Modeling of the effect of coping with stress styles on generalized anxiety disorder by brain's executive functions

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Submitted: 10 July 2015
Accepted: 29 October 2015

Int J Behav Sci. 2015; 10(1): 42-48

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Abstract

Introduction: The purpose of this study was to investigate the executive functions (EFs) as the mediators between coping with stress styles and generalized anxiety disorder (GAD). Two styles of coping with stress (problem focused coping (PFC) and emotion focused coping (EFC)) and eight executive functions (inhibition, flexibility, focusing, working memory, decision making, reasoning, problem solving, and meta-cognition) were examined during this study.
Method: This research was administrated in 250 GAD clinical patients that were selected as available samples. SCID interview and DASS-21 applied to diagnose the moderate level of GAD as well as to quantify the data. The N-Back, Strop, Tower of London and the other tests were the software tests which measured the executive functions.
Results: Results showed that the model of coping with stress styles with eight EF mediators to GAD contains the goodness of fit. Both inhibition and flexibility were the mediators that affected GAD. The meta-cognition was an EF that was affected from both the inhibition and working memory.
Conclusion: Findings generally showed that PFC is not applied by GAD patients and do not affect GAD except by meta-cognition. This is while EFC affects it by inhibition, flexibility, working memory and decision making.

Keywords: Coping With Stress Styles, Executive Functions, Flexibility, Generalized Anxiety Disorder, Inhibition

Introduction

Prefrontal cortex is the largest part of the brain's cortex which involves 28 percent of the cortex that is connected with motor processing and higher mental processing [1]. This part involves the complex movement controls and the assignments that are required to the information integrity over time [2]. *Baddely* showed that the prefrontal cortex forms the complex cognitive functions through the collaboration with temporal and parietal cortexes [3]. For example, one should note the role of parietal dorso-prefrontal system which is created by the parietal-prefrontal collaboration and leads to the working memory formation. The dorso-lateral part of the prefrontal cortex is the origin of the brain EFs. EFs are the wide range of the superior cognitive processing that organize the behavioral responses through inhibition, flexibility, focusing, working memory, decision making, reasoning, problem solving, and meta-cognition. The outcomes of their performance are cognitive, behavioral, and emotional management [4, 5]. Besides, executive functions manage complex cognitive processing that result in goal-oriented behaviors. Barkely notes that the main task of EFs are supervising and managing the cognitive processes [6]. He emphasizes that the EFs interact with each other and the outcomes of these interactions are the formation of the complex system of regulation and management processes that act as an integrated model. Therefore, impairment in a part of the system may impact and disrupt the other parts of the model.

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Lazarus and *Folkman* explain the coping styles as cognitive-behavioral changing processes which are applied by the person to fight, avoid, and reduce or control the stress factors that have three major functions: firstly, providing the desired information about the situation; secondly, information processing and thirdly, keeping freedom, independence and using skills [7]. They consider coping styles as a formal, complex and acquisitive processes that are totally divided in two categories:

1. Problem focused coping (PFC) involves logical responses to change the stressor origin. This coping style focuses on threat source and aims at cognitive evaluation, rational analysis; and identifying the problem solutions.
2. Emotion focused coping (EFC) involves coping with emotions due to threat sources that eventually leads to reduce or manage the distress [7]. It includes avoidance, escape, aggression, dependence to others, etc. Generally, PFC is activated in controllable situations conversely EFC is activated in uncontrollable situations; nevertheless, the influx of psychological stressors arouse both styles.

The main features of GAD are anxiety plus excessive worries (anticipation combined with concern) about events or activities that happen at least for six months. The intensity, duration and frequency of the anxiety symptoms are much more extreme than the person's toleration to encounter with a scary event [8]. Three of the six main symptoms of GAD are enough to diagnose GAD: restlessness and worry, tiredness, focusing on difficulties, irritability, muscle tension, and sleep difficulties [8].

How to express and cope with stress relates to dorso-lateral cortex's destruction [9]. Some especially severe stressors create negative feedbacks on cognitive functions such as working memory that is one of the dorso-lateral cortex functions. Coping with stress styles directly trace cognitive functions to encounter with life situations and this will consequently lead to end or persistence the situational stressors [10]. Strong evidence represents that there are positive and significant correlations between cognitive insufficiency and coping with stress styles as any executive dysfunction may leave destructive and disruptive impacts on choosing the adaptation strategies in stressful situations [11]. These insufficiencies prevent people to search more information about problems and to plan for problem solving and consequently, they over apply emotional or avoidance coping styles [12, 13]. When the attention is attracted by internal or external events, the coping strategies are affected and obviously working memory processing is disrupted while coping with stress. The powerful working memory makes the access of goals possible [14] and increases the attentional control [15]. These findings represent that the working memory is very necessary to set thoughts in coping with stress that strongly needs attention.

