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Executive function and self-regulation mediate dispositional mindfulness and well-being

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ABSTRACT

Research indicates that mindfulness is linked to higher-order neurocognitive control processes, and the associated executive functions and self-regulation capacities needed in daily life. The current study examines the roles of executive function and self-regulation in the link between dispositional mindfulness and well-being using a multi-method, two-phase longitudinal design. Two multiple mediator models were tested in a sample of 77 undergraduate students. Self-regulation independently mediated the relationship between mindfulness and positive affect; however, both executive function and self-regulation independently mediated the relationship between mindfulness and negative affect. The mindfulness facets of acting with awareness and non-judgment were most strongly related to executive function and well-being outcomes, while describing and acting with awareness were most strongly related to self-regulation. Performance-based neurocognitive control was related to self-regulation and positive affect, and a test of inhibition/shifting was related to executive function in daily life. Thus, students who are more dispositionally mindful than their peers tend to be non-judgmental and act with awareness, rather than on automatic pilot, which may engage executive functions and self-regulation.

1. Introduction

Recent evidence suggests the involvement of higher-order neurocognitive functions (i.e., processes supported by the prefrontal cortex and associated brain regions, related to the self-regulation of behavior, cognition, and emotion) in explaining the beneficial effects of mindfulness (Lyvers, Makin, Toms, Thorberg, & Samios, 2014). Although mindfulness research has markedly grown in the past two decades (i.e., five empirical publications in 1990 vs. 397 in 2011; Williams & Kabat-Zinn, 2011), research examining underlying neurocognitive mechanisms and associated behaviors may further our understanding of how this quality of attention fosters and maintains psychological well-being.

1.1. Effects of mindfulness on well-being and neurocognitive processes

Mindfulness is consistently associated with reducing psychological distress and enhancing well-being when incorporated into interventions for psychological and medical complaints, including but not limited to depression, anxiety, chronic health problems, and brain injuries (Bédard et al., 2012; Kabat-Zinn, 1994; Keng, Smoski, & Robins, 2011). Moreover, when mindfulness techniques are taught to students, they report improvements in mood, sleep, and stress (Caldwell, Harrison, Adams, Quin, & Greeson, 2010).

Research indicates that mindfulness is associated with enhanced neurocognitive functions related to self-regulation, such as executive functions, attention, and memory (see Chiesa, Calati, & Serretti, 2011 for a review). Brief training (e.g., four sessions of formal mindfulness practices) improves executive function, such as working memory and verbal fluency (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), and enhances self-regulation in students (Short, Mazmanian, Ozen, & Bédard, 2015). The fact that mindfulness training improves both psychological well-being and neurocognitive functions suggests that neurocognitive processes may underlie, or at least be associated with, the link between mindfulness and well-being.

Beyond the benefits of mindfulness training, individuals with elevated levels of dispositional mindfulness are described as better attuned to the present moment and more capable of regulating their emotions and behaviors (Anicha, Ode, Moeller, & Robinson, 2012). Baer, Smith, Hopkins, Krietemeyer, and Toney (2006) empirically validated a five facet model of mindfulness, consisting of: (1) observing internal (e.g., sensations, thoughts, emotions) and external stimuli (e.g., sights, sounds, smells), (2) objectively describing and labeling internal and external stimuli, (3) acting with awareness, rather than acting mechanically with attention focused elsewhere, (4) non-judging of inner experiences, and (5) non-reactivity to inner experiences. Dispositional levels of these facets, particularly acting with awareness, non-judging of inner experience, and non-reactivity to inner experience, are associated with

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enhanced well-being (e.g., positive affect) and decreased psychological distress (e.g., negative affect, depression, anxiety, and stress) among students (Short & Mazmanian, 2013). Moreover, research investigating dispositional mindfulness in relation to neurocognitive functions indicates that individuals high in observing demonstrate enhanced visual working memory, while individuals high in non-reactivity exhibit greater cognitive flexibility, as assessed by the Stroop Task (Anicha et al., 2012). Based on these results, dispositional mindfulness is posited as a potential protective factor against developing various forms of psychological distress and a factor that promotes enhanced neurocognitive functioning.

