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Wei Xing TOH
Singapore Management University, weixing.toh.2017@phdps.smu.edu.sg

Hwajin YANG
Singapore Management University, hjyang@smu.edu.sg

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Executive Function Moderates the Effect of Reappraisal on Life Satisfaction: A Latent Variable Analysis

Wei Xing Toh and Hwajin Yang

Singapore Management University

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Address correspondence to:

Wei Xing Toh and Hwajin Yang, Ph.D.
Singapore Management University
School of Social Sciences
90 Stamford Road, Level 4
Singapore 178903

Emails: weixing.toh.2017@phdps.smu.edu.sg and
hjyang@smu.edu.sg
Phone: +65 6828 0975

Abstract

Emotion regulation strategies, such as reappraisal and suppression, have been shown to dissimilarly affect life satisfaction. Specifically, reappraisal is linked to higher life satisfaction, while suppression is associated with lower life satisfaction. Less is known, however, about the potential moderators of these established relations. Given that reappraisal and suppression are contingent, in part, on executive function (EF), which comprises a group of adaptive, goal-orientated control processes (i.e., inhibitory control, working memory, and shifting), we explored whether different components of EF could moderate the impact of reappraisal and suppression on life satisfaction. Using a latent moderated structural equation analysis, we found that the positive contribution of reappraisal to life satisfaction was more pronounced at higher than lower levels of inhibitory control and working memory. Shifting did not moderate the associations of reappraisal and suppression with life satisfaction. Further analyses, however, indicated that the interactive effects of reappraisal with inhibitory control and working memory on life satisfaction were driven primarily by the shared variance among EF constructs (i.e., common EF). Our findings underscore the pivotal role of common EF in moderating the relation of reappraisal with life satisfaction.

Key words: reappraisal, suppression, emotion regulation, executive function, life satisfaction.

Executive Function Moderates the Effects of Reappraisal on Life Satisfaction: A Latent Variable Analysis

Emotion regulation refers to the strategies that serve to modulate emotional experiences and responses in line with personal goals and environmental demands (Gross, 1999). Two prominent strategies that have been extensively investigated are cognitive reappraisal and expressive suppression (e.g., Butler et al., 2003; Butler, Lee, & Gross, 2007; John & Gross, 2004). Cognitive reappraisal (hereinafter *reappraisal*), which occurs early during the emotion-generative process, relates to the revision of one or more interpretations of an emotion-eliciting event in a way that changes its emotional impact (Gross, 2008). Expressive suppression (hereinafter *suppression*), which occurs later in the development of emotions, represses ongoing emotion-expressive behaviors (Gross, 2008). Past work has examined the consequences of these emotion regulation strategies on various psychological markers of well-being (e.g., interpersonal functioning and affective balance; Butler et al., 2003; Gross & John, 2003), but few studies have examined the factors that may moderate the associations between emotion regulation strategies and the cognitive aspect of well-being—life satisfaction, which is a crucial predictor of health and longevity, marital harmony, job performance, and resilience (Diener, Oishi, & Tay, 2018). Given that reappraisal and suppression have been shown to rely, in part, on executive function (EF; Schmeichel & Tang, 2015)—a collection of adaptive, general-purpose control processes that regulate many of our everyday behaviors (Diamond, 2013)—we sought to close this gap in the literature by investigating whether EF, which is a multifaceted construct, could moderate the effects of reappraisal and suppression on life satisfaction.

Reappraisal, suppression, and life satisfaction

A large body of research has shown that reappraisal and suppression differentially affect life satisfaction, which refers to the global judgment of one's quality of life and how close one is to personal goals and ideals (Diener, Emmons, Larsen, & Griffin, 1985; Diener, Suh, Lucas, & Smith, 1999). Specifically, reappraisal diminishes the negative emotional impact of adversity (e.g., by construing setbacks as positive learning opportunities; Gross & John, 2003), which likely augments perceptions of goal progress—and, in turn, increases life satisfaction. In favor of this view, individuals who habitually use reappraisal reported experiencing greater positive emotions and closer interpersonal relations, as well as higher levels of environmental mastery, personal growth, self-acceptance, purpose in life, and sense of autonomy, all of which likely contribute to lower depressive symptomology and higher life satisfaction (Garnefski, Kraaij, & Spinhoven, 2001; Gross & John, 2003; Haga, Kraft, & Corby, 2009; John & Gross, 2004). Experimental evidence similarly shows that better reappraisal performance on laboratory-based measures, in which participants had to reinterpret the meaning of negative stimuli, corresponds to higher life satisfaction (McRae, Jacobs, Ray, John, & Gross, 2012). Taken together, this evidence underscores the positive relation between reappraisal and life satisfaction.

In contrast, maladaptive reliance on suppression in everyday life has been posited to induce a sense of discrepancy between inner self and external behaviors. This may lead to negative perceptions of the self (John & Gross, 2004) and misalignment with personal ideals, thereby engendering lower life satisfaction. More frequent use of suppression has been linked to decreased experience of positive emotions, greater experience of negative emotions, poorer interpersonal functioning, lower social support, higher levels of depressive symptomatology, and lower life satisfaction (Butler et al., 2003; Gross & John, 2003; Gross & Levenson, 1997; Sheldon, Ryan, Rawsthorne, & Ilardi, 1997). In a similar vein, Richards and Gross (1999) found that prolonged suppression may be physiologically taxing, as reflected by heightened sympathetic activation in the cardiovascular system (e.g., blood pressure), and could have a detrimental effect on psychological and physical health (Goldin, McRae, Ramel, & Gross, 2008), which is critical for life satisfaction (Diener et al., 2018). These findings imply that suppression is negatively associated with life satisfaction.

Reappraisal, suppression, and EF

The theoretical construct of EF has been postulated to comprise three interrelated, but separable, goal-oriented processes (Miyake et al., 2000): (a) inhibitory control—the ability to suppress nonrelevant or distracting stimuli; (b) working memory—the ability to retain information within a mental work space while monitoring and manipulating information; and (c) shifting—the ability to switch back and forth between multiple tasks and mental sets. Further, all three EF constituents are subserved by a common EF component, which relates to the general goal-management ability to monitor and maintain task-relevant goals, while ignoring task-irrelevant information (Miyake & Friedman, 2012). The literature suggests, based on two lines of accumulated evidence, that reappraisal and suppression rely, in part, on EF.

First, neuroimaging studies have shown that emotion regulation is associated with the activation of brain regions that are similarly responsible for EF (Ochsner & Gross, 2005). Specifically, fMRI studies show that the suppression and reappraisal of negative emotions while viewing aversive images involve the lateral prefrontal regions, which are also implicated in executive functioning; such control-related prefrontal areas are thought to regulate activities in emotion-related regions, such as the amygdala and insula (Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Goldin et al., 2008; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004). Likewise, Friese et al. (2013) demonstrated that a measure that taps inhibitory control (i.e., the Stroop task) and the suppression of emotional responses to affect-inducing pictures were similarly subserved by the right lateral prefrontal cortex and medial frontal cortex. These findings lend support to the view that emotion regulation and EF may tap similar neural mechanisms.

