshari *et al.*, 2019; Fleming *et al.*, 2015; Rodrigo, 2015; Smith *et al.*, 2018; Soler *et al.*, 2012;

Table 1. Characteristics of participants in the intervention group across studies.

I st author (year)	Research design	Age range, participants	Avg. age of participants	Population	Sample size	Gender	Comorbidities	Psychiatric medication status
Abdolghaddri (2019)	RCT (3 groups), pre-post	N.r.	35.5	Multiple sclerosis	N=45	N.r.	N.r.	N.r.
Afshari (2019)	RCT, pre-post with follow-up	18-45	36.5	Type 1 and Type 2 BPAD	N=60, DBT=30, control group=30	Females=34, males=26	N=21 with comorbid diagnoses	Lithium, SSRI, clozapine, and carbamazepine
Fleming (2015)	RCT, testing at pre-treatment, post-treatment and 3-month follow-up	18-24	21.35	Undergraduate students with ADHD	N=33, DBT-ST=17, self-guided skill training handout group=16	Females=14, males=19	Anxiety and depressive symptoms	No medication/methylphenidate only/amphetamine only/methylphenidate and SSRI/amphetamine/SSRI only
Mancke (2018)	NRCT, pre-post	N.r.	25.92	BPD	N=48, DBT=31, TAU=17	All females	Affective disorders/anxiety disorders/PTSD/somatoform disorders/eating disorders	SSRI/SNRI/TD/antipsychotics/NDRI/mood stabilizers/anticonvulsants/other psychotropics
Rodrigo (2015)	Single group pre-post	N.r.	28.65	BPD	N=29	90.32% females	None	N.r.
Schmitt (2016)	N-RCT with 3 groups, pre-post	N.r.	26.83	BPD	N=72, BPD with DBT=32, BPD with another unspecific treatment=16, healthy participants=24	All female	Axis I diagnosis	Psychotropic medication
Secrist (2014)	RCT, testing done once in 4-months for one year during treatment and after one year during follow up	18-45	29.30	BPD	N=101	All females	None	N.r.
Smith (2018)	Single group pre-post	12-18	15.05	Adolescents with a history of DSH	N=93	Females=81, males=12	95% of the adolescents - primary diagnosis of major depression	N.r.
Soler (2012)	N-RCT, pre-post	18-48	30.55	BPD	N=59, DBT+GPM=40, GPM alone=19	Females=51, males=8	None	Antidepressant/benzodiazepine/stabilizer/antipsychotics
Soler (2016)	RCT, pre-post	18-45	32.47	BPD	N=64, DBT (mindfulness module)=32, DBT (IE module)=32	Females=41, males=23	Anxiety disorders/major depressive disorder/bulimia nervosa/substance abuse disorder/other PD diagnosis	SSRI/benzodiazepines/mood stabilizers/antipsychotics
Wayne (2018)	Testing at baseline, during treatment and post treatment	9 th -12 th grade students (age 15-18) and teachers (age 21-50)	Students=16.3	Educators and high school students with emotional dysregulation, difficulty coping with frustration, poor interpersonal relationships, and an inability to be calm and maintain attentiveness	N=48 educators + 20 students	Students (male=10, female=10) Teachers (male=18, female=30)	N.r.	N.r.
Zargar (2019)	RCT, pre-post with follow-up	20-45	30.96	Type 1, BPAD	N=49, DBT=24, control group=25	Females=29, males=20	None	Mood stabilizers and atypical antipsychotics

RCT, randomized controlled trial; n.r., not reported; n, sample size; BPAD, bipolar affective disorder; DBT, dialectical behavior therapy; SSRI, selective serotonin reuptake inhibitors; ADHD, attention deficit hyperactivity disorder; DBT-ST, dialectical behavior therapy skills training; BPD, borderline personality disorder; TAU, treatment as usual; PTSD, post-traumatic stress disorder; SNRI, serotonin and norepinephrine reuptake inhibitors; TD/NDRI, tricyclic antidepressants/norepinephrine-dopamine reuptake inhibitor; DSH, deliberate self-harm; N-RCT, Non-randomized controlled trial; GPM, general psychiatric management; PD, personality disorder.

Soler *et al.*, 2016; Wayne, 2018; Zargar *et al.*, 2019) males were 121 and females were 286 in number, indicating that the number of females was more than double of that of males. Since the current study is concerned with a transdiagnostic approach, a broad range of disorders were considered for the review. Six studies had individuals with BPD (Mancke *et al.*, 2018; Rodrigo, 2015; Secrist, 2014; Schmitt *et al.*, 2016; Soler *et al.*, 2012; Soler *et al.*, 2016), two studies had individuals with BPAD (Afshari *et al.*, 2019; Zargar *et al.*, 2019), and two studies consisted of adolescents with tendencies of deliberate self-harm (DSH)/other emotional difficulties (Smith *et al.*, 2018; Wayne, 2018). The review also included one study each on individuals with ADHD (Fleming *et al.*, 2015), and individuals with multiple sclerosis (Abdolghaddri *et al.*, 2019). Out of all the studies, four studies had participants with no comorbidities (Rodrigo, 2015; Secrist, 2014; Soler *et al.*, 2012; Zargar *et al.*, 2019) and six studies had participants with comorbid mental health conditions (Afshari *et al.*, 2019; Fleming *et al.*, 2015; Mancke *et al.*, 2018; Schmitt *et al.*, 2016; Smith *et al.*, 2018; Soler *et al.*, 2016). Seven studies had participants who were also simultaneously undergoing psychiatric treatment (Afshari *et al.*, 2019; Fleming *et al.*, 2015; Mancke *et al.*, 2018; Schmitt *et al.*, 2016; Soler *et al.*, 2012; Soler *et al.*, 2016; Zargar *et al.*, 2019). Seven studies recruited participants and carried out interventions in hospital settings (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Rodrigo, 2015; Schmitt *et al.*, 2016; Soler *et al.*, 2012; Soler *et al.*, 2016; Zargar *et al.*, 2019). Four studies were conducted in university/school-based facilities (Fleming *et al.*, 2015; Secrist, 2014; Smith *et al.*, 2018; Wayne, 2018). The study conducted by Mancke *et al.* (2018) recruited participants from treatment units, licensed psychotherapists, resident's registration office and advertisements on the internet, and carried out the intervention in specialized in-patient units at a university. Table 1 shows the characteristics of the participants in the experimental group for each study.