1.2. Potential roles of executive function and self-regulation

Theory and research support the use of both performance and self-report measures in investigations examining executive function and goal-directed behavior. Performance measures involve standardized procedures that commonly assess accuracy or response time in controlled laboratory settings (e.g., limiting the influence of environmental distractors; Toplak, West, & Stanovich, 2013). Alternatively, self-report measures aim to increase ecological validity by assessing abilities in carrying out behaviors in natural settings (e.g., with the potential influence of environmental distractors). While these instruments appear to assess similar domains, they may in fact assess different abilities. Toplak et al. (2013) examined the association between performance and rating measures of executive functions in 20 studies. Findings revealed a modest correlation between the instruments (i.e., median $r = .19$), suggesting that these two measurement modalities may tap into "different levels of cognition". That is, performance measures may capture efficiency in neurocognitive abilities, while rating scales capture success in goal pursuit (Toplak et al., 2013).

1.2.1. Performance-based neurocognitive control processes

Various terms are used to describe the neurocognitive processes that relate to the prefrontal cortex, including executive functions, neurocognitive control, executive control, attentional control, and cognitive flexibility. In this paper, neurocognitive control is used to describe performance-based neurocognitive functions in controlled settings (e.g., switching between mental sets), as distinct from self-reported outcomes in daily living (e.g., staying on task to finish an assignment). Models conceptualizing neurocognitive control commonly focus on working memory operations such as monitoring and updating information, inhibition of dominant impulses, and shifting between multiple mental sets (Hofmann, Schmeichel, & Baddeley, 2012; Miyake et al., 2000).

1.2.2. Self-reported executive functions and self-regulation in daily life

Research suggests that neurocognitive control promotes the capacity for effective self-regulation and executive function in real-life contexts (Hofmann et al., 2012). Executive functions allow individuals to adapt to changing situations, break out of unhelpful habits, and consider alternative solutions to problems (Barkley, 2001). These functions may be conceptualized as: (1) behavioral regulation, such as inhibiting impulsive responses, shifting or adjusting to changes in routine or task demands, and regulating emotional responses, or (2) metacognition, such as organizing problem solving approaches, initiating activities, and sustaining information in memory (Roth, Isquith, & Gioia, 2005). Lower levels of behavioral regulation and metacognition are related to greater depressive symptoms, interpersonal problems, and academic difficulties in undergraduate students (Wingo, Kalkut, Tuminello, Asconape, & Han, 2013).

Although there are overlapping conceptual boundaries between executive function and self-regulation, the construct of self-regulation involves a more narrowly defined set of skills. Self-regulation underlies self-governing behavior change and may be reduced to three core facets: self-monitoring, self-evaluation, self-reinforcement (Bandura, 1991; Mezo, 2009). For example, an individual who wishes to decrease his or her "road rage" may self-monitor behaviors and emotions while driving, self-evaluate these behaviors and emotions to his or her internalized standard, and self-reinforce through self-praise when they do not impulsively engage in anger with other drivers. Thus, self-regulation relies on an ability to be aware of and identify one's emotions and behavior.

A relevant question to the study of executive function and self-regulation is how do individuals know when to initiate self-regulation? Teper, Segal, and Inzlicht (2013) proposed a model that conceptualized how mindfulness may enhance executive functions and self-regulation. The present-moment awareness and non-judgmental acceptance cultivated by mindfulness fosters openness and sensitivity to subtle changes in affect, which may activate self-regulation (Teper et al., 2013). Moreover, executive functions are effortful processes that are active when "the novelty and/or complexity of a situation precludes an automatic, routine response" (Suchy, 2009, p. 106). A recent study indicates that dispositional mindfulness is negatively related to self-report measures of frontal lobe dysfunction and positively related to emotional self-regulation (Lyvers et al., 2014). In sum, mindfulness may activate executive functions and the ability to self-regulate, which may explain why dispositional mindfulness is related to enhanced well-being and lower intensities of psychological distress.