Second, behavioral evidence demonstrates that reappraisal and suppression are contingent on EF. For instance, during reappraisal, working memory processing facilitates the generation and manipulation of alternative narratives in one’s mind, while inhibitory control aids in the suppression of undesired appraisals of situations (McRae et al., 2012). Specifically, individuals with higher levels of working memory (assessed by the operation span task) were better able to reappraise by identifying positive aspects of negatively valenced pictures (McRae et al., 2012). Regarding inhibitory control, Tabibnia et al. (2011) compared methamphetamine-dependent individuals, who have been shown to exhibit lapses in EF, with healthy individuals on tasks that draw on inhibitory control (i.e., the stop-signal task) and reappraisal ability (i.e., to reinterpret evocative pictures in nonnegative ways). Inhibitory control was positively correlated with reappraisal ability, and methamphetamine-dependent individuals had poorer performance than healthy individuals on inhibitory control and reappraisal tasks. Similarly, Cohen, Mor, and Henik (2015) found that impaired inhibition of irrelevant, negatively valenced content was linked with reduced reappraisal and increased tendency to ruminate. In contrast, while the shifting aspect of EF has been speculated to support the switching of a negative appraisal to a more desirable narrative (McRae et al., 2012), the empirical evidence is equivocal. Notably, McRae et al. (2012) found that greater reappraisal ability was concomitant with more accurate, but slower, shifting performance (assessed by the global/local task), thereby signifying a speed-accuracy tradeoff. Collectively, the cumulative evidence demonstrates that inhibitory control and working memory facilitate reappraisal, whereas the role of shifting in reappraisal is uncertain and requires further examination.

With regard to suppression, inhibitory control and working memory may assist in the maintenance of goal-relevant responses and the suppression of emotional behaviors (Schmeichel & Tang, 2015). Consistent with this proposition, Tang and Schmeichel (2014) found that higher levels of inhibitory control (assessed by the stop-signal task) were associated with less intense anger and anxiety after recalling emotionally charged memories, suggesting that suppression could potentially account for the reduction in emotional intensity. In a study by von Hippel and Gonsalkorale (2005), American participants were placed under social pressure to pretend that an unfamiliar and visually unappetizing dish (chicken feet) was appealing. Participants with better inhibitory control (as assessed by the Stroop task) had less difficulty restraining their negative facial and verbal behavioral responses, thereby implying that inhibitory control facilitates the suppression of socially inappropriate behaviors. For working memory, Schmeichel, Volokhov, and Demaree (2008) showed that more competent performance on the operation span task was associated with better suppression of facial expressions and emotional experiences while watching highly aversive or amusing films. Conversely, shifting does not appear to be involved in suppression. For instance, Gyurak et al. (2012) found a null relation between shifting (as assessed by a trail-making test) and suppression. Accordingly, the literature holds that inhibitory control and working memory, but not shifting, contribute to suppression.

Emotion regulation strategies, EF, and life satisfaction

In considering the roles of EF in reappraisal and suppression, an intriguing question arises regarding potential interactions between the two emotion regulation strategies and core EF components in engendering life satisfaction. Specifically, given that reappraisal and suppression are dependent on some aspects of EF, more proficient EF abilities may aid reappraisal and suppression, thereby potentiating the effects of those emotion regulation strategies on life satisfaction. Notably, past studies have highlighted the moderating influence of EF on the relation between automatic (and affective) tendencies and various behavioral outcomes, such as eating behaviors (Hofmann, Friese, & Roefs, 2009) and the expression of stereotypic behaviors (Ito et al., 2015). Other studies have shown that EF diminishes the detrimental effects of rejection sensitivity (i.e., disposition to anxiously expect rejection) on interpersonal relations (e.g., peer aggression and acceptance) and positive functioning (e.g., self-worth, ability to cope with stress, mood fluctuations; Ayduk et al., 2000, 2008), all of which are related to life satisfaction (Diener et al., 2018).

More relevantly, Pe, Raes, and Kuppens (2013) investigated the moderating role of working memory ability (assessed by the emotional *n*-back task) on the relation between self-reported reappraisal and high-arousal negative emotions (i.e., anger and anxiety). Results showed that higher reappraisal was associated with lower negative emotions for individuals with better working memory, but not for those with poorer working memory, thereby underscoring the role of working memory in modulating the efficacy of reappraisal efforts in diminishing negative emotions. Further, Cohen, Henik, and Moyal (2012) examined the effects of self-reported reappraisal tendencies on the ability of inhibitory control to reduce emotional interference effects. Specifically, individuals with higher reappraisal were less susceptible to the detrimental effects of negatively valenced stimuli on inhibitory control than those with lower levels of reappraisal. These findings highlight that individuals with higher levels of reappraisal possess better inhibitory control to resist interference from negative emotions. Nevertheless, the potential interactive effects between EF (i.e., inhibitory control and working memory) and emotion regulation on the attenuation of negative affect does not necessarily imply that well-being will be enhanced (e.g., Seligman, Parks, & Steen, 2004). Therefore, it remains to be determined whether EF, as a multidimensional construct, could moderate the impact of reappraisal and suppression on life satisfaction.

In view of previous work on emotion regulation and EF, several limitations persist. First and foremost, the use of a single measure to index each EF component is particularly problematic, due to the task-impurity issues inherent in EF measures. Notably, EF tasks have been shown to correlate poorly with each other (Miyake et al., 2000), because EF measures typically involve not only EF abilities, but also non-EF skills (e.g., verbal proficiency). Importantly, it is possible that previously reported positive findings on the role of EF in emotion regulation (e.g., McRae et al., 2012; Tang & Schmeichel, 2014) may be spuriously driven by task-specific idiosyncrasies rather than EF per se. On the other hand, such non-EF task-specific variances may also mask genuine contributions of EF to emotion regulation, which might explain the null findings observed in some studies (e.g., Gyurak et al., 2012). To this end, it is crucial to account for task-impurity issues to more appropriately and reliably capture the influence of EF. Moreover, most studies have considered only limited aspects of EF (e.g., Tang & Schmeichel, 2014; von Hippel & Gonsalkorale, 2005). Given that EF is a multifaceted construct that consists of three related, but separable, component processes, there is insufficient understanding of how each EF component and common EF (i.e., shared variance among EF components; Miyake & Friedman, 2012)—would moderate the relation between emotion regulation strategies and life satisfaction.

Considering these limitations, our study sought to investigate whether the three EF components (inhibitory control, working memory, and shifting), as well as their shared variance (i.e., common EF), could moderate the effects of reappraisal and suppression on life satisfaction. To address task-impurity problems associated with EF measures in the literature, we employed a latent variable approach based on a comprehensive battery of tasks to tap all three EF components. Notably, the latent variable approach affords a purer measure of EF constructs by accounting for task-specific idiosyncrasies and statistically “extracting” common variance between multiple EF tasks (Miyake et al., 2000). Based on findings in the literature that reappraisal and suppression are contingent on EF (in particular, inhibitory control and working memory; e.g., McRae et al., 2012; Tabibnia et al., 2011), we explored if the effects of reappraisal and suppression on life satisfaction would vary as a function of individual differences in inhibitory control, working memory, and shifting. Further, given that common EF has been suggested to underlie performance on all types of EF tasks (Miyake & Friedman, 2012), it stands to reason that common EF may moderate the effects of emotion regulation strategies on life satisfaction. No study to date, however, has investigated the role of common EF in reappraisal and suppression. Therefore, we also explored the possible interactive effect of common EF with reappraisal and suppression on life satisfaction.