Intervention

All the studies selected in the review used DBT as the primary mode of psychotherapeutic treatment. Four studies in the review (Fleming *et al.*, 2015; Rodrigo, 2015; Schmitt *et al.*, 2016; Secrist, 2014) used the standard version of DBT developed by Linehan (1993) while four studies (Mancke *et al.*, 2018; Soler *et al.*, 2012; Soler *et al.*, 2016; Wayne, 2018) used only DBT Skills Training

(Linehan, 2014). Smith *et al.* (2018) used a modified version of DBT developed by Miller (Miller *et al.*, 1997) which has been tailor-made for adolescents. This version modified the standard DBT by shortening of the length of treatment from 1 year to 12 weeks, decreasing the total number of skills taught, including family members into the treatment, using a simple language in handouts and skills training lectures, and incorporating a 12-week follow-up patient consultation group that is optional. The adaptation of DBT by Sheri Van Dijk for Bipolar Disorder (Van Dijk *et al.* 2013) was used in the studies conducted by Afshari *et al.* (2019) and Zargar *et al.* (2019). This adaptation consists of twelve 90-minute sessions that include psychoeducation about bipolar disorder, presentation by a psychiatrist on medications used to treat bipolar disorder, importance of self-care and lifestyle modifications, and the four skills of the DBT-ST customized for patients with bipolar disorder. DBT-ST based on the workbook developed by McKay *et al.* (2019) was used in the study conducted by Abdolghaddri *et al.* (2019). This workbook contains practical DBT exercises for learning the four skills of DBT-ST by putting together basic skills chapters that teach necessary concepts, identify the components of the new skill, and lead the participant through the initial steps for acquiring the skill. The advanced skills chapters in the workbook cover the remaining components of the skill, developing level by level. The duration of DBT sessions varied across studies, with an average of 22 weeks. The sessions lasted for roughly 102 minutes on an average. With respect to the format of the intervention, six studies conducted both individual and group therapy sessions (Fleming *et al.*, 2015; Mancke *et al.*, 2018; Rodrigo, 2015; Schmitt *et al.*, 2016; Secrist, 2014; Smith *et al.*, 2018), one study conducted only individual therapy (Abdolghaddri *et al.*, 2019), and five studies conducted only group therapy (Afshari *et al.*, 2019; Soler *et al.*, 2012; Soler *et al.*, 2016; Wayne, 2018; Zargar *et al.*, 2019). Table 3 shows the details of the intervention for the experimental group across studies.

Outcomes

The outcome domain of interest included any measure of cognitive functioning. For convenience, the outcome measures used in the studies have been classified as objective neuropsychological measures that were used by eight studies (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Rodrigo, 2015; Secrist, 2014; Soler *et al.*, 2012; Soler *et al.*,

Table 2. Comparison of group conditions across studies.

1 st author (year)	Comparison/control group intervention
Abdolghaddri (2019)	2 groups for comparison - 1 group receiving positive psychotherapy and 1 group receiving no treatment
Afshari (2019)	Wait-list control group
Fleming (2015)	Self-guided Skills Handouts for ADHD (Tuckman, 2007)
Mancke (2018)	TAU group receiving outpatient psychotherapy/ residential crisis intervention/ pharmacotherapy/ no treatment
Rodrigo (2015)	No control group
Schmitt (2016)	2 groups for comparison - 1 group with healthy participants and 1 group receiving another unspecific treatment
Secrist (2014)	Community treatment by experts' group
Smith (2018)	No control group
Soler (2012)	General psychiatric management group
Soler (2016)	DBT interpersonal effectiveness module group (Linehan, 1993)
Wayne (2018)	No control group
Zargar (2019)	No treatment for the control group other than routine medications

ADHD, attention deficit hyperactivity disorder; TAU, treatment as usual; DBT, dialectical behavior therapy.