1.3. Current investigation

Existing studies examining mindfulness and neurocognitive functions commonly use mono-method designs that rely on participants' self-reports (e.g., Lyvers et al., 2014). Including both self-reports and performance tasks help clarify whether these instruments tap into different levels of cognition. Thus, the current study used a multi-method, two-phase longitudinal design, and aimed to examine the relationships among the five facets of mindfulness, neurocognitive control, executive functions, self-regulation, and different aspects of well-being. General levels of positive and negative affect were included as primary outcomes, and specific measures of psychological distress (i.e., depression, anxiety, and stress) were included as secondary outcomes.

It was hypothesized that self-report and performance measures would differ in terms of the strength of their relationships with mindfulness and well-being. Additionally, based on prior research examining the five facets of mindfulness (Short & Mazmanian, 2013), it was expected that acting with awareness, non-judging of inner experience, and non-reactivity to inner experience would independently contribute to the well-being outcomes. Lastly, two multiple mediator models were tested and it was expected that higher levels of executive function and self-regulation help explain why dispositional mindfulness predicts greater well-being (i.e., higher positive affect and lower negative affect).

2. Method

2.1. Participants

Participants were students recruited from undergraduate courses at a Canadian university. Exclusion criteria were self-reported history of a neurological condition or head injury that involved a loss of consciousness for more than 30 min.[1] A total of 91 participants completed Phase 1, and 77 of those participants met inclusion criteria and completed Phase 2 (i.e., 85% completion rate). The mean age of the final sample was 21.23 ($SD = 5.98$). The sample was predominately White (87.0%), female (71.4%), and either in a committed relationship (57.1%) or single (42.9%). Most participants were full-time students (93.5%), with 63.6%

[1] This timeframe is from the DSM-5 (American Psychiatric Association, 2013) criteria for mild traumatic brain injury.

of students in their first year of study, 11.7% in second year, 18.2% in third year, and 6.5% in fourth year.

2.2. Self-report questionnaires

Given that mindfulness is conceptualized as a disposition in this study, a long-term time frame (i.e., "generally, as in the past several years") was used for this measure. Consistent with the short-term longitudinal nature of the study, a "past few weeks" time frame was used for the other self-report questionnaires. Higher scores indicate higher levels of the construct for all instruments, with the exception of the executive function. Higher scores on this measure indicate higher levels of executive dysfunction.

2.2.1. Five Factor Mindfulness Questionnaire (FFMQ; Baer et al., 2006)

The FFMQ is a 39-item multifaceted measure of mindfulness. It is composed of five subscales including observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. Participants rated their responses on a five-point Likert-type scale, ranging from one (never true) to five (always true). In this study, Cronbach's alpha was .86 for the total score, and .83, .90, .84, .93, .74 for the observe, describe, act with awareness, non-judgment, and non-reactivity subscales, respectively.

2.2.2. Positive Affect and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988)

The PANAS is a 20-item scale that was developed to measure positive and negative affect. Items were administered using a five-point Likert-type scale ranging from one (very slightly or not at all) to five (extremely). In this study, Cronbach's alphas for positive affect and negative affect were .92 and .91, respectively.

2.2.3. Depression Anxiety and Stress Scales-21 (DASS-21; Antony, Bieling, Cox, Enns, & Swinson, 1998)

The DASS-21 is a 21-item measure that yields three factors: depression, anxiety, and stress. Participants responded on a four-point Likert-type scale (0 = did not apply to me at all, 3 = applied to me very much). For this study, Cronbach's alphas for the depression, anxiety, and stress scales were .91, .85, and 84, respectively.

2.2.4. Self-Control Self-Management Scale (SCMS; Mezo, 2009)

The SCMS is a 16-item measure of self-regulation, comprised of three subscales: self-monitoring, self-evaluation, and self-reinforcement. Participants responded on a six-point Likert-type scale, ranging from zero (very undescriptive of me) to five (very descriptive of me). Cronbach's alpha for the total score was .90 for this study.

