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Cognitive-Affective control training reduces worry and GAD symptoms: investigating training and transfer effect

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Abstract

Symptoms of Generalized Anxiety Disorder (GAD), have been considered as an index of cognitive control deficiency. The aim of this study was to investigate whether enhancing cognitive control over emotional stimuli can decrease worry intrusions and severity of GAD symptoms. To gather GAD participants, an announcement was made in the psychotherapy and counselling clinic of the Ferdowsi University of Mashhad (FUM), so those who had GAD symptoms contacted researchers. Based on results of structured clinical interview for the DSM-5 (SCID) and other exclusion criteria, 45 students were chosen to participate in this study. Then they were assigned equally and randomly to three conditions of intervention, control and active control; then they completed PSWQ, GAD-7, emotional stroop task and Go/No Go task as pre-test. The intervention group received 16 sessions of cognitive-affective control training using emotional stroop with trial-based feedback, also the active control group received the same amount of training sessions of emotional stroop with no feedback, and finally the control group was on a waiting list. After post-test assessments, results of ANCOVA showed that training sessions was effective on stroop performance, reduction in worry intrusions and GAD symptoms, and also training in cognitive inhibition did not transfer to behavioral inhibition. Findings revealed that cognitive control plays a major role in worry and GAD symptoms, and also cognitive control training might be a promising path to decrease the severity of anxiety disorders. Training with emotional stimuli can enhance performance and using trial-based feedback can pave the way to get better clinical results.

Keywords: Generalized Anxiety Disorder, Worry, Cognitive Control Training, Inhibition.

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Introduction

Generalized Anxiety Disorder (GAD) is one of the most enduring and prevalent mental disorders, whose core characteristic is excessive and uncontrollable worry (APA, 2013). Worry has been defined as a chain of future-oriented and catastrophic thoughts and images which cause emotional distress (Borkovec, Robinson, Pruzinsky, & DePree, 1983). There are several psychological and neurocognitive accounts on etiology of worry and GAD (for a review see Behar, DiMarco, Hekler, Mohlman, & Staples, 2009).

Neurocognitive accounts of GAD consider cognitive control as an underlying potential mechanism of psychopathology (Hirsch & Mathews, 2012). Cognitive control (CC) is the capacity of pursuing goal-directed behaviors, in almost all domains of voluntary performance of human being (Cohen, 2017). Several symptoms of GAD, like lack of concentration and intrusive, excessive and uncontrollable worry which interfere with goal-directed behaviors are considered as indicators of cognitive control deficiency (Hallion, Ruscio, & Jha, 2014). For example; uncontrollability and severity of worry is associated with comorbidity and severity of GAD symptoms (Hallion & Ruscio, 2013). Eysenck and Derakhshan (2011) in their attentional control theory, suggest that worry and anxiety impair attentional control (cognitive control) and its components. Similarly, Hirsch and Mathews (2012) in the cognitive model of worry suggest that anxious individuals have deficiency in top down processes. Worriers selectively but not voluntarily attend to threatening information (e.g. emotional processing biases) and allocate more attentional resources on worry content, so less amount of attentional resources remain to allocate to the current task. Therefore, threatening intrusions easily find their way to consciousness and interfere with the intended task.

A considerable number of findings support this assumption that worry is associated with impairments in cognitive control. In an experimental study (Hayes, Hirsch, & Mathews, 2008) participants were asked to worry or think about a positive situation, while doing a random key-press task. Less random responses were indicator of less attentional control resources assigned to the task. Results showed that high worriers exert less attentional control while worrying, and there was no difference between high and low worriers in key-press task while thinking about positive situations, which means worry depleted attentional resources specially in people who habitually worry.

Miyake et al (2000) suggested that cognitive control constitutes of three distinct but interrelated components; (1) working memory: the ability of maintaining and updating information (2) shifting: the ability of switching between cognitive tasks (3) inhibition: the ability of halting a dominant but task-irrelevant response in favor of a less dominant but task-relevant response.