Anxious people learn to avoid decisions that have immediate benefits [16]. Their emotional regulation which is likely due to long term visceral responses is weak in decision making tasks [17]. However, all the anxiety groups suffer from decision making dysfunction [18]. Results of Russo, Mahon and Burdick showed that anxiety is significantly correlated with problem solving, decision making and selective attention [19]. This is while, training the decision making and problem solving strategies could positively affect these people's helplessness [20]. Patients are weak in functioning and choose less and safer benefits with low risk and variation [21]. Moreover, they choose the situations with less punishment and possibilities.

Although many researches emphasize the correlation between coping with stress styles and GAD and the significant correlation between EFs and GAD, there are some questions such as, what makes some people cope with stress better than others in the same situations? Why they are able to use problem focused coping styles in threat situations while others act very emotionally in safer situations? It is known that the cognitive and executive functions interact with coping with stress styles [14, 15], [22, 23] and the people with strong executive functions effectively interact with their environments according to information processing theories [5]. So it is important to investigate the role of EFs and to find how they mediate the connection between coping with stress and mental disorders such as GAD. Are the EFs components equally shared in GAD? Or would all of them be inefficient together? The main target of this research was to investigate the effect of coping with stress styles and EFs

in GAD and to provide a significant model to determine the contribution of each component of EFs in GAD. However the long-term and practical targets were to develop the existing knowledge about EFs in anxiety and to take an important step in GAD's differential diagnosis and etiology that lead to providing an effective therapeutic protocol for anxiety treatments. The proposed model of this research which is provided below represents the direct and indirect effects produced by the coping styles and EF mediators on GAD plus the inhibition and working memory impacts on other EFs:

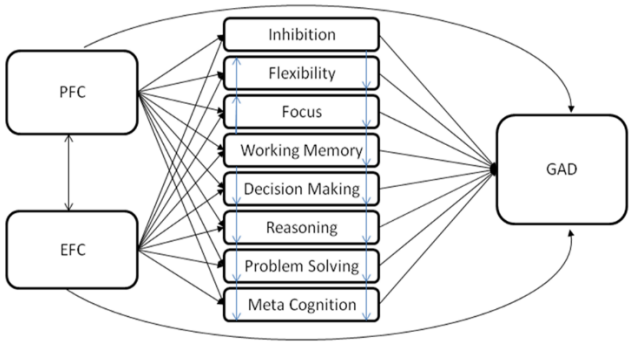

Figure 1. The conceptual framework of coping with stress styles, EF mediators, and GAD. GAD = Generalized Anxiety Disorder; PFC = Problem Focused Coping; EFC = Emotion Focused Coping.

Method

The research participants consisted of 250 GAD patients from the Tehran mental health clinics and the hospitals that were selected by convince sampling method. The participants' entry criteria were GAD clinical diagnosis without co-morbid depression disorders. These participants were between 20-40 years old (85 men and 115 women), an average number of 27.5 and 33 percent were holding their high school diploma, 36 percent a college degree and 24 percent a Bachelor degree. Since there are no differences in clinical symptoms between men and women [8], the gender was not a control variable in this study. Any psychological or therapeutic treatment was controlled before the assessment for the effects of these interventions could affect the pure data.

The predictor variables were coping with stress styles (EFC and PFC) and the mediators were eight EFs (inhibition, cognitive flexibility, focusing, working memory, decision making, reasoning, problem solving, and meta-cognition) between coping styles and GAD.

GAD diagnosis was performed by semi-structured inventory (SCID-I); however, to make the GAD data quantitative, we used Depression, Anxiety and stress scale-21 (DASS-21) [24]. Working conditions and control questionnaire (WOCCQ) with 65 items was applied in order to measure coping with stress styles [7]. Wason selection task is a test to measure conditional reasoning [25]. The conditional reasoning is characterized by "if "p" then "q" or if "not p" then "not q"" 12 questions that assesses the capability of this kind of reasoning. The N-Back scale [26] is an appropriate tool to measure focusing, working memory and decision making. This test involves three levels of measuring (1-Back, 2-Back and 3-Back) using the numbers as stimulus that run respectively. There were 120 trials in every level of N-Back which were presented in 0.5 second on the monitor. Participants should select the correct or incorrect button immediately. The reaction time, correct responses and incorrect responses are the criteria to evaluate the focusing, working memory and decision making. The Strop test [27] is a test for accessing the cognitive inhibition and flexibility. The stimulus was the inconsistently colored words that were presented in 48 trials (each one were presented in 0.5 second) and measures this inconsistency interference with the responses. The mean scores of the responses delay and interference responses are the criteria to measure the flexibility and inhibition. Furthermore, the Tower of London test [28] applied for measuring the problem solving capability. Participants should solve 12 questions by using three rings that have to be placed in three unequal columns. The correct responses were the criteria to measure this EF. These three tools (Strop Test, N-Back and Tower of London Test) were developed as software and operated on five laptops that ran on the Microsoft Windows 7 home premium version 6.1.7600.