2.2.5. Behavior Rating Inventory of Executive Function — Adult (BRIEF; Roth et al., 2005)

The BRIEF was designed as an ecologically valid measure of self-reported executive function deficits in daily life. The measure consists of 75 items, and includes two indexes: metacognition and behavioral regulation. Participants rated their responses on a three-point Likert-type scale, ranging from one (never a problem) to three (often a problem). Cronbach's alpha was .97 for the present study.

2.2.6. Personality Research Form — Infrequency Scale (PRF–IN; Jackson, 1984)

The Infrequency Scale of the PRF was included to identify non-purposeful responding. It consists of 16 true–false items that were divided to appear at the beginning, middle, and end of the questionnaire battery.

2.3. Performance measures

2.3.1. Delis–Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001)

The DKEFS is a set of performance measures designed to objectively assess frontal lobe involvement in neurocognitive control processes. Full details regarding administration procedures and psychometrics are found in the examiner's manual (Delis et al., 2001). Raw scores were converted to age-adjusted scaled scores[2]; higher scores indicate greater abilities in neurocognitive control. Four DKEFS tests were employed to measure aspects of neurocognitive control.

The Verbal Fluency Test (Condition 3) was used to measure verbal shifting. Participants were asked to generate different words alternating between two categories as quickly as possible in 60 s.

The Design Fluency Test (Condition 3) was used to measure non-verbal shifting. Participants were asked to draw as many different designs as possible by switching between filled and empty dots in 60 s.

The Trail Making Test (Condition 4) was used to measure updating and shifting. This test engages working memory to draw a trail by switching between numbers and letters.

The Color–Word Interference Test (Condition 4) was used to measure inhibition/shifting. This test requires participants to switch between inhibitory (i.e., name the ink color) and non-inhibitory (i.e., read the word) responses.

2.4. Procedure

The appropriate Institutional Ethics Board approved this investigation. An incentive of three bonus course marks was offered for participation in the study (one mark for each hour of participation). In Phase 1, participants attended a laboratory session to complete the performance tasks. Participants then completed an online questionnaire battery consisting of the self-report measures. Phase 2 occurred four weeks after Phase 1 and involved completing the same online questionnaire battery.

3. Results

3.1. Pre-analysis

Little's (1988) MCAR tests indicated that missing data were missing at random ($p = .99$). Given that less than 1% of values were missing, single imputation using an expectation maximization algorithm was used to impute missing data (Scheffer, 2002). No participants obtained a score greater than the cut-off of four on the infrequency measure; therefore, the full sample was used for analyses ($N = 77$).

To examine overall neurocognitive control, a composite measure was calculated by summing the scaled scores of the four DKEFS performance tests. Bivariate correlations indicated that the demographic variables were not related to the study variables ($p > .05$); therefore, no covariates were included in the mediation models. A bootstrapped procedure (Hayes & Preacher, 2014) used to test the mediator models controls Type I error rates. Test statistics for the correlation and regression analyses are evaluated at the .05 and .01 alpha levels. Additionally, effect sizes are emphasized and described according to Cohen's (1992) guidelines.

3.2. Relationships among mindfulness, neurocognitive control, executive function, self-regulation, and well-being

Means, standard deviations, and score ranges of the measures are presented in Table 1, and are comparable to other university samples (Short & Mazmanian, 2013; Wingo et al., 2013). Bivariate correlations

[2] A similar pattern of results was observed for the raw scores of the performance tests.

Table 1
Descriptive statistics of the study variables.