Method

Participants

One hundred and seventy-five students (M_{age} = 21.59 years, *SD* = 1.83; 66.3% female) from a local university in Singapore participated in the study for course credit or monetary reward (S$30). We determined our sample size based on recommendations that a minimum sample size of 150 is appropriate for structural equation models with seven constructs or fewer (Hair, Black, Babin, & Anderson, 2009; Tabachnick & Fidell, 2001). Our sample is also comparable to other studies that have used multiple tasks to index EF (e.g., Miyake et al., 2000; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). Further, based on past research investigating the interactive effects of EF with self-reported and performance-based measures ($|\beta|$s = .16 to .34; Ito et al., 2015), our sample size meets the minimum requirement of $N = 165$, based on Monte Carlo simulations, in detecting an effect size of .27 at 80% power. Participants were recruited over two academic semesters. As the data for this study are a subset of a larger dataset, only the variables of interest for this study were reported (see Table 1 for descriptive statistics); note that there was no experimental manipulation that might affect participants' performance on EF tasks.[1]

Table 1

Descriptive Statistics and Standardized Factor Loadings

	M	*SD*	Min	Max	Skewness	Kurtosis	Factor loading	Reliability
Life satisfaction								.899
In most ways, my life is close to my ideal	4.12	1.46	1	7	-.36	-.77	.85 (.03)	
The conditions of my life are excellent	4.57	1.25	1	7	-.35	-.41	.78 (.04)	
I am completely satisfied with my life	4.26	1.43	1	7	-.48	-.37	.88 (.03)	
So far I have gotten the most important things I want in life	4.35	1.48	1	7	-.39	-.58	.77 (.04)	
If I could live my life over, I would change nothing	3.87	1.81	1	7	.04	-1.09	.76 (.05)	
Reappraisal								.871
When I want to feel more positive emotion, I change what I'm thinking about	5.05	1.25	1	7	-.81	.58	.58 (.08)	
When I want to feel less negative emotion, I change what I'm thinking about	5.13	1.25	1	7	-.92	.95	.70 (.06)	
When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm	4.94	1.20	2	7	-.62	.20	.61 (.07)	
When I want to feel more positive emotion, I change the way I'm thinking about the situation	5.23	1.20	2	7	-.88	.79	.85 (.04)	
I control my emotions by changing the way I think about the situation I'm in	5.13	1.17	2	7	-.86	.71	.90 (.03)	
When I want to feel less negative emotion, I change the way I'm thinking about the situation	4.99	1.23	1	7	-.76	.39	.75 (.07)	
Suppression								.708

I keep my emotions to myself	4.91	1.32	1	7	-.69	.29	.63 (.08)	
When I am feeling positive emotions, I am careful not to express them	3.18	1.33	1	6	.39	-.46	.40 (.09)	
I control my emotions by not expressing them	4.27	1.58	1	7	-.18	-.88	.86 (.07)	
When I am feeling negative emotions, I make sure not to express them	4.44	1.48	1	7	-.34	-.68	.58 (.08)	
Inhibition								
Arrow flanker	-6.27	1.66	-14.78	-3.69	-1.87	5.76	.46 (.10)	.925
Color flanker	-6.31	0.96	-9.24	-3.52	-0.17	0.73	.66 (.07)	.709
Eriksen flanker	-6.19	0.87	-9.66	-4.20	-0.94	1.53	.65 (.09)	.703
Working memory								
Operation span	0.87	0.13	0.36	1.00	-1.52	2.14	.45 (.08)	.639
Rotation span	0.72	0.18	0.08	1.00	-1.03	1.47	.83 (.07)	.733
Symmetry span	0.80	0.16	0.26	1.00	-1.05	0.57	.66 (.07)	.735
Shifting								
Animacy-locomotion	-6.96	1.44	-12.51	-4.52	-0.96	1.07	.73 (.07)	.886
Color-shape	-6.64	1.48	-12.93	-3.55	-0.96	1.91	.55 (.08)	.866
Magnitude-parity	-7.09	1.55	-12.36	-4.01	-0.84	0.94	.82 (.06)	.874
Fluid intelligence (KBIT-2)	24.70	5.75	3.00	32.00	1.54	2.40	-	

Note. Higher values for all EF tasks reflect better performance; for the inhibition and shifting tasks, values for descriptive statistics denote reverse-scored bin scores (multiplied by -1). As a result of administrative and technical errors, data were missing for the following EF tasks: arrow flanker (n = 2), Eriksen flanker (n = 1), rotation span (n = 2), and symmetry span (n = 2). All standardized factor loadings (with *SE*s in parentheses) were significant, $p < .001$. For life satisfaction and emotion regulation scales, reliability estimates were computed based on Cronbach’s alpha. For EF tasks, reliability estimates were calculated using Spearman-Brown adjusted split-half correlations.

Materials

Reappraisal and suppression. The Emotion Regulation Questionnaire (Gross & John, 2003) was employed to measure the tendency to rely on cognitive reappraisal (6 items) and expressive suppression (4 items) based on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*). Higher scores within each subscale denoted greater tendency to use the respective emotion regulation strategy.

Life satisfaction. The 5-item Satisfaction with Life Scale (Diener et al., 1985) was used to index life satisfaction based on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*). Higher scores reflected greater global life satisfaction.

Inhibitory control. Three inhibitory control tasks assessed resistance to distractor interference, which relates to the ability to resolve interference from irrelevant information in the external environment (Friedman & Miyake, 2004). The dependent variable in each inhibition task was reverse-scored bin scores (see below for detailed binning procedure), with higher values denoting better performance.

Modified Eriksen flanker task. Adapted from the Eriksen flanker task (Eriksen & Eriksen, 1974), participants were shown a row of five letters and directed to identify, by pressing the *G* or *H* key, the central target letter, which could be similar (congruent trials; e.g., *HHHHH*) or dissimilar (incongruent trials; e.g., *GGHGG*) to the surrounding four letters. In each trial, a central fixation point lasting 350 ms was first presented, followed by the target stimulus, which remained on the screen for 2,000 ms or until a response was entered. Next, a blank screen was shown for 250 ms prior to commencement of the next trial. Participants were instructed to respond as quickly and accurately as possible.

To increase task difficulty, the central target letter was displaced toward either the right or left side of the screen (vigilance trials; e.g., *GG HGG*), and participants were instructed to press the spacebar instead of identifying the central target letter. There were 85 congruent trials, 85 incongruent trials, and 30 vigilance trials. Since vigilance trials were not related to our goals, they were omitted from analysis.

Modified arrow flanker task. Participants were shown a string of arrows and directed to identify the direction of the central target arrow by pressing the *F* (left) or *J* (right) key, which could be similar (e.g., <<<<<) or dissimilar (e.g., <<><<) to the surrounding four arrows. All other methodological aspects were identical to the modified Eriksen flanker task.

Modified color flanker task. Participants were presented with a row of colored boxes and instructed to identify the color of the central target box by pressing the *G* (green) or *R* (red) key, which could be in the same or a different color as the other four colored boxes. All other methodological aspects were identical to the modified Eriksen flanker task.

Working memory. Three complex span tasks, adapted from Foster et al. (2015), assessed working memory capacity. Participants alternated between performing distractor tasks and encoding to-be-remembered items. The dependent variable in each working memory task was the proportion of correctly remembered items over the total number of to-be-remembered items (i.e., partial credit unit scores; called PCU scores hereafter); higher values reflected better performance.

Operation span task. In the distractor task, participants solved arithmetic problems and indicated, by clicking on the boxes shown on the screen, if they were true or false (e.g., (2 x 2) -1 = 3). The distractor task was timed such that if participants took longer than 2.5 *SD* above their mean reaction time (RT)—which was calculated during practice trials—to solve the arithmetic problems, the program automatically proceeded and the trial was counted as an error. This was done to reduce participants' tendency to rehearse the to-be-remembered items during the distractor task (Foster et al., 2015). Next, participants were asked to remember a letter, which was presented on screen for 800 ms, after which they were shown a 4x3 matrix of letters and instructed to click the appropriate letters in the correct order. The recall task was untimed and remained on screen until participants completed their responses. The set size (i.e., the total number of letters to be recalled) of a trial varied from three to seven and was randomly presented across trials.

Prior to the experiment trials, participants completed four practice trials requiring the recollection of a string of letters (i.e., two trials of set sizes two and three each). Subsequently, they completed 15 practice trials of arithmetic problems; here, each participant's mean RT to complete the distractor trials was recorded. Next, they completed three practice trials comprising both distractor and encoding trials, with each of set size two. In the experimental trials, two blocks comprised one trial each, with three to seven to-be-remembered letters (i.e., set size) presented in random order.