Based on empirical and theoretical accounts, Inhibition construct has been subdivided to behavioral inhibition; stopping an inappropriate but dominant motor response, and cognitive inhibition; resolving interference by ignoring task-irrelevant information (Friedman & Miyake, 2004; Nigg, 2000). Considering worry intrusions as distractors, cognitive inhibition helps one to stop this train of thoughts and stay focused on the current task (McKenna & Sharma, 1995).

Many studies have shown that people with high anxiety and worry have deficiency in overriding distractors and task irrelevant information, even in the absence of threatening information. Bishop (2009) in a neuroimaging study showed that participants who were high in trait anxiety, were slower in responding to the target stimuli and ignoring the distractors. This slowing

was accompanied by reduced activation in dorsolateral prefrontal cortex (dLPFC), a critical region for cognitive control; suggesting that anxious people exert less attentional control on distractors. Another study (Hallion, Tolin, Assaf, Goethe, & Diefenbach, 2017) suggests that GAD participants have difficulty in Stroop Task, a typical task of cognitive inhibition, which requires them to name the *color* and ignore the *word.* Meanwhile there was no significant difference between GAD and normal participants in Go/No Go task which means people with GAD have impairments in cognitive inhibition and their behavioral inhibition is intact. Despite the evidence that high worriers and GAD people have deficiency in cold (neutral) cognitive inhibition, most of the research on inhibition in anxiety and worry focused on cognitive inhibition of hot (emotional) stimuli.

Findings showed that high worriers who report attentional difficulties, have troubles in ignoring the threatening stimuli (Derryberry & Reed, 2002; Lonigan & Vasey, 2009; Peers & Lawrence, 2009). Furthermore, Goodwin, Yiend & Hirsch (2017) in their systematic review suggested that GAD and worry are associated with difficulty in disengaging from negative valence stimuli and also this deficiency was addressed vigorously when material was presented in a verbal-linguistic format rather than pictorial form, which means that verbal nature of worry depletes more capacity of cognitive control than other forms of thinking, specially imagery.

Several models of anxiety assume that worry is a learned and automatic response for high worriers in uncertain and threatening situations, so one must inhibit worry to be able to focus on the intended task, and failure to do so is an index of deficiency in inhibition of hot cognition (Beck & Clark, 1997; Mathews, 1990; McNally, 1995).

Considering cognitive control as a central mechanism in psychopathology, cognitive control training (CCT), has been investigated

in various populations with different problems like depression (Calkins, McMorran, Siegle, & Otto, 2015; Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017; Van den Bergh, Hoorelbeke, De Raedt, & Koster, 2018), math anxiety (Sokolowski & Necka, 2016), brain traumatic injuries (Han, Chapman, & Krawczyk, 2018), worry (Han et al., 2018), maladaptive emotion regulation (Hoorelbeke, Koster, Demeyer, Loeys, & Vanderhasselt, 2016), impulsivity (Peckham & Johnson, 2018), and it seems to be an effective way to reduce symptoms and severity of disorders.

Cognitive control training, by changing the brain functions, works through neuroplasticity (D. Lee, Kwak, & Chey, 2019). Plasticity refers to the ability of the brain to change structurally and functionally as a result of experience, which leads to different responses to the same stimuli (Pascual-Leone, Amedi, Fregni, & Merabet, 2005). Neuroplasticity takes place through several biological processes which involve: (1) synaptogenesis: formation of new synaptic connections or strengthening existing one (2) synaptic pruning: losing or weakening existing synapses (3) homeostatic plasticity: adjustments in the excitability of neurons; changes to the function of ion channels in the cell membrane result in modifications in the electrical features of neurons like synaptic integration, spike generation and subthreshold propagation. These changes can result in alteration in higher brain functions, like memory, learning and cognitive control (4) neurogenesis: the birth and growth of new neurons which plays a minor role in neuroplasticity, compared to homeostatic plasticity and synaptogenesis (Cramer et al., 2011).