Variable	Mean	*SD*	Actual range	Potential range
FFMQ mindfulness P1[a]	125.44	17.37	64–165	39–195
FFMQ observe P1[a]	25.12	6.28	12–39	8–40
FFMQ describe P1[a]	26.90	7.07	9–40	8–40
FFMQ awareness P1[a]	25.36	6.02	8–39	8–40
FFMQ non-judgment P1[a]	27.19	7.90	8–40	8–40
FFMQ non-reactivity P1[a]	20.86	4.66	12–33	7–35
DKEFS neurocognitive control P1[b]	41.82	7.35	24–58	4–76
DKEFS verbal shifting P1[b]	10.39	3.13	3–19	1–19
DKEFS non-verbal shifting P1[b]	11.34	2.75	4–17	1–19
DKEFS monitoring/updating P1[b]	9.88	2.44	1–14	1–19
DKEFS inhibition/shifting P1[b]	10.21	2.73	1–15	1–19
BRIEF executive dysfunction P2[a]	116.44	27.10	70–201	70–210
BRIEF behavior regulation P2[a]	50.09	12.18	30–84	30–90
BRIEF metacognition P2[a]	66.35	16.88	40–119	40–120
SCMS self-regulation P2[a]	53.03	12.21	23–80	0–80
SCMS self-monitoring P2[a]	18.84	5.45	0–30	0–30
SCMS self-evaluation P2[a]	17.64	4.84	6–25	0–25
SCMS self-reinforcement P2[a]	16.56	4.93	0–25	0–25
PANAS positive affect P2[a]	31.74	8.82	10–49	10–50
PANAS negative affect P2[a]	21.78	8.36	10–47	10–50
DASS-21 depression P2[a]	4.98	5.16	0–21	0–21
DASS-21 anxiety P2[a]	5.38	4.77	0–21	0–21
DASS-21 stress P2[a]	6.78	4.71	0–21	0–21

Note: P1 = Phase 1; P2 = Phase 2.
[a] Raw scores of self-report measures.
[b] Scaled scores of performance measures.

among mindfulness and performance measures of neurocognitive control at Phase 1, and executive functions, self-regulation, and well-being at Phase 2 are presented in Table 2. Dispositional mindfulness correlated in the expected directions with all of the self-report measures (r = medium to large effects). Executive function and self-regulation generally correlated as expected with each other and the measures of well-being. Notably, daily problems with total executive function, behavioral regulation, and metacognition positively correlated with indicators of poor well-being (i.e., negative affect, depression, anxiety, and stress; r = large effects).

The neurocognitive control performance measures were not significantly correlated with mindfulness, or negative affect, depression, anxiety, and stress. Total neurocognitive control positively correlated with positive affect, total self-regulation, self-monitoring, and self-reinforcement (r = small to medium effects). Non-verbal shifting positively correlated with total self-regulation and self-reinforcement (r = small effects). Similarly, updating/shifting positively correlated with positive affect, total self-regulation, and self-reinforcement (r = small effects). Inhibition/shifting positively correlated with total self-regulation and self-monitoring, and negatively correlated with executive function and metacognition (r = small effects).

3.3. Five facets of mindfulness as independent predictors of future outcomes

To examine the independent contributions of each mindfulness facet at Phase 1 to executive function, self-regulation, positive affect, negative affect, depression, anxiety, and stress at Phase 2, bivariate and partial correlation analyses were conducted (controlling for the other mindfulness facets; see Table 3). The neurocognitive control measures were not included in the partial correlation analyses, as bivariate correlation analyses indicated that the five facets of mindfulness were not correlated with any of the neurocognitive control performance measures ($ps > .05$). Observe and non-reactivity were not independently related to any of the outcomes, with the exception that non-reactivity negatively correlated with behavioral regulation (pr = small effect). Describe positively correlated with total self-regulation, self-monitoring, and self-evaluation (pr = small to medium effects), and negatively correlated with depression and anxiety (pr = small effects). Acting with awareness correlated in the expected directions with total executive function and its facets, total self-regulation, self-monitoring, self-evaluation, positive affect, depression, anxiety, and stress (pr = small to medium effects). Non-judgment of inner experience negatively correlated with total executive function, behavioral regulation, negative affect, depression, anxiety, and stress (pr = small to medium effects).