Rotation span task. In the distractor task, participants indicated whether a rotated letter, if in its upright orientation, is presented correctly or is a mirrored image of the letter. Next, participants were directed to remember the length (either short or long) and directionality (pointing in one of eight directions) of an arrow. In the recall task, participants were instructed to click on all previously presented arrow stimuli in the correct order when all 16 possible combinations of directionality and length of the arrows were shown on screen. The total number of arrows to recall (i.e., set size) varied from two to five per trial and was randomized across two blocks of trials. All other methodological aspects were identical to the operation span task.

Symmetry span task. In the distractor task, participants were shown a geometric figure and instructed to identify whether it was symmetrical along its vertical axis. Next, they were directed to remember the locations of red squares on a 4x4 grid. In the recall task, the same 4x4 grid was shown (without the red squares) and participants had to click on the positions of the previously presented red squares in the correct order. The set size of each symmetrylocation sequence varied from two to five per trial and was randomized across two blocks of trials. All other methodological details were identical to the operation span task.

Shifting. The three shifting tasks, based on the task-switching paradigm (Monsell, 2003), tap the ability to switch back and forth between two rules. The dependent variable in each shifting task was reverse-scored bin scores (see Results), with higher values reflecting better performance.

Color-shape task. Participants were directed to sort, based on a given cue, a bivalent target (i.e., green circle or red triangle) according to its color (green or red) or shape (circle or triangle) by pressing the *D* (circle or red) or *K* (green or triangle) key. The color rule was cued by a color gradient, and the shape rule by a row of black squares. In each trial, a fixation point (350 ms) followed by a black screen (150 ms) were presented. Next, the cue was shown, and after a delay of 250 ms, the target was presented. The cue and target remained on the screen until a response was entered. The inter-trial interval, signaled by a blank screen, was 850 ms.

Four mixed blocks (41 trials each) alternated with four pure blocks (20 trials each) in a sandwich-like design, which consisted of either color or shape rules. For each mixed block, there was an equal number of switch trials (e.g., color rule followed by shape rule) and repeat trials (e.g., shape rule for two consecutive trials), and the first trials in each mixed block were excluded. Trial order was randomized, and the maximum number of consecutive repeat trials was set at four. There were 80 switch trials, 80 repeat trials, and 80 pure trials.

Magnitude-parity task. Participants were instructed to sort bivalent target numbers—2 (an even number less than five) and 7 (an odd number more than five)—based on either its magnitude or parity by pressing the *D* (odd number or less than five) or *K* (even number or more than five) keys. The magnitude rule was denoted by a row of circles that varied in size and the parity rule by rows of odd-numbered and even-numbered squares. Depending on the cue presented, participants indicated either the parity (odd or even number) or magnitude (smaller or greater than five) of the bivalent target. All other methodological aspects were identical to the color-shape task.

Animacy-locomotion task. Participants were instructed to sort a target (plane or rabbit) according to its animacy (animate or inanimate) or locomotion (flying or nonflying) by pressing the *D* (animate or flying) or *K* (inanimate or nonflying) keys. The animacy rule was cued by a picture of dog paws and the locomotion rule was denoted by a picture of roads and skies. All other methodological aspects were identical to the color-shape task.

Fluid intelligence. The Kaufman Brief Intelligence Test 2nd Edition (KBIT-2) matrices subtest (Kaufman & Kaufman, 2004) was used to assess nonverbal fluid intelligence. Participants were directed to solve visual analogies of target stimuli, which consisted of illustrations of concrete or abstract figures.

Binning procedure. Performance on inhibitory control and working memory tasks was indexed by bin scores, which have been shown to provide better reliability, validity, and sensitivity in the detection of larger effect sizes than pure latency or accuracy scores or inverse efficiency scores (Draheim et al., 2016; Hughes et al., 2014). Based on the procedures delineated by Draheim, Hicks, and Engle (2016), we computed bin scores as follows. First, the following exclusion criteria were applied: (a) incorrect trials, (b) trials with RTs below 200 ms, and (c) trials with RTs that departed from each participant’s mean RT by more than 2.5 *SD* (for shifting tasks) or 3 *SD* (for inhibitory control tasks). Note that a 3 *SD*, rather than 2.5 *SD*, trimming criterion for the inhibitory control tasks was chosen because shorter RT cutoffs have been shown to mask potential effects on inhibitory control tasks (Zhou & Krott, 2016). Second, for the inhibitory control tasks, each participant’s mean RT for congruent trials was subtracted from the RT of every accurate incongruent trial. Similarly, for the shifting tasks, each participant's mean RT for repeat trials was deducted from the RT of every accurate switch trial. Third, for each inhibitory control and shifting task, all participants' difference scores were rank-ordered into deciles and assigned bin values ranging from 1 to 10, with 1 containing the fastest and 10 containing the slowest 10%. Inaccurate trials on both inhibitory and shifting tasks were assigned a bin value of 20. Fourth, a single bin score for each participant was computed by averaging all of their respective bin values across all trials. Last, each participant's bin score was reverse-scored (multiplied by -1), with higher values reflecting better performance.

Procedure

The study was spread out across three sessions, with 1-week intervals between each session. In the first session, participants completed a battery of questionnaires that included the Emotion Regulation Questionnaire, Satisfaction with Life Scale, demographics, and K-BIT-2. In the second session, the operation span, color-shape, modified Eriksen flanker, and rotation span tasks were administered. For the third session, the modified arrow flanker, animacy-locomotion, symmetry span, modified color flanker, and parity-magnitude tasks were administered. The order of the EF tasks was fixed for every participant, with the condition that no two consecutive tasks assessed the same EF construct, in order to minimize order effects that arise from various permutations of the task order. Having a fixed task order would, therefore, render task-order effects to be consistent for all participants, thereby allowing for individuals' scores to be more directly comparable. The study was approved by the University's Institutional Review Board, and informed consent was obtained from all participants before the study began.

Results

Data analysis

All analyses were conducted with M*plus* 7.4 (Muthén & Muthén, 1998-2015), using the full information maximum likelihood procedure with robust standard errors. The moderators (i.e., inhibitory control, working memory, shifting, and common EF); predictors (reappraisal, suppression); and criterion (life satisfaction) were modeled as latent variables. We also controlled for fluid intelligence (manifest variable), as it has been shown to correlate with EF (Arffa, 2007); further, controlling for intelligence allowed us to rule out the alternative explanation that the moderating effects of EF on the associations between emotion regulation strategies and life satisfaction were driven by intelligence, rather than EF per se. We also considered other covariates such as gender and income, which have been shown to be related to life satisfaction and the use of suppression (Batz & Tay, 2018; Diener, Tay, & Oishi, 2013; Gross & John, 2003). Gender and income, however, were not significantly related to reappraisal, suppression, or life satisfaction, and controlling for them did not alter any of our principle findings; therefore, we omitted these variables from our analyses.

Following the two-step estimation procedure for assessing latent moderated structural equations (Klein & Moosbrugger, 2000), we first determined whether the structural equation model without the latent interaction terms fitted the data well. Next, we evaluated the significance of the added interaction terms and differences in model fit, as indicated by log-likelihood values and scaling correction factors. Subsequently, we assessed whether each EF component—inhibitory control (Model 1), working memory (Model 2), and shifting (Model 3)—independently moderated the relations of reappraisal and suppression with life satisfaction. Given that each of the three EF processes can be further decomposed into unique, construct-specific variance and interrelated shared variance (i.e., common EF) (Miyake & Friedman, 2012), we conducted further analyses to elucidate the extent to which the findings from Models 1 to 3 were driven by the unique construct-specific (i.e., inhibitory-control-specific, working-memory-specific, or shifting-specific) variance (Model 4) and/or shared components among EF facets (i.e., common EF; Model 5).[2] Significant interactions were further probed using the Johnson-Neyman procedure. All reported estimates were standardized. Following Hu and Bentler (1999), we adopted the following criteria as indications of good model fit: root mean square error of approximation (RMSEA) of .06 or lower, standardized root mean squared residual (SRMR) of .08 or lower, and comparative fit index (CFI) close to or above .95.