2016; Zargar *et al.*, 2019), self-report/ subjective measures of cognitive functioning that were used by two studies (Smith *et al.*, 2018; Wayne, 2018) and neuroimaging techniques that were used by three studies (Mancke *et al.*, 2018; Rodrigo, 2015; Schmitt *et al.*, 2016). The objective neuropsychological measures used across studies included the Ruff Figural Fluency Test (Ruff *et al.*, 1987) for figural fluency, the Benton Controlled Order Word Association Test (Benton *et al.*, 1994) for verbal associative fluency, and the Victoria version of the Stroop Color and Word Test (Regard, 1981 as cited in Strauss *et al.*, 2006) for inhibition, the Two Choice Impulsivity Paradigm (TCIP) and the Single Key Impulsivity Paradigm (SKIP; Dougherty *et al.*, 2005) for tolerance for delayed awards and the Time Paradigm Test (Dougherty *et al.*, 2003) for assessing time estimation. Some of the other neuropsychological tests used across studies were Tower of London (TOL; Shallice, 1982), Wisconsin Card Sorting Test (WCST; Shahgholian *et al.*, 2012), Color Trail Test (CTT; Tavakoli *et al.*, 2015), Brown ADD Rating Scales (BADDS; Brown, 1996), and Conners' Continuous Performance Test - 2nd edition (CPT-2; Conners, 2000). Attentional bias was assessed with a Visual Probe Task (VPT; Field *et al.*, 2006) and disinhibition was assessed using Stop Signal Task (SST; Verbruggen *et al.*, 2008). Wechsler Memory Scale (Wechsler, 1945), Computerized Complex Stroop Test and Scarborough Non-Affective Go/No-Go task (Rodrigo *et al.*, 2014) were also used in some studies included in the review. The self-report/subjective measures of cognitive functioning consisted of the Behavior Rating Inventory of Executive Function - Self Report (BRIEF-

SR; Guy *et al.*, 2004) and the percentage of assignments completed by high school students. The neuroimaging techniques included FMRI, MRI - Voxel-based Morphometry, and fNIRS. Table 4 shows the mode of assessment of cognitive functions across studies.

Cognitive changes in borderline personality disorder

Three studies in the current review attempted to understand the effect of DBT in improving cognitive functions among individuals with BPD using neuropsychological tests (Secrist, 2014; Soler *et al.*, 2012; Soler *et al.*, 2016). Secrist (2014) aimed at studying the role of executive functions in the treatment of BPD. This study demonstrated that after one year of DBT (Linehan, 1993), only slight improvements were found across all of the executive functioning ratings as assessed by Ruff Figural Fluency Test (Ruff *et al.*, 1987), Benton Controlled Order Word Association Test (Benton *et al.*, 1994), and Victoria version of the Stroop Color and Word Test (Regard, 1981 as cited in Strauss *et al.*, 2006), in both DBT group and the Community Treatment by Experts (CTBE) group. The author suggested that this improvement may have been either due to chance, the direct effect of the treatment, practice effects, or the mediation by the treatment's effects on other factors such as drug use. There were no significant differences between the DBT and CTBE groups in their effect on any of the three measures of executive functioning. Despite this, the study still concluded that participants demonstrated some im-

Table 3. Types of interventions carried out for the experimental group across studies.

1 st author (year)	Format/adaptation of DBT	Duration	Mode of administration
Abdolghaddri (2019)	DBT based on the workbook by McKay <i>et al.</i> (2019)	8 weeks	Individual
Afshari (2019)	Adaptation of DBT by Sheri Van Dijk (Van Dijk <i>et al.</i> , 2013) for bipolar disorder	12 sessions, 90 minutes each session	Group
Fleming (2015)	DBT skills training + individual coaching phone calls + booster group session (Linehan, 1993)	9 group sessions (90 minutes each), 7 individual coaching phone calls + one 90-minute booster group session held during the first week of the follow-up quarter	Individual and group
Mancke (2018)	Standard residential DBT consisting of individual and group-based skills training (Linehan, 1993)	12 weeks	Individual and group
Rodrigo (2015)	Standard DBT (Linehan, 2003)	6 months	Individual and group
Schmitt (2016)	Standard DBT inpatient treatment program including weekly, manualized skills training groups (Linehan, 1993)	12 weeks	Individual and group
Secrist (2014)	5 modes of DBT (Linehan, 1993)	12 months	Individual and group
Smith (2018)	Modified version of DBT developed Miller (Miller <i>et al.</i> , 1997); an adolescent skills training group, parent skills training group, multifamily skills training group, and individual therapy sessions	16 weeks	Individual and group
Soler (2012)	Mindfulness module - DBT skills training (Linehan, 1993)	8 weeks, 120 minutes each session	Group
Soler (2016)	Mindfulness module - DBT skills training (Linehan, 1993)	10 weeks, 120 minutes each session	Group
Wayne (2018)	For teachers - DBT skills in schools program developed by Mazza <i>et al.</i> (2016); for students - DBT skills training (Linehan, 2014)	For teachers - six instructor-led 1-hour sessions after school hours one time per week and two 1-hour online training sessions during the alternating weeks; For students - 8 DBT skills training sessions	Group
Zargar (2019)	Adaptation of DBT by Sheri Van Dijk (Van Dijk <i>et al.</i> , 2013) for bipolar disorder	12 sessions lasting for 1 to 1.5 hours each	Group

DBT, dialectical behavior therapy.

improvements across figural fluency, verbal fluency, and inhibition in both the treatment conditions, based on the means ratings before and after completion of one year in therapy.