3.4. Roles of executive function and self-regulation

Two multiple mediator models examining the indirect effects of executive function and self-regulation between dispositional mindfulness and general well-being were tested, using a bootstrapped multivariate procedure (Hayes & Preacher, 2014). Five thousand random

Table 2
Bivariate correlations between mindfulness, cognitive flexibility, executive functions, self-regulation, and psychological well-being.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. FFMQ mindfulness P1[a]	–																
2. DKEFS neurocognitive control P1[b]	.06	–															
3. DKEFS verbal shifting P1[b]	.20	.65**	–														
4. DKEFS non-verbal shifting P1[b]	.03	.65**	.14	–													
5. DKEFS updating/shifting P1[b]	.05	.69**	.18	.40**	–												
6. DKEFS inhibition/shifting P1[b]	.06	.68**	.27*	.22*	.34**	–											
7. BRIEF executive dysfunction P2[a]	−.62**	−.18	−.04	−.14	−.07	−.24*	–										
8. BRIEF behavior regulation P2[a]	−.63**	−.15	−.07	−.10	−.02	−.21	.91**	–									
9. BRIEF metacognition P2[a]	−.55**	−.18	−.01	−.16	−.09	−.23*	.95**	.73**	–								
10. SCMS self-regulation P2[a]	.59**	.32**	.11	.26*	.26*	.24*	−.54**	−.44**	−.54**	–							
11. SCMS self-monitoring P2[a]	.47**	.31**	.13	.21	.20	.29*	−.46**	−.36**	−.49**	.89**	–						
12. SCMS self-evaluation P2[a]	.65**	.16	−.03	.17	.17	.14	−.58**	−.48**	−.58**	.69**	.43**	–					
13. SCMS self-reinforcement P2[a]	.30**	.28*	.16	.24*	.25*	.13	−.24*	−.21	−.24*	.81**	.68**	.26*	–				
14. PANAS positive affect P2[a]	.50**	.27*	.10	.20	.22*	.21	−.34**	−.27*	−.34**	.64**	.61**	.44**	.48**	–			
15. PANAS negative affect P2[a]	−.50**	−.13	−.11	.02	−.13	−.12	.60**	.69**	.52**	−.23*	−.18	−.26*	−.12	−.20	–		
16. DASS-21 depression P2[a]	−.66**	−.21	−.11	−.17	−.15	−.14	.68**	.67**	.61**	−.51**	−.42**	−.51**	−.29*	−.49**	.64**	–	
17. DASS-21 anxiety P2[a]	−.58**	−.04	−.07	−.01	−.07	−.04	.57**	.60**	.49**	−.28*	−.20	−.30**	−.17	−.33**	.62**	.76**	–
18. DASS-21 stress P2[a]	−.61**	−.06	−.06	−.05	−.05	−.01	.61**	.70**	.48**	−.27*	−.19	−.31**	−.16	−.35**	.68**	.78**	.83**

Note. Verbal shifting = DKEFS verbal fluency condition 3; non-verbal shifting = DKEFS design fluency condition 3; monitoring/updating = DKEFS trail-making condition 4; inhibition/shifting = DKEFS color–word interference condition 4.
[a] Raw scores of self-report measures.
[b] Scaled scores of performance measures.
* $p < .05$.
** $p < .01$.

Table 3
Bivariate and partial correlations examining independent relationships between mindfulness facets and outcomes.