Additionally, we supplemented our core findings, based on the frequentist approach, with Bayesian analysis, which is more appropriate for small samples as it does not rely on asymptotic (large-sample) theory and provides more trustworthy estimates than frequentist maximum likelihood with both informative and non-informative priors (Muthén & Asparouhov, 2012). For our Bayesian analysis, we relied on the default, non-informative priors in M*plus*, and the presence of an effect was signified by 95% credible intervals (CI) not containing zero (see Appendix D).

Measurement model

Prior to conducting latent moderated structural equation analyses, we assessed the measurement model comprising all latent variables of reappraisal, suppression, inhibitory control, working memory, shifting, and life satisfaction. The EF tasks served as indicators for the three EF constructs, and the scale items were the indicators for the self-report constructs of reappraisal, suppression, and life satisfaction. All indicators significantly loaded on their intended constructs (ps < .001; see Table 1), and the fit of the overall measurement model was good, $\chi^2(237) = 327.57$, $p < .001$, RMSEA = .047, SRMR = .060, CFI = .935 (see Appendix A for latent variable correlations). Further, in line with modification indices, we correlated the residuals of items 1 and 2 of the Satisfaction with Life scale—which represent how ideal the conditions of one's life are currently—and items 4 and 5, which reflect satisfaction with previous accomplishments (Oishi, 2006). Modification indices also point to significant residual correlation between items 1 and 2 of the reappraisal subscale of the Emotion Regulation Questionnaire, which seem to anchor and define the concepts of positive and negative emotions. Doing so resulted in an improved model fit, $\chi^2(234) = 273.90$, $p = .038$, RMSEA = .031, SRMR = .058, CFI = .972, and this model was used for the rest of our analyses.

To ascertain the three-factor structure of EF, we separately evaluated the measurement model of the EF latent variables. The three-factor model of EF fitted the data well, $\chi^2(24) = 25.77$, $p = .36$, RMSEA = .021, SRMR = .047, CFI = .993, and all EF latent variables significantly correlated with each other (*r*s = .31 to .46; *p*s < .001), thereby reflecting the unity and diversity of EF, as established by Miyake et al. (2000). Further, in line with a more recent theoretical development of the EF construct (Miyake & Friedman, 2012), we also modeled a hierarchical EF structure with one second-order common EF factor and three first-order EF factors (inhibitory control, working memory, and shifting) in order to account for the common variance shared by EF components. This model fitted the data well, $\chi^2(24) = 25.77$, $p = .365$, RMSEA = .021, SRMR = .047, CFI = .993, and all factor loadings were significant (βs > .42, *p*s < .001), which indicates that the three EF constructs share a common EF component (Miyake & Friedman, 2012).

Latent moderated structural equation analyses

Fit indices for the latent moderated structural equation analyses are shown in Table 2 and parameter estimates are shown in Tables 3 and B1 in Appendix B. We first examined the models without interactions, which fitted the data well (see Table 2). As shown in Table 3, reappraisal and suppression positively and negatively predicted life satisfaction, respectively. Inhibitory control, but not working memory or shifting, negatively predicted life satisfaction.

Fluid intelligence did not significantly predict life satisfaction (see Appendix B for unstandardized estimates).

Table 2

Fit Indices for Latent Moderated Structural Equation Models

	Log-Likelihood	*c*	*df*	χ^2	RMSEA	SRMR	CFI
Model 1							
Without interactions	-5196.31	1.34	140	177.42	.039	.056	.967
With interactions	-5193.04	1.31	-	-	-	-	-
Model 2							
Without interactions	-4138.88	1.32	140	178.34	.040	.059	.967
With interactions	-4136.10	1.30	-	-	-	-	-
Model 3							
Without interactions	-5317.66	1.32	140	173.96	.037	.059	.971
With interactions	-5317.14	1.32	-	-	-	-	-
Model 4							
Without interactions	-5762.50	1.31	252	295.92	.032	.059	.970
With interactions	-5757.43	1.28	-	-	-	-	-
Model 5							
Without interactions	-5766.99	1.33	260	304.14	.031	.062	.970
With interactions	-5764.74	1.32	-	-	-	-	-

Note. *c* = scaling correction factor; *df* = degrees of freedom; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; CFI = comparative fit index. As M*plus* 7.4 does not generate fit indices for models with latent interactions, only log-likelihood values and scaling correction factors are provided for model comparisons.

Table 3

Standardized Coefficient Estimates for Latent Moderated Structural Equation Models

	Model 1		Model 2		Model 3		Model 4		Model 5	
	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B
Path coefficients										
Reappraisal	**.28 (.09)**	**.27 (.08)**	**.26 (.09)**	**.27 (.09)**	**.27 (.10)**	**.27 (.10)**	**.28 (.09)**	**.27 (.08)**	**.27 (.10)**	**.28 (.09)**
Suppression	**-.25 (.09)**	**-.22 (.08)**	**-.24 (.09)**	**-.25 (.09)**	**-.23 (.09)**	**-.23 (.09)**	**-.25 (.09)**	**-.25 (.08)**	**-.22 (.09)**	**-.20 (.09)**
Inhibition	**-.27 (.09)**	**-.26 (.09)**	-	-	-	-	**-.26 (.11)**	**-.28 (.12)**	-	-
Working memory (WM)	-	-	-.03 (.11)	-.03 (.12)	-	-	.02 (.12)	.06 (.14)	-	-
Shifting	-	-	-	-	-.11 (.10)	-.09 (.11)	-.02 (.12)	.03 (.14)	-	-
Common EF	-	-	-	-	-	-	-	-	-.30 (.17)	-.27 (.25)
Intelligence (IQ)	.04 (.07)	.05 (.08)	-.04 (.10)	-.01 (.10)	-.01 (.08)	-.02 (.08)	.04 (.09)	.02 (.09)	.17 (.14)	.18 (.19)
Interactions										
Inhibition x reappraisal	-	**.23 (.08)**	-	-	-	-	-	**.22 (.11)**	-	-
Inhibition x suppression	-	-.13 (.08)	-	-	-	-	-	-.19 (.10)	-	-
WM x reappraisal	-	-	-	**.20 (.08)**	-	-	-	.09 (.11)	-	-
WM x suppression	-	-	-	.07 (.09)	-	-	-	.07 (.12)	-	-
Shifting x reappraisal	-	-	-	-	-	-.03 (.13)	-	-.14 (.10)	-	-
Shifting x suppression	-	-	-	-	-	.13 (.14)	-	.20 (.13)	-	-
Common EF x reappraisal	-	-	-	-	-	-	-	-	-	**.21 (.08)**
Common EF x suppression	-	-	-	-	-	-	-	-	-	-.03 (.14)
Residual correlations										
Suppression ↔ reappraisal	.14 (.11)	.14 (.11)	.15 (.11)	.15 (.11)	.14 (.11)	.15 (.11)	.14 (.11)	.15 (.11)	.15 (.11)	.15 (.11)
IQ ↔ reappraisal	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)
IQ ↔ suppression	**-.14 (.07)**	**-.15 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**
Inhibition ↔ IQ	**.37 (.12)**	**.37 (.12)**	-	-	-	-	**.37 (.12)**	**.38 (.12)**	-	-
Inhibition ↔ reappraisal	.07 (.10)	.08 (.11)	-	-	-	-	.08 (.10)	.08 (.11)	-	-
Inhibition ↔ suppression	-.09 (.11)	-.09 (.11)	-	-	-	-	-.09 (.11)	-.07 (.11)	-	-