The exclusive effect of the DBT Mindfulness Module on Borderline Personality Disorder has been thoroughly investigated by Soler *et al.* (2012) and Soler *et al.* (2016). In the study conducted by Soler *et al.* (2012), when DBT Mindfulness Module (Linehan, 1993) was provided along with general psychiatric management, participants demonstrated a significant improvement in commissions, hit reaction time, and detectability scores in Conners' Continuous Performance Test - 2 (Conners, 2000), as well as on the composite scores of inattention and impulsivity, compared to a group that only received general psychiatric management. Another similar study by Soler *et al.* (2016) showed that the participants in the Mindfulness (Linehan, 1993) group improved their ability to delay their gratification and demonstrated changes in time perception, which was also consistent with a decrease in impulsivity, when assessed using CPT-2 (Conners, 2000), TCIP and SKIP (Dougherty *et al.*, 2005), and Time Paradigm Test (Dougherty *et al.*, 2003). The results of these studies suggest that the Mindfulness Module of DBT Skills Training has a positive effect on attention, tolerance for delayed rewards, time perception and impulsivity variables among patients with BPD.

Measuring cognitive changes in borderline personality disorder using neuroimaging techniques

Apart from the traditional neuropsychological measures and self-report/subjective measures of cognitive functions, three studies in the current review used neuroimaging techniques to assess the changes in brain functions (Mancke *et al.*, 2018; Rodrigo, 2015; Schmitt *et al.*, 2016) following DBT. Schmitt *et al.* (2016) conducted a study on BPD patients using fMRI to investigate

which brain regions associated with explicit emotion regulation are modulated after DBT (Linehan, 1993). Findings demonstrated reduced activity and increased connectivity in the salience processing and neural networks related to emotion regulation after DBT. More efficient emotion regulation during a reappraisal task involving negative pictures was indicated through an attenuated limbic hyperarousal along with an elevated coupling between limbic and prefrontal control regions among BPD patients after successful DBT. Such brain-related changes can also be associated with improved cognitive functioning.

Mancke *et al.* (2018) applied voxel-based morphometry to observe the structural changes in the brain by studying the voxel-wise changes in grey matter volume over time for BPD patients undergoing DBT (Linehan, 1993). The results showed that the patients receiving DBT demonstrated an increase in grey matter volume in the anterior cingulate cortex, inferior frontal gyrus, and superior temporal gyrus along with an alteration of grey matter volume in the angular gyrus and supramarginal gyrus compared to the patients receiving TAU. The results also showed that the therapy response correlated with an increase in grey matter volume in the angular gyrus. The findings indicated that DBT increased the grey matter volume of brain regions that play an important role in emotion regulation and higher-order cognitive functions such as mentalizing. The authors suggested that such findings can enhance the brain-related mechanisms of change caused by psychotherapy and can foster the development of neurobiologically informed therapeutic interventions. Similarly, Rodrigo (2015) used fNIRS to understand the neural correlates of inhibitory control within the prefrontal cortex (PFC) among self-harming patients with BPD who attended approximately six months DBT (Linehan, 2003). Prior to treatment, the patients showed lower activation bilaterally and higher activation medially in the PFC. The results of the study revealed that after approximately six months of DBT, patients showed higher activation in the bilateral regions of the PFC and the right medial PFC. These

Table 4. Mode of assessment of cognitive functions across studies.

1 st author (year)	The domain of cognitive changes	Mode of assessment
Abdolghaddri (2019)	Memory and attention	Wechsler Memory Scale (Wechsler, 1945) and Computerized Complex Stroop Test
Afshari (2019)	A measure of executive functions	TOL (Shallice, 1982), WCST (Shahgholian <i>et al.</i> , 2012)
Fleming (2015)	A measure of executive functions	BADDS (Brown, 1996), CPT-2 (Conners, 2000)
Mancke (2018)	Voxel-wise changes in grey matter volume	MRI - Voxel-based morphometry
Rodrigo (2015)	Neural correlates of inhibitory control within the prefrontal cortex	Scarborough non-affective go/no-go task (Rodrigo <i>et al.</i> , 2014) and brain imaging using fNIRS
Schmitt (2016)	Changes in brain activity using a reappraisal paradigm	fMRI
Secrist (2014)	Three forms of executive functioning (figural fluency, verbal fluency, and inhibition)	Ruff Figural Fluency Test (Ruff <i>et al.</i> , 1987) for figural fluency, Benton Controlled Order Word Association Test (Benton <i>et al.</i> , 1994) for verbal associative fluency, and Victoria version of the Stroop Color and Word Test (Regard, 1981 as cited in Strauss <i>et al.</i> , 2006) for inhibition
Smith (2018)	The measure of self-report of executive functions	BRIEF-SR (Guy <i>et al.</i> , 2004)
Soler (2012)	Measure of attention	CPT-2 (Conners, 2000)
Soler (2016)	Measures of response inhibition, tolerance for delayed rewards, and time perception	CPT-2 (Conners, 2000) for response inhibition, Two Choice Impulsivity Paradigm and Single Key Impulsivity Paradigm (Dougherty <i>et al.</i> , 2005) for tolerance for delayed awards, and Time Paradigm test for assessing time estimation (Dougherty <i>et al.</i> , 2003)
Wayne (2018)	Academic performance	Percentage of assignments completed by students
Zargar (2019)	A measure of executive functions	CTT (Tavakoli <i>et al.</i> , 2015)

TOL, Tower of London; WCST, Wisconsin Card Sorting Test; BADDS, Brown ADD Rating Scales; CPT 2, Conners' Continuous Performance Test - 2; MRI, magnetic resonance imaging; fNIRS, functional near-infrared spectroscopy; fMRI, functional magnetic resonance imaging; BRIEF-SR, Behavior Rating Inventory of Executive Function-Self Report; CTT, Color Trail Test.

activation patterns also indicated improvements in BPD symptom domains. This study provided an understanding of the neural mechanisms underlying the treatment-related symptom change in BPD. Higher activation in the bilateral regions of PFC is associated with improved cognitive functioning (Miotto *et al.* 2006).