We used *Behavior Rating Inventory of Executive Function–Adult Version (*BRIEF-A) for assessing the meta-cognition [29]. This involves five subscales including initiate, organization, planning, working memory and self-regulatory subscales which were implemented in this study to measure the meta-cognition. In order to make the test reliable, the researchers obtained the Cronbach's alpha coefficients for all those which were 0.82 to 0.85 and there were significant values in evaluating the behavioral science test reliabilities. The criterion validity of DASS-21 with correlation of Beck anxiety inventory (BAI) was 0.81 [30]. *Aghauseffi* reported that the constructive validity of the WOCQ inventory was acceptable [31]. The criterion validity of the Tower of London with a correlation of Porteus mazes was 0.44 [32]. Furthermore, the constructive validities of Strop and N-Back tests were significant [33, 34]. All tests were counter balanced in order to reduce the test effects. Moreover, it was not possible to present the tests in two or more sessions and control the tiredness effect as patients would meet their psychologists at the first session and the assessment process was in conflict with any intervention. Therefore to investigate the size of this effect we polled them. Among the participants, 50 percent were not tired and had enjoyed it, 28 percent were not tired, 17 percent were indifferent and 4 percent were tired to the extent that they wouldn't have enough energy to start the first treatment session. The data of this group (10 people) were excluded.

Results

The results represent the correlation between the predictor and mediator variables and GAD as well as the correlation between predictors and mediators with each other. Table 1 displays the descriptive statistics and correlation matrix of the predictor and criterion variables:

Table 1. Descriptive statistics and correlation matrix of coping styles, EFs, and GAD

Variables	1	2	3	4	5	6	7	8	9	10	11
1. GAD	1										
2. PFC	-.18**	1									
3. EFC	.52**	-.08**	1								
4. Inhibition	-.45**	-.10	-.49**	1							
5. Flexibility	-.33**	-.01	-.29**	-.28**	1						
6. Focus	-.09	-.05	-.01	-.03	-.04	1					
7. Working memory	-.46**	-.16**	-.51**	-.44**	.18**	.02	1				
8. Decision making	-.51**	.06	-.42**	.34**	.16**	.10	.41**	1			
9. Reasoning	.00	-.36**	-.03	-.02	-.08	.02	.01	-.04	1		
10. Problem solving	-.06	-.05	.00	.00	.00	.07	-.08	-.05	.05	1	
11. Meta-cognition	-.26**	-.13**	-.32**	.21**	-.28**	.39**	.37**	.43**	.15**	.06	1
Mean	11.47	34.58	36.85	8.43	86.85	40.25	46.50	58.32	5.35	26.55	4.36
STD	1.01	12.24	12.00	3.18	56.85	20.24	22.46	25.39	3.34	6.14	3.14

**p< 0.01

Note. STD = Standard Deviation.

We used the structural equation modeling (SEM) and maximum likelihood methods by Lisrel software to investigate the fitness of the research model. All of the SEM assumptions were regarded in this research (e.g. data normality, interval scale, the absence of Multicollinearity between variables…., etc). Firstly, the univariate normality and then the multivariate normality were investigated. Table 3 demonstrates the effect coefficients and the tolerated values of all the model effects and paths:

Table 2. Standard effect coefficients and tolerate values

Effect	Est.	T value	Effect	Est.	T value
PFC → Inhibition	0.06	1.53	EFC → Inhibition	-0.56	-14.61*
PFC → Flexibility	-0.02	-0.45	EFC → Flexibility	-0.21	-3.09*
PFC → Focus	-0.06	-1.26	EFC → Focus	-0.55	-8.60*
PFC → Work M.	0.12	3.17*	EFC → Work M.	-0.53	-8.14*
PFC → Decision	-0.03	-0.68	EFC → Decision	-0.11	-1.55
PFC → Reasoning	0.46	10.34*	EFC → Reasoning	-0.02	-0.28
PFC → Problem S.	0.09	1.89*	EFC → Problem S.	-0.00	-0.03
PFC → Meta-Cog.	0.10	2.11*	EFC → Meta-Cog.	-0.25	-4.30*
PFC → GAD	-0.10	-2.46*	EFC → GAD	0.28	3.06*
Inhibition → Flexibility	-0.85	-16.17*	Work M. → Flexibility	0.23	3.96*
Inhibition → Focus	0.08	1.43	Work M. → Focus	0.11	1.54
Inhibition → Work M.	0.25	5.12*	Work M. → Decision	0.36	5.89*
Inhibition → Decision	0.07	1.34	Work M. → Reasoning	0.08	1.48
Inhibition → Reasoning	0.03	0.48	Work M. → Problem S.	0.18	2.57*
Inhibition → Problem S.	0.03	0.52	Work M. → Meta-Cog.	0.35	5.47*
Inhibition → Meta-Cog.	0.12	2.28*	Decision → GAD	-0.20	-4.91*
Inhibition → GAD	-0.89	-11.17*	Reasoning → GAD	-0.02	-0.56
Flexibility → GAD	-0.82	-13.52*	Problem S. → GAD	-0.05	-0.92
Focus → GAD	-0.03	-0.91	Meta-Cog. → GAD	-0.32	-8.21*
Work M. → GAD	-0.19	-3.08*	EFC → Inhibition → Flexibility →	-0.40	-8.81*
EFC → Inhibition → GAD	0.50	8.87*	EFC → Inhibition → Work. M. →	0.02	0.42
EFC → Flexibility → GAD	0.17	3.03*	EFC → Inhibition → Meta-Cog. →	0.02	0.44
EFC → work M. → GAD	0.10	1.99*	EFC → Work. M. → Flexibility →	0.10	1.98*
EFC → Decision → GAD	0.02	0.56	EFC → Work. M. → Decision →	0.04	1.21
PFC → Meta-Cog. → GAD	0.03	0.86	EFC → Work. M. → Meta-Cog. →	0.06	1.87

* T value > 1.96

Note. Est. = Estimate; Work M. = Working memory; Decision = Decision making; Problem S. = Problem solving; Meta-Cog. = Meta-cognition;

According to Table 2, the significant effects are shown higher than 1.96 T values. The significant paths from PFC to EFs are reasoning and meta-cognition as well as from EFC to EFs are inhibition, flexibility, working memory and decision making.

Table 3. Coping with Stress, EFs and GAD models' Coefficient Fitness indexes

Chi2:df	RMSEA	CFI	NFI	NNFI	RMR	IFI	GFI	P
(154.44 : 78) = 1.98	0.05	0.90	0.91	0.91	0.05	0.90	0.90	0.65

Note. Chi2 = Chi Square; DF = Degree of Freedom; RSMA = Root Mean Square Error of Approximation; CFI = Comparative Fit Index; NFI = Normed Fit Index; NNFI = Non-Normed Fit Index; RMR = Root Mean Square Residual; IFI = Incremental Fit Index; GFI = Goodness of Fit Index; P = P-Value.

So this theorical model is approved. To evaluate the new standard effect coefficients and tolerate values, the non-significant effects were excluded. The developed model by Lisrel software with a standard effect on coefficients is presented below:

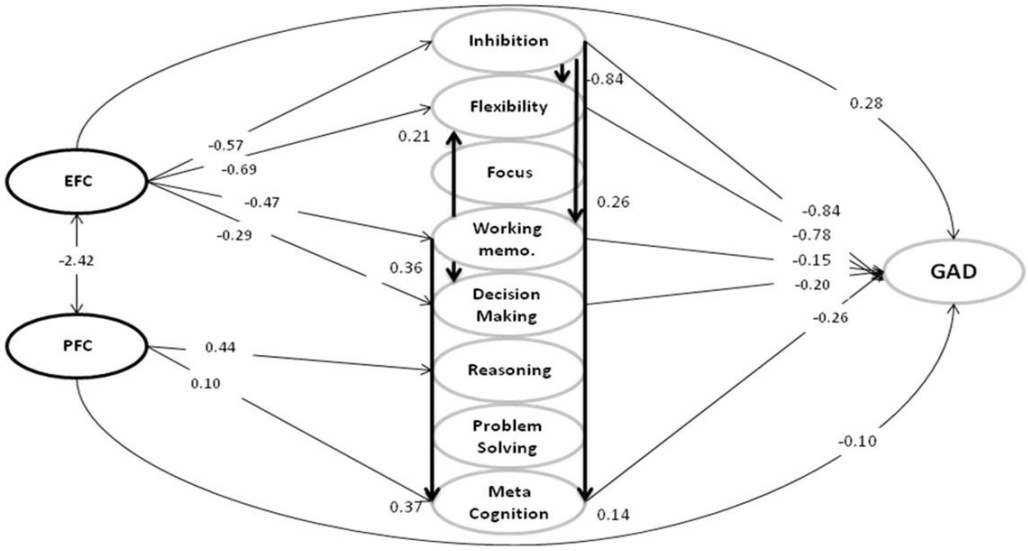

Figure 2. Model of coping with stress, EFs and GAD associate with direct and indirect effects