WM ↔ IQ	-	-	**.55 (.08)**	**.56 (.08)**	-	-	**.55 (.08)**	**.55 (.08)**	-	-
WM ↔ reappraisal	-	-	.03 (.10)	.03 (.10)	-	-	.03 (.09)	.03 (.09)	-	-
WM ↔ suppression	-	-	-.03 (.11)	-.03 (.11)	-	-	-.04 (.10)	-.03 (.11)	-	-
Shifting ↔ IQ	-	-	-	-	**.43 (.10)**	**.43 (.10)**	**.43 (.10)**	**.43 (.10)**	-	-
Shifting ↔ reappraisal	-	-	-	-	.07 (.10)	.07 (.10)	.07 (.10)	.07 (.10)	-	-
Shifting ↔ suppression	-	-	-	-	.05 (.08)	.05 (.09)	.05 (.08)	.05 (.08)	-	-
Inhibition ↔ WM	-	-	-	-	-	-	**.33 (.10)**	**.33 (.10)**	-	-
Shifting ↔ WM	-	-	-	-	-	-	**.42 (.09)**	**.42 (.09)**	-	-
Shifting ↔ inhibition	-	-	-	-	-	-	**.46 (.12)**	**.46 (.12)**	-	-
Common EF ↔ IQ	-	-	-	-	-	-	-	-	**.72 (.08)**	**.73 (.08)**
Common EF ↔ reappraisal	-	-	-	-	-	-	-	-	.08 (.10)	.10 (.10)
Common EF ↔suppression	-	-	-	-	-	-	-	-	-.03 (.11)	-.03 (.11)

Note. *SE* values are shown in parentheses. The EF moderators of inhibition (Model 1), working memory (Model 2), and shifting (Model 3) were assessed independently. All three EF moderators were evaluated simultaneously in Model 4, while the common EF moderator was assessed in Model 5. All models were first estimated without interactions (Models A), and interaction terms were added subsequently (Models B). Significant results are marked in boldface, $p < .05$.

We now turn to the models with interactions. For inhibitory control (Model 1), the model without inhibitory control as a moderator had a significantly worse fit than the model with interactions, $\Delta\chi^2(2) = 13.14$, *p* = .001. Specifically, the inhibitory control x reappraisal (β = .23, *p* = .003), but not inhibitory control x suppression, interaction term was significant. Moreover, the Bayesian estimates corroborate the interactive effects of inhibitory control with reappraisal, but not suppression, on life satisfaction, β = .24, 95% CI [.05, .41]. Further, when the Johnson-Neyman procedure was employed to determine the significance region, the positive relation between reappraisal and life satisfaction was significant above the value at –0.63 *SD* for inhibitory control. Specifically, at higher levels (e.g., +1 *SD*) of inhibitory control, the relation between reappraisal and life satisfaction was significantly positive, but not at lower levels of inhibitory control (e.g., -1 *SD*). Therefore, the positive relation between reappraisal and life satisfaction increases with more proficient inhibitory abilities (see Figure 1).

Similarly, for working memory (Model 2), the model without working memory as a moderator had a significantly poorer fit than the model with interactions, $\Delta\chi^2(2) = 11.13$, *p* = .004. In addition, the working memory x reappraisal (β = .20, *p* = .010), but not working memory x suppression, interaction term was significant. This was further supported by the Bayesian estimates for the working memory x suppression interaction term, β = .21, 95% CI [.02, .40]. The Johnson-Neyman procedure showed that the positive relation between reappraisal and life satisfaction was significant above the value at -0.62 *SD* for working memory. Notably, the association between reappraisal and life satisfaction was significantly positive at higher levels (e.g., +1 *SD*), but not at lower levels (e.g., -1 *SD*), of working memory. Hence, the positive contribution of reappraisal toward life satisfaction strengthens with better working memory abilities (see Figure 2).

For shifting (Model 3), the model without shifting as a moderator did not significantly differ from the model with interactions in its model fit, $\Delta\chi^2(2) = 0.69$, $p = .709$; moreover, none of the interaction terms were significant (see Tables 2 and 3). Likewise, the Bayesian estimates reflected the lack of support for the shifting x reappraisal and shifting x suppression interaction terms, thereby indicating that shifting did not moderate the influences of reappraisal and suppression on life satisfaction.

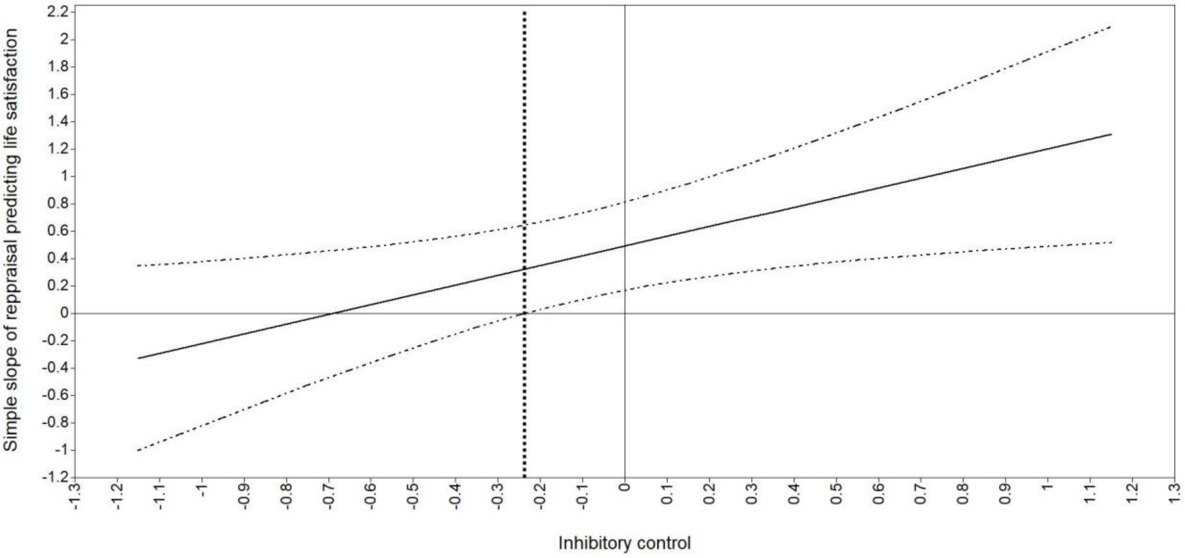

Figure 1. Johnson-Neyman plot for Model 1 illustrates how the slope of reappraisal that predicts life satisfaction (represented by the solid line, with dash-dot lines indicating 95% confidence intervals) varies across values of inhibitory control (mean-centered), which range from -1.15 (-3 *SD*) to +1.15 (+3 *SD*). The association between reappraisal and life satisfaction becomes more positive with increasing values of inhibitory control. At the inhibitory control value of -0.24 (i.e., –0.63 *SD*, as indicated by the vertical dashed line) and higher, the effect of reappraisal on life satisfaction is significant.