Cognitive changes in bipolar affective disorder

Two studies in the current review have conducted DBT based on the manual by Sheri Van Dijk (Van Dijk *et al.* 2013) for patients with BPAD (Afshari *et al.*, 2019; Zargar *et al.*, 2019). Afshari *et al.* (2019) examined the impact of DBT skills on executive functions, emotion regulation, and mindfulness in patients with BPAD. TOL (Shallice, 1982) and WCST (Shahgholian *et al.*, 2012) were used as measures of executive functions that were measured at baseline, immediately after the intervention, and three months later. The findings of this study showed that the intervention group not only improved over time for bipolar symptoms and emotion dysregulation but also demonstrated improvements in mindfulness, planning, problem-solving, and cognitive flexibility, compared to the waitlist control group. Another similar study carried out by Zargar *et al.* (2019) attempted to determine the effects of DBT on executive function, emotional control, and symptom relief among patients with Type 1 BPAD. For evaluating the executive functions, CTT (Tavakoli *et al.*, 2015) was used for evaluating the executive function. The findings showed that depression and executive function of the patients had no significant difference between the experimental group (DBT + routine medications) and the control group (no treatment other than routine medications) during the post intervention period and only a modest and non-significant change was noted. It was inferred that DBT along with drug therapy had been effective in reducing the intensity of mania but was not as effective in reducing the emotional instability and impulsivity of the patients, even though it had modestly improved the executive functions and depression of the patients. Overall, these studies done on patients with BPAD suggest that DBT along with prescription medication, can be an effective therapy for BPAD that not only has the potential to reduce manic and depressive symptoms but also to improve executive functions.

Cognitive changes in attention deficit and hyperactivity disorder

Fleming *et al.* (2015) conducted a randomized controlled trial that evaluated a pilot DBT group Skills Training, which was adapted for college students with ADHD. In this study, 33 undergraduate students with ADHD were randomized to either receive DBT group Skills Training (Linehan, 1993) or Self-guided Skills Handouts for ADHD (Tuckman, 2007). The assessments were done at pre-treatment, post-treatment, and 3-month follow-up, by an interviewer who was blind to participant conditions. Executive functioning was measured using the BADDSS (Brown, 1996) and neuropsychological performance was assessed using the CPT-2 (Conners, 2000). The intervention for the experimental group was delivered as per the DBT group skills training format (Linehan, 1993) which consisted of 9 group sessions lasting for 90 minutes each and 7 individual coaching phone calls. Participants in the skills handouts comparison condition received 34 pages of skills handouts, taken from a manual for the treatment of adults with ADHD (Tuckman, 2007), which was designed in the form of publicly available self-help materials for ADHD. The findings showed that the participants receiving DBT group Skills Training demon-

strated greater treatment response rates (59-65% versus 19-25%) and clinical recovery rates (53- 59% versus 6-13%) on ADHD symptoms and executive functions. The authors concluded that DBT group Skills Training can be used even for treating ADHD among college students, which can result in improvements in ADHD symptoms as well as executive functioning.

Cognitive changes in multiple sclerosis

Individuals with multiple sclerosis struggle with serious emotional and cognitive challenges (Goretti *et al.*, 2010). Abdolghadri *et al.* (2019) attempted to examine the efficacy of DBT and positive psychotherapy respectively on the memory and attention of multiple sclerosis patients. 45 patients with multiple sclerosis were randomly assigned to three groups - 1 group receiving DBT based on the protocol by McKay *et al.* (2019), 1 group receiving positive psychotherapy, and a control group receiving no intervention. The measures used to assess memory and attention were Wechsler Memory Scale (Wechsler, 1945) and Computerized Complex Stroop Test. Both the experimental groups received eight sessions of DBT and positive psychotherapy respectively, and the control group did not receive any intervention. Findings showed that positive psychotherapy and DBT both increased memory and attention among patients with multiple sclerosis. Findings also showed that with respect to attention, DBT was more effective than positive psychotherapy. The study concluded that positive psychotherapy and especially DBT can be provided for patients with multiple sclerosis to improve their memory and attention. Based on the finding, it can be inferred that DBT's effect on treating emotional difficulties may have contributed to strengthened cognitive functioning.