Variable	FFMQ mindfulness P1									
	Observe		Describe		Aware		Non-judgment		Non-reactivity	
	r	*pr*	*r*	*pr*	*r*	*pr*	*r*	*pr*	*r*	*pr*
BRIEF executive dysfunction P2	.17	.02	−.42**	−.20	−.65**	−.45**	−.54**	−.29**	−.18	−.08
BRIEF behavior regulation P2	.17	.03	−.36**	−.14	−.55**	−.32**	−.60**	−.39**	−.30**	−.24*
BRIEF metacognition P2	.15	.01	−.40**	−.20	−.65**	−.47**	−.43**	−.16	−.07	.04
SCMS self-regulation P2	.01	.11	.52**	.37**	.59**	.30**	.29*	.07	.28*	.17
SCMS self-monitoring P2	.01	.04	.40**	.24*	.44**	.27*	.26*	.06	.19	.10
SCMS self-evaluation P2	.04	.13	.60**	.46**	.52**	.34**	.29*	.06	.30**	.19
SCMS self-reinforcement P2	−.04	.07	.26**	.17	.21	.09	.13	.04	.19	.11
PANAS positive affect P2	.02	.13	.37**	.21	.48**	.31**	.30**	.11	.16	.05
PANAS negative affect P2	.10	−.06	−.20	−.04	−.35**	−.07	−.58**	−.47**	−.28*	−.18
DASS-21 depression P2	.19	.02	−.41**	−.22*	−.58**	−.32**	−.64**	−.47**	−.28*	−.19
DASS-21 anxiety P2	.20	.11	−.40**	−.22*	−.57**	−.31**	−.59**	−.37**	−.19	−.09
DASS-21 stress P2	.21	.17	−.36**	−.13	−.60**	−.37**	−.65**	−.43**	−.24*	−.19

Note. The partial correlations examine the independent contributions of each mindfulness facet at Phase 1 to outcomes at Phase 2.
* $p < .05$.
** $p < .01$.

samples were taken from the data and indirect effects were computed in each sample. This procedure reports the independent effect of each mediator, controlling for the other. If the bias-corrected 95% confidence intervals do not contain zero, the indirect effect is significant.

Regression coefficient estimates and 95% confidence intervals for the first model indicated that self-regulation independently mediated the relationship between dispositional mindfulness and positive affect (see Fig. 1). However, executive function was not an independent mediator beyond the effects of self-regulation.

Regression coefficient estimates and 95% confidence intervals for the second model indicated that executive function and self-regulation, both independently and together, mediated the relationship between dispositional mindfulness and negative affect (see Fig. 2).

4. Discussion

The aim of the current investigation was to examine the relationships among the five facets of mindfulness, neurocognitive control, executive function, self-regulation, and well-being in an undergraduate academic context. The multiple mediation models suggested that for students who tend toward higher levels of dispositional mindfulness, experiences of positive affect are promoted by self-regulation — a cycle of behavioral change and control that includes the unique aspect of self-reinforcement when a goal is met. Yet, both executive function and self-regulation may be protective in terms of negative affect.

Examination of the separate mindfulness facets revealed that acting with awareness and non-judgment of inner experience are most strongly related to executive function and well-being. These findings align with existing theoretical models suggesting that present-moment awareness and non-judgmental acceptance foster openness and sensitivity to subtle changes in sensations, emotions, thoughts, and the environment (Teper et al., 2013). These cues may activate executive functions and allow individuals to navigate situations in a manner that promotes well-being. Moreover, describing and acting with awareness emerged as the facets most strongly related to self-regulation. Being aware of ongoing actions and being able to objectively describe and label internal and external stimuli may play a role in monitoring the status of a target behavior and comparing the behavior to an internalized standard. Exploring the five facet model of mindfulness highlights the benefit of multifaceted measures, as prior research commonly used unidimensional scales (e.g., Lyvers et al., 2014).

Results from the performance tests indicated that although total neurocognitive control was related to self-regulation and positive affect, only the inhibition/shifting test was related to executive function in daily life. Higher-order inhibitory abilities may be particularly relevant to disregarding distractions in real-life contexts to accomplish goal-directed behavior. Although connections to specific brain areas go beyond the current data, research indicates that activation of cortical areas related to inhibition is implicated in value-based decision-making, which may be relevant to successful daily executive functions (Henri-Bhargava, Simioni, & Fellows, 2012).