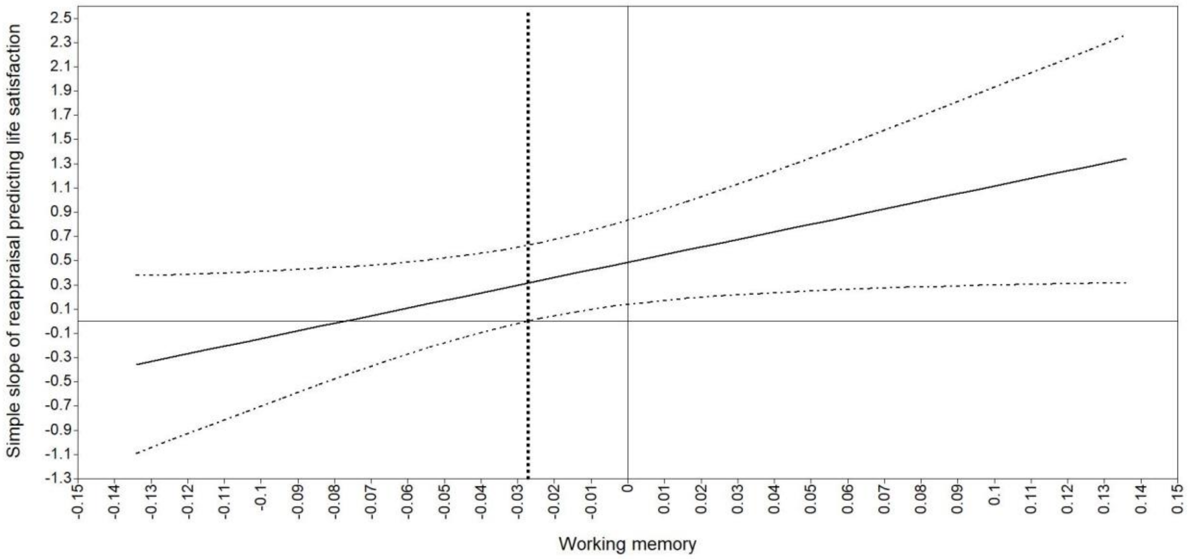

Figure 2. Johnson-Neyman plot for Model 2 illustrates how the slope of reappraisal that predicts life satisfaction (represented by the solid line, with dash-dot lines indicating 95% confidence intervals) varies across values of working memory (mean-centered), which range from -0.13 (-3 *SD*) to +0.13 (+3 *SD*). The effect of reappraisal on life satisfaction becomes more positive with increasing values of working memory. At the working memory value of -0.03 (i.e., -0.62 *SD*, as indicated by the vertical dashed line) and higher, the association between reappraisal and life satisfaction is significant.

For Model 4, which was to explore unique, construct-specific variances of each EF dimension (i.e., inhibitory-control-specific, working-memory-specific, and shifting-specific components), the model without interactions was not significantly different from the model with interactions, $\Delta\chi^2(6) = 11.83$, $p = .066$. Specifically, in contrast to the positive findings from Models 1 and 2, the inhibitory control x reappraisal term was barely significant ($\beta = .22$, $p = .047$) and the working memory x reappraisal term was not significant ($\beta = .09$, $p = .395$). Similar to the findings from Models 1 and 2, the interactive effects of inhibitory control and working memory with suppression were not significant. Akin to the results from Model 3, interactions involving shifting with reappraisal and suppression were not significant. Additionally, the Bayesian estimates indicated that none of the interaction terms were supported. Moreover, Model 4 lacked sufficient statistical power (< 70%), and thus the results should be regarded with care. These equivocal findings indicate that the moderating effects of each EF facet on the relation between reappraisal and life satisfaction remain elusive.

For Model 5, which reflects the hierarchical structure of the EF construct with one second-order common EF factor, the model without interactions did not significantly differ from the model with interactions, $\Delta\chi^2(2) = 5.48$, $p = .064$. Nevertheless, the common EF x reappraisal ($\beta = .21$, $SE = .08$, $p = .009$), but not the common EF x suppression, interaction term was significant. Further, omitting the nonsignificant common EF x suppression interaction term resulted in a significantly improved fit for the model with interactions, $\Delta\chi^2(1) = 4.64$, $p = .031$. Similarly, the common EF x reappraisal interaction was supported by the Bayesian analysis, $\beta = .21$, 95% CI [.02, .42]. The Johnson-Neyman plot demonstrated that the positive relation between reappraisal and life satisfaction was significant above the value of -0.65 *SD* for common EF (see Figure 3). Moreover, the effect of reappraisal on life satisfaction was significantly positive at higher levels (e.g., +1 *SD*), but not at lower levels (e.g., -1 *SD*), of common EF. Specifically, the positive contribution of reappraisal toward life satisfaction becomes more pronounced with higher levels of common EF abilities, which underlie all three EF facets.

In summary, the results from Models 4 and 5 qualify our initial findings from Models 1 to 3. Specifically, the interactive effects of inhibitory control (Model 1) and working memory (Model 2) with reappraisal were primarily driven by the common EF component (Model 5), rather than the inhibitory-control-specific and working-memory-specific components (Model 4). On the other hand, the lack of interactive effect between shifting and reappraisal (Model 3) was primarily attributed to the null interaction between shifting-specific ability and reappraisal (Model 4) which attenuated the interaction of common EF with reappraisal (Model 5).

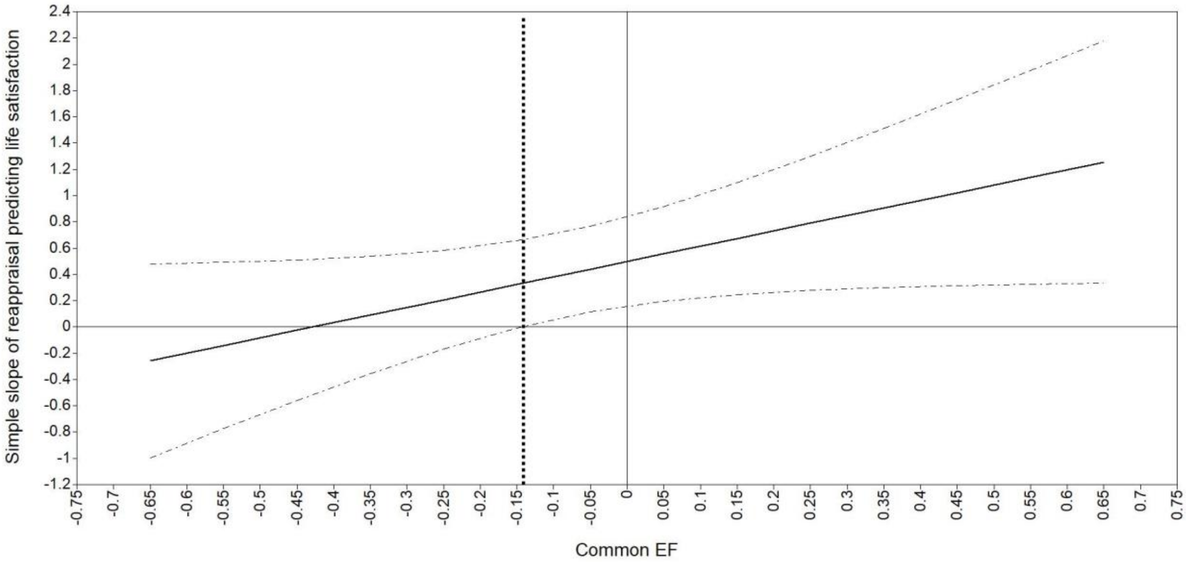

Figure 3. Johnson-Neyman plot for Model 4 illustrates how the slope of reappraisal that predicts life satisfaction (represented by the solid line, with dash-dot lines indicating 95% confidence intervals) varies across values of Common EF (mean-centered), which range from -0.65 (-3 *SD*) to +0.65 (+3 *SD*). The influence of reappraisal on life satisfaction becomes more positive with increasing values of Common EF. At the Common EF value of -0.14 (i.e., -0.65 *SD*, as indicated by the vertical dashed line) and higher, the association between reappraisal and life satisfaction is significant.