The rationale of cognitive intervention emphasizes on the alterations of neural circuitry which in turn orchestrates larger populations of neurons and facilitates their future actions which leads to stronger neural networks (Calabrese, Molteni, Racagni, & Riva, 2009). Cognitive interventions

result in structural and functional modifications which are aligned with expected clinical consequences (Alvarez & Iacoviello, 2015). learning new ways of responding occurs through corrective experiences and feedback (Vinogradov, Fisher, & de Villers-Sidani, 2012). Based on reinforcement theory, immediate feedback can result in better understanding of one's responses and they can regulate "speed-accuracy' trade off in their responses. Feedback strengthens the correct response and weakens the wrong one, and all this procedure can be traced in behavioral and neural levels (Littman, 2015).

Animal (H. Lee et al., 2012) and Human (Chiesa, Calati, & Serretti, 2011; Siegle, Ghinassi, & Thase, 2007; Teasdale, Segal, & Williams, 1995) studies suggest that cognitive control training leads to neural change. for example, Lee et al. (2019) found that using a Multi-Component Training of Cognitive Control (MTCC) in adolescents leads to changes in visuospatial fluid intelligence and enhanced grey matter volume in right inferior cortex (rIFC) which was associated with higher stroop performance. Also Kim, Chey & Lee (2017) suggest that MTCC can help elderly individuals to improve their cognitive control and general cognitive functions and this improvement is associated with expanding their frontoparietal network. Imaging studies have shown that cognitive behavior therapy (CBT) for anxiety and depression have changed functions of neural circuits engaged in emotion regulation and cognitive control (DeRubeis, Siegle, & Hollon, 2008).

Findings of a systematic review (Koster et al., 2017) suggests that CCT can be effective on rumination and depression symptoms, especially when using emotional material, which means cognitive-affective control training can be more effective than approaches using neutral stimuli. Siegle et al. (2007) in their systematic review found that cognitive-affective control

training can normalize disruptions related to depression in the amygdala and dLPFC, therefore getting control over emotional stimuli can bring about more beneficial results.

Worry and rumination are negative, repetitive thinking styles which share properties (Segerstrom, Tsao, Alden, & Craske, 2000) and neural networks (Alvarez & Iacoviello, 2015) but despite evidence of effectiveness of CCT on rumination and depression, research on worry is still rare (Hallion et al., 2017). Putting all this together, inhibition of hot cognitions (e, g. worry) seems to be an appropriate candidate of cognitive control training in GAD and we hypothesize that training with immediate feedback to ignore threatening distractors, will help people with GAD to be more capable of inhibiting worry intrusions. As mentioned earlier, worry is the central process in GAD, therefore the second hypothesis is that by reduction in worry severity, GAD symptoms will decrease as well. A critical question in the field of neurobehavioral therapy and neuroplasticity is that whether the acquired abilities are transferable to other cognitive faculties, so we investigate whether training in cognitive inhibition can be transferred to behavioral inhibition or not.

Method

Participants

In order to gather people with GAD diagnosis, an announcement was made in the psychotherapy and counselling clinic of the Ferdowsi University of Mashhad (FUM). 45 treatment-seeking individuals (32 female), aged between 18 to 40 (mean= 24.3), whose primary diagnosis was GAD participated in this study. Structured clinical interview was carried out by a clinical psychologist and it was ensured that participants do not meet criteria for another DSM-5 diagnosis. Participants who had history of using

prescribed / unprescribed psychotropic medicine during the last 6 months were excluded from the study. Other exclusion criteria included a history of concussion or loss of consciousness >5 min, history of severe mental illness or neurodevelopmental disorders, a moderate to severe depression score on Beck Depression Inventory.

Measures

Clinical Measures

Penn State Worry Questionnaire (PSWQ): Contains 16 self-report questions which is used to assess pathological worry and screening people with GAD. Using a 5-point Likert in this scale, expands the range of scores between 16 to 80 (Meyer, Miller, Metzger, & Borkovec, 1990). This questionnaire has a high internal consistency not only for GAD but also for other anxiety disorders (Brown, Antony, & Barlow, 1992). Cronbach's alpha and test-retest reliability coefficient for this scale in Iranian college students have been reported respectively 0.87 and 0.79 (Dehshiri, Golzari, Borjali, & Sohrabi, 2010).