Discussion

Our study expanded the results of previous studies about deficits in coping styles and executive functions in GAD [12, 13]. We predicted direct effects of coping styles to GAD. Moreover, we assumed that GAD may receive some indirect effects from coping styles by EFs mediators. The results in the eight EF domains (inhibition, flexibility, focusing, working memory, decision making, reasoning, problem solving and meta-cognition) confirm the hypothesis that GAD patients are indirectly affected by coping styles. In this impact model, the role of emotion focused style is more serious than the problem focused style. These finding are in accordance with the previous findings [22]. The model represents the contribution of the predictor and the mediator variables in determining the direct and indirect effects on GAD. It could be inferred from the model that the most powerful and negative effect is specified from EFC to inhibition to GAD which significantly supports Barkley's suggestion i.e., the inhibition is the most important EF which controls the other EFs activity [5]. We found that the inhibition impact on the other EFs are significant merely on flexibility, working memory and meta-cognition but the effect on flexibility is significantly high and negative. This means that the brain's cognitive inhibition limited the flexibility function when dealing with difficult assignments. Flexibility helps both to easily alter the attention route and to learn new subjects. It seems that the inhibition tasks are in conflict with the flexibility functions. These findings are in line with the previous findings [16], (35], which show that the EFs are essential to control stress. The results postulate the most effective EFs are cognitive inhibition and flexibility that negatively shape the bond between EFC and GAD. Accordingly, the inhibition and flexibility are the proprietary EFs of GAD. It means EFC could predict deficits on cognitive inhibition and flexibility processing and eventually, leads to GAD.

The effects of the working memory on the EFs are positive and only significant for flexibility, decision making and meta-cognition. Consequently, both inhibition and working memory affect the flexibility and meta-cognition. In fact, they represent that the role of these two variables are rather similar to manage and control the other EFs especially in meta-cognition. Many recent studies have shown that the working memory has an undeniable role in anxiety [36, 37, 3, 38] and our research represents that this role passes through the EFC to GAD. EFC indirectly and negatively affects inhibition, working memory, flexibility, and decision making and then this negative path leads to anxiety as well as EFC which positively and directly affects GAD. This means that the coping styles of those who suffer from avoidance, flight, aggressiveness, etc., will increase their anxiety symptoms.

Similarly, PFC predicts GAD by affecting on meta-

cognition as well as negatively and directly affecting on GAD. Nevertheless this impact is low compared to the other EFs impact on GAD. Obviously the people with problem solving capabilities may control stress levels and keep their mental health. The mediator effecting focusing, reasoning and problem solving were not significant in the model. Maybe the effects of these EFs are not important in GAD or their effects overlapped the other EFs especially between problem solving, reasoning and problem focused coping style.

Generally, this study should be interpreted in the context of considerable diversity of neuropsychological test methods, large sample sizes (that significantly increased the statistical power), individual and experimental measuring methods and clinical interviews that will accordingly be led to the valuable information about EFs and GAD. In return, confrontation with technological and modality limitation is one of the limitations of every studies. Firstly, it is important to notice the use of FMRI and PET scans to study on brain prefrontal reactions when participants get involved with the tests. This is while these methods were absent in this study due to that lack of laboratory equipment. Secondly, we should consider the comorbid disorders with GAD while there were just depressive disorders which were excluded from the sample size. The personality disorders that may affect the study findings were not excluded from this research. Thirdly, the participants' intelligence has to be controlled, due to the fact that this variable might affect the executive functioning in people. These limitations should be considered in future researches.

Conclusion

Our research suggests that mediating the executive functions leads to indirect effects from coping styles to GAD. EFC is a more considerable coping style compared to PFC and manipulates the inhibition and flexibility functions which are two proprietary executive functions in GAD and significantly predict the GAD symptoms. Particularly, inhibition and working memory similarly affect the other EFs as well as the inhibition role is more significant than working memory in these criteria. For future studies, it is suggested to study about the role and efficiency of inhibition and flexibility in etiology and in the treatment of anxiety disorders.

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