Cognitive changes in adolescents with emotional dysregulation

Two studies in the current review have attempted to understand the effect of DBT in improving cognitive functions among adolescents with emotional dysregulation (Smith *et al.*, 2018; Wayne, 2018). A single group pre-post study conducted by Smith *et al.* (2018) aimed at examining the changes in the executive functions of adolescents with emotional dysregulation, behavioral problems, and current or recent history of DSH, undergoing DBT (Miller *et al.*, 1997). When these adolescents were assessed using the Behavior Rating Inventory of Executive Function - Self Report Version (BRIEF-SR; Guy *et al.*, 2004), their scores improved from the high to non-clinical range on the Emotional Control, Shifting, Monitor scales, and the Global Executive Composite after 16 weeks of DBT. Another similar study conducted by Wayne (2018) attempted to understand the impact of DBT on the school functioning of high school students with emotional dysregulation, difficulty coping with frustration, poor interpersonal relationships, and inability to remain calm and maintain attentiveness. These students were trained with DBT-ST modules (Linehan, 2014) to reduce disciplinary referrals, increase using positive coping skills, and improve resiliency. Results of the study showed that the percentage of assignments completed by students participating in DBT significantly improved. The improvement in the percentage of assignments completed by students can indicate an enhanced cognitive capacity to perform the assignments, which can be related to elevated cognitive functioning.

Overall, results of the current review provide reasonable evidence for the effectiveness of DBT in enhancing cognitive functions across various mental health conditions. Among individuals

with BPD, DBT was found to only modestly improve figural fluency, verbal fluency and inhibition (Secrist, 2014) when assessed using neuropsychological tests. However, the mindfulness module of DBT-ST exclusively had significant positive effects on attention, tolerance for delayed rewards, time perception and impulsivity variables among the BPD population (Soler *et al.*, 2012; Soler *et al.*, 2016). Neuroimaging techniques employed in the studies involving individuals with BPD showed remarkable brain related changes underlying the DBT-related symptom change (Mancke *et al.*, 2018; Rodrigo, 2015; Schmitt *et al.*, 2016), which is indicative of improved cognitive functioning. While the study conducted by Zargar *et al.* (2019) showed that DBT only modestly improved the executive functions among patients with BPAD, the study conducted by Afshari *et al.* (2019) showed significant improvements in planning, problem solving and cognitive flexibility following DBT, among the same population. DBT group Skills Training contributed to higher treatment response rates and clinical recovery rates on executive functions among patients with ADHD (Fleming *et al.*, 2015). Also, the memory and attention of patients with multiple sclerosis showed significant improvements following DBT (Abdolghaddri *et al.*, 2019). Improvements in the self-report/subjective measures of cognitive functions among adolescents with emotional dysregulation were evidenced by im-

proved emotional control, shifting, monitoring (Smith *et al.*, 2018) and a higher percentage of assignments completed by high school students (Wayne, 2018).

Risk of bias

Risks of bias assessment of the twelve studies are summarized in Tables 5 and 6. Out of the 12 studies, 6 studies were RCTs (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Secrist, 2014; Soler *et al.*, 2016; Zargar *et al.*, 2019) and 6 studies were quasi-experimental studies (Mancke *et al.*, 2018; Rodrigo, 2015; Schmitt *et al.*, 2016; Smith *et al.*, 2018; Soler *et al.*, 2012; Wayne, 2018). None of the studies met all the JBI criteria. Out of the 13 criteria in the RCT checklist, the 6 RCTs met 5-10 criteria as per the JBI checklist. Risk of bias assessment for RCTs showed that 5 RCTs (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Soler *et al.*, 2016; Zargar *et al.*, 2019) used true randomization for assigning participants to treatment conditions. In 5 RCTs (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Soler *et al.*, 2016; Zargar *et al.*, 2019), treatment groups were similar at baseline as evidenced by pre-treatment comparability tables. The treatment groups in all the RCTs were

Table 5. Risk of bias of the randomized controlled trials.

	Abdolghaddri (2019)	Afshari (2019)	Fleming (2015)	Secrist (2014)	Soler (2016)	Zargar (2019)
1 True randomization	+	+	+	-	+	+
2 Allocation concealment	?	?	?	?	+	?
3 Similar at baseline	+	+	+	?	+	+
4 Blinding of participants	?	?	?	?	?	?
5 Blinding of treatment providers	?	?	?	?	?	?
6 Blinding of assessors	?	?	+	+	+	?
7 Identical treatment other than intervention	+	+	+	+	+	+
8 Follow-up description	?	+	+	+	+	+
9 Intention-to-treat analysis	?	?	+	?	?	?
10 Similar outcome measurements	+	+	+	+	+	+
11 Reliability of outcome measurements	?	+	+	+	+	+
12 Appropriate statistical analysis	+	+	+	+	+	+
13 Appropriate trial design	?	+	+	+	+	+

+ means Yes; - means No; ? means Unclear.

Table 6. Risk of bias of the quasi-experimental and non-randomized controlled trials.