Beck Depression Inventory-II (BDI-II): Containing 21 questions which covers depression symptoms based on cognitive theory, is widely used in clinical and research settings (Beck, Epstein, Brown, & Steer, 1988). The scores of this scale can differentiate amongst different depression severities which are categorized as follows: minimal;0 to 13, mild; 14 to 19, moderate, 20 to 28, and severe; 29 to 63. Psychometric properties of BDI-II in an Iranian college student sample proved to be sufficient; reported Cronbach's alpha was 0.91 and test-retest reliability was 0.96 (Rajabi & Karju Kasmai, 2013).

GAD-7: is a well-validated self-report questionnaire which is used as screening tool and severity measure of GAD symptoms during the last two weeks (Spitzer, Kroenke, Williams, & Löwe, 2006). Using a 4-point Likert,

the minimum and the maximum scores in this scale respectively are; 0 and 21. The cut-off points of this scale can distinguish between different severities of anxiety as listed below: 5; mild, 10; moderate and 15; severe. (Löwe et al., 2008). Persian version of GAD-7 has good psychometric features: the internal consistency was 0.81 and test-retest reliability was 0.79 (Nainian, Shoeiri, Sharifi, & Hadian, 2011).

Structured Clinical Interview for the DSM-5 (SCID): is a tool to enhance validity and reliability of clinical diagnosis. This interview for the first time was presented during 90's and it was based on DSM-III-R and the current version is updated for DSM-5. Reliability and validity of SCID in different studies have been reported between 0.81 to 0.84. This interview has clinical, research and clinical trial counterparts which in this study the research version has been used (First, 2014).

Neuropsychological Measures

Emotional Stroop Task: In a classic stroop, participants should respond to a conflictual stimulus; naming the color and ignoring the word as fast as possible (Stroop, 1935). In an emotional stroop task, words are affect-laden stimuli which capture the participant's attention so the more response latency to emotional words compared to neutral words, the more biased is the participant's attention (Williams, Mathews, & MacLeod, 1996). In order to collect a list of words which are emotionally-relevant to worry and GAD, we used Williams, Mathews and Hirsch(2014) method in which, first of all worry domains in GAD were considered. Tallis (Tallis, Eysenck, & Mathews, 1992) identified six worry topics: aimless future, incompetence at work, lack of confidence, socio-political, financial, relationships. As Williams et al (2014) suggest, two more aspects were included: social and physical because they are common topics in pathological worry and GAD.

Each domain has five subdomains which in total there are 40 subdomains. For each subdomain, two representative words were chosen by the authors then they were presented to 5 GAD participants to rate the valence of each word (positive or negative) between-3 to +3. Those words which had a score lesser than -1 were chosen to be in the final list. If two words of each subdomain met the criteria, the one which had a lesser score was chosen. Finally, 40 GAD-related words were included in the final corpus (table 1). For neutral words the same process was carried out and those which had a score equal or above 0, were chosen.

During the task performance, each trial began with a fixation point in the middle of the screen, lasting for 500 ms, then the words were presented for 2500 ms or until the participant gave a response. The task contained 100 trials and 40 trials of them were emotional. Before starting the experimental block and in order to learn the task requirements, participants completed a practice block with 28 trials. To assess the stroop performance, response accuracy (e.g., the number of correct responses) and interference scores (e.g., by subtracting reaction time of neutral words from that of emotional words) were calculated.

Emotional Stroop Train: Emotional stroop train is exactly as the same as emotional stroop task, except after each trial, the participants receive a feedback on their performance. If the response was given after 900 ms this message would appear on the screen; “too slow, respond faster!”, if the response was not given in the determined time period (e.g. 2500 ms), then this message would be presented; “You missed it. Pay attention!”, if the response was wrong, the name of the color was shown in the same color, for example; “Wrong! It was BLUE” and the word blue was printed in blue color, finally if the response was correct this message would appear on the

screen; “Correct. Great!”. Each feedback message was appeared on the screen for 1500 ms.