Overall, self-reported measures of executive function and self-regulation more strongly correlated with mindfulness and well-being outcomes compared to objective performance measures of neurocognitive control. One possible explanation of this finding is that self-reports of executive function and self-regulation skills align more closely with subjective experiences of well-being (both of which may be susceptible to reporting bias), rather than one's neurocognitive abilities. Another possible explanation is that these findings are consistent

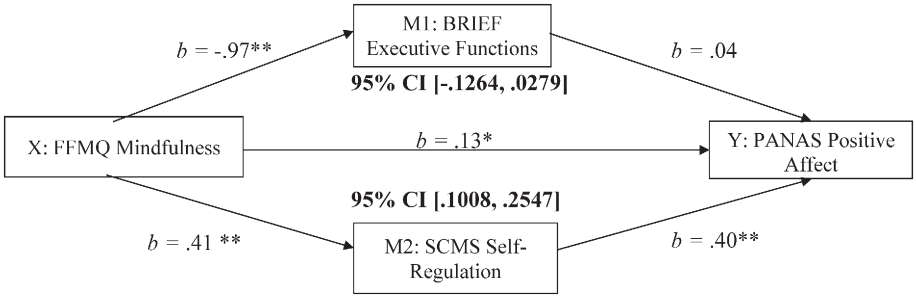

Fig. 1. Indirect effects of Phase 2 executive functions and self-regulation on the relationship between Phase 1 mindfulness and Phase 2 positive affect ($N = 77$). CI = confidence interval.
*$p < .05$; **$p < .01$.

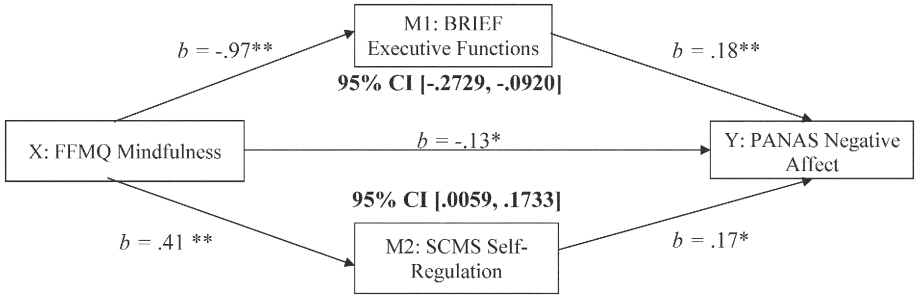

Fig. 2. Indirect effects of Phase 2 executive functions and self-regulation on the relationship between Phase 1 mindfulness and Phase 2 negative affect ($N = 77$). CI = confidence interval. $^{*}p < .05$; $^{**}p < .01$.

with prior literature that suggests that different measurement modalities tap into different levels of cognition (Toplak et al., 2013). More specifically, self-report scales capture success in behavioral regulation and metacognition in the context of daily living, as opposed to optional performance conditions. Performance tests often have limited ecological validity, and similar distinctions between laboratory and ecological measures exist in other cognitive domains, such as attention (Naglieri, Goldstein, Delauder, & Schwebach, 2005). These findings emphasize the relevance of multi-method designs, particularly when executive function is examined outside the area of neuropsychology and in relation to personality and emotional functioning.

4.1. Limitations and future research

This study used a two-phase longitudinal design; however, the findings do not address whether dispositional mindfulness predicts changes in well-being. Given that levels of well-being did not change over the four weeks, a longer time frame with multiple measurements may be needed to capture true change. Future studies may examine whether neurocognitive control measures predict objective outcomes, informant reports, or other models of well-being. While the findings generalize to undergraduates, and particularly White females, future research may target a broader range of executive functions and self-regulation abilities by recruiting a community sample. Lastly, studies might examine whether incorporating mindfulness training on campus promotes executive function and self-regulatory capacity, and reduces psychological distress.

5. Conclusions

The current findings provide insight into why dispositional levels of mindfulness relate to subjective experiences of well-being. Individuals with high levels of dispositional mindfulness have an inherent ability to sustain non-evaluative awareness to present-moment events, and are capable of regulating behaviors and adapting to daily life. Thus, greater intensities of positive affect and lower intensities (or perhaps more fleeting experiences) of negative affect result. That is, executive function and self-regulatory abilities help explain why dispositional mindfulness is protective against future experiences of psychological distress and promotes well-being.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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