	Mancke (2018)	Rodrigo (2015)	Schmitt (2016)	Smith (2018)	Soler (2012)	Wayne (2018)
1 Clear cause and effect	+	+	+	+	+	+
2 Similar participants in comparisons	+	+	-	+	+	+
3 Similar treatment other than intervention	+	+	+	+	+	+
4 Control group	+	-	+	-	+	-
5 Multiple measurements	-	-	-	-	-	-
6 Follow-up description	+	+	+	+	+	+
7 Similar outcome measurements	+	+	+	+	+	+
8 Reliability of outcome measurements	+	+	+	+	+	+
9 Appropriate statistical analysis	+	+	+	+	+	+

+ means Yes; - means No.

treated in an identical manner. No RCT deviated drastically from the intended interventions and the non-protocol interventions (such as psychiatric medications) were adequately balanced across intervention and comparison groups. Follow-ups were completed adequately and there were no significant differences between groups in the ways in which follow-up was done. There were no failures or disruptions in implementing the interventions and all the study participants across the RCTs adhered to the assigned treatment. Outcome variables were measured in the same way for all the treatment groups. Across all the studies, outcomes were measured in a reliable way and appropriate statistical analyses were used. None of the RCTs deviated from the standard RCT design in terms of the conduct and the analysis of the trials. In most RCTs however, there was unclear information regarding whether the allocation to treatment groups were concealed (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Secrist, 2014; Zargar *et al.*, 2019) and if the participants (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Secrist, 2014; Soler *et al.*, 2016; Zargar *et al.*, 2019) and those delivering the treatment (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Fleming *et al.*, 2015; Secrist, 2014; Soler *et al.*, 2016; Zargar *et al.*, 2019) were blind to treatment assignment and condition, although in three of the RCTs (Fleming *et al.*, 2015; Secrist, 2014; Soler *et al.*, 2016), outcome assessors were blind to treatment assignment. Also, 5 RCTs (Abdolghaddri *et al.*, 2019; Afshari *et al.*, 2019; Secrist, 2014; Soler *et al.*, 2016; Zargar *et al.*, 2019) provided unclear information regarding whether the participants were analyzed in the groups to which they were randomized, based on accounts related to the intention-to-treat analysis.

Out of the 9 criteria in the quasi-experimental studies checklist, the 6 quasi-experimental studies met 7-8 criteria as per the JBI checklist. All the quasi-experimental studies were able to clearly establish the *cause* and the *effect*. Participants in all the comparisons were similar and were treated in an identical manner. While three studies had non-randomized control groups (Mancke *et al.*, 2018; Schmitt *et al.*, 2016; Soler *et al.*, 2012), three other studies adopted single group designs (Rodrigo, 2015; Smith *et al.*, 2018; Wayne, 2018). Similar to the RCTs, quasi-experimental studies also adequately completed follow-ups and there were no significant differences between groups in the ways in which follow-up was done. Outcomes were also reliably measured in a similar manner for all the comparisons. All the quasi-experimental studies used appropriate statistical analyses. However, none of the studies had multiple measurements of the outcomes both pre and post the interventions.

Discussion

The current systematic review was concerned with examining the effectiveness of DBT in improving cognitive functions, across various mental health conditions. Twelve studies that used several versions of DBT were reviewed for the outcome domain related to cognitive functions. Cognitive functions were assessed using either objective neuropsychological measures, self-report/subjective measures of cognitive functioning, or neuroimaging techniques. Most studies in the review showed improvements in cognitive functions with varying degrees, in comparing post- *versus* pre-intervention scores or experimental *versus* comparison/control group scores, or both.

This review showed that regardless of the type of mental condition, participants in most of the studies showed improvements in cognitive functions. The findings of the current review corre-

spond closely to the reviews conducted by Poissant *et al.* (2019) and Iskrac and Barkley-Levenson (2021) wherein both studies provided conclusive evidence for improvements in different aspects of cognition following mindfulness-based interventions and DBT, among individuals with ADHD and BPD respectively. Given that individuals with BPD experience deficits in higher order thinking abilities (Thomsen *et al.*, 2017), DBT's effectiveness in improving attention, tolerance for delayed rewards, time perception, and impulsivity as evidenced by the neuropsychological tests and neuroimaging techniques, can play a crucial role in improving the efficiency and productivity of BPD patients. According to a study conducted by Torrent *et al.* (2006), deficits in attention, executive functions and verbal memory are evident among patients with BPAD. The current review has shown the effectiveness of DBT in bipolar disorder with respect to improvements in planning, problem solving and cognitive flexibility, all of which are core executive functions. Besides the typical symptoms of inattention, hyperactivity and impulsivity among patients with ADHD, these patients also suffer from deficits in executive functions like impulse control and working memory, as well as non-executive functions like memory and reaction time (Coghill *et al.*, 2013). In view of this, DBT's significant treatment response rates and clinical recovery rates on executive functions can possibly address the issues concerned with executive dysfunction in ADHD. Apart from the apparent emotional symptoms experienced by patients with multiple sclerosis (Silveira *et al.*, 2019), 40-65% of them also demonstrate cognitive impairment involving complex attention, information processing speed, memory and executive functions (Jongen *et al.* 2012). Improvements in memory and attention following DBT can significantly improve the wellbeing and help restore the quality of life for patients with multiple sclerosis.

Studies in the past have shown that DBT is highly efficacious for adolescents with a wide range of emotion regulation difficulties (MacPherson *et al.*, 2012). DBT's effectiveness in enhancing the executive functions (emotional control, shifting, monitoring, etc.) of adolescents suffering from emotional dysregulation can possibly shape desirable behavioral patterns during this critical phase of development. Based on the studies conducted by Smith *et al.* (2018) and Wayne (2018), it can be inferred that such improvements among adolescents may be maintained in a manner similar to that of adults. Moreover, psychiatric diagnoses during adolescence may not always remain stable (Mattanah *et al.*, 1995). For instance, the diagnosis of BPD for some severely affected adolescents may remain stable over time, but a less severe subgroup of youth moves in and out of diagnosis (Miller *et al.* 2008). Hence, early intervention using DBT for adolescents with emotional dysregulation may not only improve their executive functions but also lead to favorable prognoses.