Go/No Go task: Participants completed the Go/No Go continuous performance task (e.g. Riccio, Reynolds, & Lowe, 2001) a well-stablished assessment of behavioral inhibition. This task has a good convergent validity with the Conners CPT-II (r=0.87; Schweiger, Abramovitch, Doniger, & Simon, 2007) and alternate forms test–retest reliability (Doniger, 2011). During the task, colored squares (green, blue, white or red) were shown sequentially but randomly to the participants and they had to respond via pressing space bar as quickly as possible to all squares except for the red one which was presented %35 of all the trials. To assess behavioral inhibition performance, omission errors, commission errors and reaction time were calculated.

Table 1 *List of threatening words used in emotional stroop and their domains*

Threat word	Domain
Separation	Relationships
Unattractive	Relationships
Rejected	Relationships
Disliked	Relationships
lonely	Relationships
Passive	Lack of confidence
Criticized	Lack of confidence
Clumsy	Lack of confidence
Stupid	Lack of confidence
Unsure	Lack of confidence
Useless	Aimless future
Distracted	Aimless future

Failure	Aimless future
Unemployed	Aimless future
Purposeless	Aimless future
Inadequate	Incompetence at work
Deadlines	Incompetence at work
Sluggish	Incompetence at work
Lazy	Incompetence at work
Feeble	Incompetence at work
Homeless	Financial
Bankrupt	Financial
indebted	Financial
Poverty	Financial
Inflation	Financial
Starvation	Socio-political
Violence	Socio-political
War	Socio-political
Terrorism	Socio-political
Sanction	Socio-political
Hospital	Physical
Cancer	Physical
Pain	Physical
Crippled	Physical
Murder	Physical
Miserable	Social
Despicable	Social
Valueless	Social
Abandoned	Social
Humiliated	Social

Procedure: After completing clinical and neuropsychological measures as pre-test, participants were equally and randomly assigned to 3 different groups; training, active control and control. Participants in training group received 16 sessions of training; using emotional stroop train in four weeks (four sessions per week), active control group like training group, received 16 sessions of practicing emotional stroop task (with no feedback) and participants in control group were in a waiting list. After finishing the intervention phase, post-test measures were completed.

Results

Descriptive Statistics

In order to analyze the data, first descriptive statistics indices (table 2) were calculated and then by meeting the assumptions of ANCOVA as an appropriate method, research hypotheses were tested.

training effect:

To investigate whether training sessions could enhance cognitive inhibition; first the score of interference was calculated for each participant and then conducting ANCOVA showed that changes in interference scores of emotional stroop was significant ($F_{(2, 41)} = 22.99$, $p < 0.001$) and by conducting Bonferoni post hoc analysis it was determined that only changes in intervention group compared to active control and control groups was significant ($p < 0.001$); which means that cognitive-affective training was effective on enhancing cognitive inhibition of emotional distractors. Comparing the number of error responses showed that there was no difference between three groups ($F_{(2, 41)} = 0.509$, $p = 605$).

severity of worry:

Results of ANCOVA on PSWQ scores showed that, after training sessions worry severity was reduced ($F(2,41) = 13.15$, $p < 0.001$) and by conducting

Bonferoni test, it was revealed that only changes in intervention group was significant ($p<0.001$); which means that cognitive-affective training was effective on worry reduction.

GAD symptoms severity:

Conducting ANCOVA on GAD-7 scores revealed that there was a significant change in symptoms of GAD ($F (2, 41) = 47.40$, $p<0.001$) and this effect was only observed in intervention group (Bonferoni post hoc analysis was significant, $p<0.001$). This finding shows that cognitive-affective training was effective on reducing symptoms of GAD.

Table 2 *Descriptive statistics of research variables*

Variable	*Control*				*Active control*				*Intervention*			
	Pre-test		*Post-test*		*Pre-test*		*Post-test*		*Pre-test*		*Post-test*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
PSWQ	*52.23*	*1.79*	*51.47*	*1.95*	*51.93*	*1.68*	*51.40*	*2.16*	*53.27*	*1.16*	*47.67*	*4.11*
GAD-7	*16.07*	*1.94*	*16.23*	*1.55*	*17.28*	*2.13*	*17.93*	*2.34*	*16.87*	*1.72*	*14.33*	*1.75*
Stroop interference (ms)	*87.40*	*6.68*	*86.90*	*5.95*	*85.31*	*5.22*	*85*	*5.46*	*84.30*	*4.89*	*72.20*	*9.96*
Stroop errors	*9.13*	*0.83*	*8.85*	*0.75*	*8.73*	*0.77*	*8.35*	*0.73*	*8.83*	*0.77*	*8.92*	*0.86*
Go/No Go reaction time (ms)	*340.67*	*3.30*	*340.05*	*3.35*	*342.40*	*3.43*	*341.80*	*3.59*	*343.47*	*4.27*	*344.13*	*4.92*
Go/No Go commission error	*9.20*	*1.32*	*9.33*	*0.81*	*8.27*	*1.28*	*8.87*	*0.91*	*9.83*	*1.35*	*9.40*	*0.91*

Go/No Go omission error	*5.80*	*1.37*	*5.61*	*0.98*	*5.82*	*1.42*	*5.73*	*1.03*	*5.71*	*1.38*	*5.82*	*1.65*

Transfer effect:

In order to investigate whether training effect of cognitive inhibition is transferable to behavioral inhibition, ANCOCA was carried out and the results showed that there was no significant difference between three groups in omission error ($F_{(2, 41)} = 0.329$, $p = 0.721$), commission error ($F_{(2, 41)} = 1.92$, $p = 0.159$) and reaction time ($F_{(2, 41)} = 0.752$, $p < 0.478$) of Go/No Go task, which indicates that training in cognitive inhibition did not transfer to behavioral inhibition.

Discussion and Conclusion

16 sessions of emotional stroop training by using real-time feedback, enhanced cognitive inhibition. Feedback informs people about their behavior and its outcome, if the outcome is not optimum, then by excreting more cognitive control they can change their response based on "speed-accuracy" balance (Kohls, Peltzer, Herpertz-Dahlmann, & Konrad, 2009; Mnih et al., 2015). According to the goal priority hypothesis, (Leotti & Wager, 2010; Liddle et al., 2009) feedback helps one to shift their priority to naming the color and ignoring the word. So more attentional resources are allocated to the color naming and less is remained for reading the word. Also based on reinforcement theory, feedback is a unit of reinforcement which can arouse people and elicit emotional states; and also by the interplay of approach-avoidance system of motivation and top-down control processes can regulate the forthcoming goal-directed response (Hare & Casey, 2005). Changed responses to the same stimuli is an

indicator of altered neural functions and structures through neuroplasticity (Pascual-Leone et al., 2005). Therefore, enhanced performance observed in the training group and no change in the active control group means that merely practicing is not helpful and in order to get the expected results, one should be informed about their responses and outcomes.

Performance in emotional Stroop is a marker of cognitive inhibition over threatening words (Williams et al., 1996); By ignoring the threatening words and naming the color, participants are trained to disregard the distractor and stay focused on the main task. Considering worry as a hot and threatening distractor (McKenna & Sharma, 1995), during the training sessions, participants learned how to gain more control of their worry process and ignore it in favor of the demanding current task. So this procedure explains how training sessions with emotional material was effective on reducing worry intrusions.

Pathological worry is associated with prolonged and negatively biased processing of threatening information which is made easy by deficiencies in cognitive control over limbic system activities (Iacoviello & Charney, 2015). Alvarez and Iacoviello (2015) suggest a neurobiological model for cognitive-affective deficiencies in mood and anxiety disorders and neurobehavioral interventions. In their model, perception of emotional stimuli is associated with increased activation of amygdala (AMY), thalamus (THAL) and hippocampus (HIPP) which in turn is accompanied with hyper activation in subgenual cingulate cortex (SGC). Hyper activation of SGC is accompanied with increased activity of medial PFC (mPFC). These activities are projected to other prefrontal cortex (PFC) regions. Simultaneously, regions in PFC which implement inhibitory control over limbic system and are known as critical regions for cognitive control and emotion regulation (e.g. dLPFC, vLPFC and the dorsal anterior