Two features that were common across all the mental health conditions covered in the current review (BPD, Bipolar Disorder, ADHD, multiple sclerosis and adolescents with emotional dysregulation) were emotional instability and deficits in executive functions. DBT's direct impact on emotion regulation may have possibly contributed to an improved mental capacity for the operation of optimal cognitive functioning, given the apparent connections between emotions and cognition. This link between emotions and cognition may have been one of the mechanisms possibly responsible for the transdiagnostic improvement involving disorders characterized by emotional instability. Apart from the interrelation between emotions and cognition, it can be understood that DBT's fine interplay between the eastern Zen Buddhist philosophies and the western contemporary behavioral principles, may give way to a unique and enhanced cognitive capacity to

think in a clear and reasonable manner, which possibly leads to improvements in cognitive functioning. This shows that considering all the favorable outcomes of DBT, transdiagnostic improvements in cognitive functions adds to yet another perk of practicing this form of psychotherapy.

It was also found that the quality of the studies was variable as per the JBI checklist for randomized controlled trials and quasi-experimental studies. On the positive side, most of the RCTs in the review used true randomization for assigning participants to treatment conditions. The treatment groups of most studies were similar at baseline and were treated in an identical manner. None of the studies majorly deviated from the intended interventions and some studies involved psychiatric medications (non-protocol intervention) that were balanced across the groups. Though the medications were balanced across treatment and control groups, some of the improvements in the symptoms may have also been caused due to the confounding effects of medications. Follow-ups were performed methodically in most studies and there were no apparent difficulties in carrying out the interventions. Across all the studies, participants adhered to the assigned treatments. Outcomes were measured in an identical and reliable manner across the treatment groups and appropriate statistical analyses were used for data analyses in all the studies. Each study included in the review was able to clearly establish the *cause* and the *effect*, thereby justifying the rigor of the respective experimental research designs. However, most studies failed to provide clear information regarding the concealment of participant allocation to treatment groups as well as the blinding of participants and treatment providers to treatment assignment and condition. Nevertheless, in interventions such as DBT which heavily operates on the awareness of the concept of *dialectics*, it is not habitual or advantageous to blind the treatment providers or participants and hence, such biases related to blinding and concealment are inevitable. On the negative side, most RCTs provided unclear information on accounts related to the intention-to-treat analysis. Most of the quasi-experimental studies failed to have multiple measurement points of the outcomes. Apart from the risk of bias assessment based on JBI checklist for randomized controlled trials and quasi-experimental studies, qualitative assessment of the quality of the studies shows that although the pre-treatment characteristics of all the comparisons were similar across most RCTs and quasi-experimental studies, some studies had a large difference in the number of participants in the experimental and control groups, which can affect the internal validity of those studies. Across all the studies (RCTs and quasi-experimental studies), the therapist effect and other non-specific factors of psychotherapy were not entirely ruled out, thereby risking the interference of potential confounding variables.

Conclusions, limitations, and future research

The current systematic review aimed to understand the effect of DBT in improving cognitive functions, across various mental health conditions. Each study was carefully selected for review using strict inclusion and exclusion criteria. The included studies measured several outcome variables out of which, the current review relied heavily only on the outcome variables relevant to cognitive functions. Based on the findings of the review, it can be inferred that DBT can be effective in improving cognitive functions across different mental health conditions.

Despite the variations in the quality of the studies, any stan-

dardized version of DBT may foster improvements in the cognitive functioning of individuals suffering from common mental health conditions. Based on this evidence, psychologists can opt for DBT as a suitable treatment either as a stand-alone or adjunct treatment, depending upon the need. Individuals with many mental health conditions quit from or fail to perform well in their schools/colleges/full-time professions due to deficits in cognitive functioning. In light of this, DBT can be used as a preferred mode of psychotherapy that could help patients reach optimal levels of cognitive and occupational functioning, aiding them to live their daily lives in a fruitful, efficient and productive manner.

Despite the comprehensive and promising findings, the current review has certain limitations that cannot be neglected. The first limitation is that, considering the transdiagnostic approach of the current review, there were not enough studies encompassing all the common mental health conditions. This is probably because the effectiveness of DBT has not yet been evaluated across many other common psychiatric disorders, with respect to improvements in cognitive functions. The second limitation is that the studies that used neuroimaging techniques did not directly report improvement in cognitive functioning among the participants. They only implied to the readers that the improvement in cognitive functions was a natural end result associated with the measured/reported outcomes of changes in the brain. The third limitation is that none of the studies met all the criteria in the Joanna Briggs Institute (JBI) checklist for randomized controlled trials and quasi-experimental studies, and a certain amount of variability in the quality of the studies was unavoidable.

This review has rendered a starting point for understanding the impact of DBT on cognitive functions. Future reviews can shortlist studies based on a specific type of outcome measurement (neuropsychological tests/self-report measures/neuroimaging). This can provide a larger scope for meta-analysis, which can further ascertain DBT's effectiveness in improving cognitive functions. Future reviews can also focus on including a larger number of high-quality studies (preferably RCTs) which will lower the overall risk of bias.

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Online supplementary material:

Part 1. List of excluded full-text studies.