cingulate cortex (dACC)) are hypoactive. Functional connectivity between the PFC regions and AMY, HIPP and THAL seems weakened which means cognitive control over these regions is poor. In sum, reduced activation in dLPFC and vLPFC which are accompanied with perseverative thinking (e.g. worry and rumination) are candidates of CCT. Emotional material in stroop activates limbic system and gaining control over these processes strengthens dLPFC, vLPFC and the neural path between PFC and limbic regions, which result in more control over threatening content of worry and reduces its intrusions. Significant reduction in worry was associated with decrease in GAD symptoms and this shows the major role worry plays in severity of GAD (Hallion et al., 2017; Hirsch, Mathews, Lequertier, Perman, & Hayes, 2013). As it has been assumed, worry is the central process in GAD and future interventions should focus on worry reduction as a critical mechanism in treatment of GAD.

On the other hand, based on avoidance theory (Borkovec, 1994) worry is an avoidant behavior which prevents more anxious arousal and stops activation of fear structure. Emotional processing theory (Foa, Huppert, & Cahill, 2006) assumes that frequent and prolonged exposure to threatening stimuli can activate fear structure which in turn reduces anxiety and worry. An explanation of reduction in worry intrusions might be long and frequent exposure to negative and threatening stimuli during training sessions.

Results showed that training effects of cognitive inhibition is not transferable to behavioral inhibition. One reason might be that these two subtypes of inhibition have different neural substrates which explains why enhanced performance on cognitive inhibition did not transfer to behavioral inhibition. While the left anterior insula is harmonic in all inhibitory aspects, regions like dACC, dorsolateral prefrontal cortex and parietal regions are active in cognitive inhibition, and in behavioral inhibition;

dACC, supplementary motor area, dorsal and lateral prefrontal cortex, midbrain regions, parietal cortex and basal ganglia are engaged (Hung, Gaillard, Yarmak, & Arsalidou, 2018) On the other hand, findings of a meta-analysis of imaging studies suggested that each inhibition task engages several different brain regions as well as shared regions. During a Go/No Go task right dLPFC, right IFG and insula are prominently active and in a stroop task regions like left dLPFC, insula and medial frontal cortex including ACC are engaged (Nee, Wager, & Jonides, 2007) which can explain why training in cognitive inhibition did not transfer to behavioral inhibition.

Another explanation for this finding might be the age of participants. WANG, LI, GAI, & CAO, (2020) found that near-transfer effect from Stop-Signal task to Go/No Go task is evident in adults and adolescents but far-transfer effect to Stroop task just observed in adolescents; which means that in the developing brain, CCT can enhance other cognitive faculties and that is because of more potential of neuroplasticity in a juvenile brain. So in the current study no significant transfer effect on behavioral inhibition in adults might be due to limited capacity of neuroplasticity in adult central nervous system.

In this study we used emotional stimuli to assess and train participants but as Hirsch and Mathews (2009) in their model suggested, inhibition deficiency might be present in the baseline. So we suggest that in the future research, applying a classic stroop with neutral stimuli to train GAD people might be insightful. In order to enhance cognitive control and specially inhibition, using brain stimulation interventions may be a promising path to understand the role of cognitive control in GAD etiology and treatment. Enhanced performance on the stroop task is a behavioral index of cognitive control, and decreased worry and GAD symptoms are based on personal

report, therefore we suggest using methods like quantitative electroencephalogram (QEEG) and functional magnetic resonance imaging (fMRI) to see how those brain regions which are engaged in inhibitory control have changed.

In summary, this study emphasizes on the importance of cognitive control, especially inhibiting emotional stimuli in the maintenance of worry and GAD symptoms. Getting control over threatening distractors can help people with GAD to ignore worry and focus on their intended task and by doing so the severity of their symptoms could be reduced. So training people in cognitive control seems to be a promising therapeutic path to enhance psychological well-being.

Conflict of interest

The Authors declare that there is no conflict of interest.

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