We performed further exploratory analyses to inquire whether intelligence would moderate the effect of emotion regulation on life satisfaction, given the shared variance between EF components and intelligence as reported in the literature.[3] To this end, we regressed life satisfaction on all three EF factors, reappraisal, suppression, and intelligence, as well as the interactions of intelligence with reappraisal and suppression. We found that the intelligence x reappraisal interaction term was significant (β = .20, *SE* = .08, *p* = .017), but not the intelligence x suppression term, thereby indicating that the positive relation between reappraisal and life satisfaction is magnified with higher levels of intelligence. Additionally, we assessed all possible interactive effects involving emotion regulation strategies with EF dimensions and intelligence within a single model (i.e., inhibitory control x reappraisal, inhibitory control x suppression, working memory x reappraisal, working memory x suppression, shifting x reappraisal, shifting x suppression, common EF x reappraisal, common EF x suppression, intelligence x reappraisal, and intelligence x suppression). Results indicated that, consistent with the findings from Model 1, the interaction between inhibitory control and reappraisal was significant ($\beta = .23$, $SE = .11$, $p = .03$); no other interactions were significant (*p*s > .10). However, it should be noted that, based on our Monte Carlo simulations, the model had insufficient statistical power (< 50%). Further, since the second-order common EF factor and the first-order EF factors were entered as predictors in this structural model, their shared variance (i.e., common EF) would be statistically removed. Therefore, the common EF latent variable may not necessarily reflect the shared variance across all EF factors, which affects the theoretical interpretability of the common EF factor. Moreover, using predictors that are considerably correlated with each other (i.e., common EF, inhibition, working memory, and shifting) results in multicollinearity issues as manifested by large error variances and unreliable estimates of path coefficients (Friedman & Miyake, 2017). Therefore, findings from our post-hoc model should be interpreted with caution.

RT and accuracy scores

Given that RT and accuracy scores are the most conventional indices of the flanker effect and switch costs for inhibition and shifting tasks, respectively (Draheim, Hicks, & Engle, 2016), we examined the RT and accuracy scores for all conditions of the inhibition and shifting tasks (see Table C1 in Appendix C). Across all inhibition tasks, the RT and accuracy scores for the congruent trials significantly differed from those for the incongruent trials, thereby demonstrating the flanker effect for both RT and accuracy. Likewise, across all shifting tasks, the RT and accuracy scores for the repeat trials significantly departed from those for the switch trials, which signify switch costs. Therefore, we confirmed the presence of the flanker effect and switch costs, which in turn highlights the fact that the inhibitory control and shifting tasks worked as expected.

Further, to examine construct validity, we performed latent moderated structural equation analyses by using RT difference scores (instead of bin scores) for the inhibitory control and shifting tasks (see Table C2 of Appendix C). For the inhibitory control tasks, the flanker effect was computed by subtracting the mean RT of congruent trials from the mean RT of incongruent trials. For the shifting tasks, switch costs were computed by subtracting the mean RT of repeat trials from the mean RT of switch trials. The flanker effect and switch costs were reversed-scored (by multiplying by -1) such that higher values reflect better inhibition and shifting performance, respectively.

In essence, the findings based on RT difference scores were consistent with those from our main analyses using bin scores; that is, the inhibition x reappraisal effect was significant ($\beta = .18$, $SE = .07$, $p = .012$), and all other interactions of inhibition and shifting with reappraisal and suppression were not significant. It should be noted, however, that although all inhibition RT difference scores significantly loaded onto the inhibition latent variable (βs < .69, *p*s < .026), the shifting RT difference scores revealed nonsignificant factor loadings for the shifting latent variable, which indicate poor construct validity for the shifting RT difference scores. Therefore, we modeled inhibition RT difference scores as a latent variable, while shifting RT difference scores were modeled as a manifest variable (based on a composite mean of all three switch costs in RT). The poor construct validity of shifting RT difference scores reinforces our use of bin scores; specifically, unlike RT scores, all bin scores significantly loaded on the shifting latent variable (see Table 1).

Discussion

Using a latent moderated structural equation analysis, we found that the EF components—inhibitory control, working memory, shifting, and common EF—differentially moderated the effects of reappraisal, but not suppression, on life satisfaction. Notably, consistent with prior evidence highlighting the role of inhibitory control and working memory in reappraisal (McRae et al., 2012; Tabibnia et al., 2011), we found that reappraisal positively predicted life satisfaction at higher, but not lower, levels of inhibitory control and working memory (Models 1 and 2; see Figures 1 and 2). Notably, inhibitory control assists in restraining undesired situational appraisals during reappraisal (Tang & Schmeichel, 2015), while working memory enables the gating and revision of situational narratives in one's mind during reappraisal (McRae et al., 2012). By analysing the shared and unique aspects of EF dimensions, we clarified that the shared, but not unique (i.e., inhibitory-control-specific, working-memory-specific), variance among EF facets was responsible for our findings from Models 1 and 2. Specifically, the impact of reappraisal on life satisfaction becomes more pronounced with more proficient levels of common EF. Common EF may be involved in reappraisal-related goal-management processes such as maintaining positive narratives in one's mind while resisting interference from conflicting negative appraisals, and monitoring the extent to which one's affective state has been changed. These findings support the idea that EF may represent tools that individuals draw on to complement their emotion regulation strategies. Crucially, more proficient common EF facilitates reappraisal processes, thereby potentiating their influences on life satisfaction.

In contrast, shifting did not moderate any associations of reappraisal and suppression with life satisfaction (Model 3). This finding dovetails with previous findings regarding the tenuous link between reappraisal and shifting (Gyurak et al., 2012; McRae et al., 2012). Although reappraisal may entail switching from one narrative to another, it does not seem to require constant and continuous switching back and forth between multiple mental sets (Monsell, 2003). In essence, once a favorable narrative has been selected, it is more adaptive to maintain the desired appraisal; hence, further switching is unlikely to occur. Therefore, the null findings could be due to the minimal demands that reappraisal imposes on shifting abilities, relative to either inhibitory control or working memory. Nevertheless, it is also plausible that reappraisal may involve other cognitive abilities that implicate some aspects of shifting, such as cognitive flexibility (e.g., being able to adaptively adjust perspectives or attention in response to changing goals; Diamond, 2013). This would be an intriguing avenue for future research.

Additionally, in contrast to the findings on reappraisal, we found that inhibitory control and working memory did not moderate the influence of suppression on life satisfaction. These outcomes appear to be at odds with past findings suggesting that inhibitory control and working memory may aid in suppression (e.g., Schmeichel et al., 2008; von Hippel & Gonsalkorale, 2005). However, given that previous studies used only single tasks to index working memory, it is possible that the positive relation between suppression with inhibitory and working memory could have been driven by non-EF task demands, owing to task-impurity problems in EF tasks (Miyake et al., 2000). Our study is the first to use a latent variable approach to address task-impurity issues in assessing the moderating effect of inhibitory control and working memory on the relation between suppression and life satisfaction. Therefore, more research, using multiple indices for inhibitory control and working memory, is needed to replicate our results and verify whether inhibitory control and working memory underlies suppression.

Our findings join recent efforts to identify the role of possible factors (e.g., culture; Butler et al., 2007; Soto et al., 2007) that could moderate the relations between emotion regulation and psychological well-being. Further, the differential moderating effect of EF on the relation between emotion regulation and life satisfaction reinforces the multifaceted nature of EF. Notably, our results align with other findings indicating that not all EF components similarly moderate the associations between behavioral outcomes (Cohen et al., 2012; Ito et al., 2015; Pe et al., 2013), thereby underscoring the importance of assessing the various components of EF. Moreover, our finding that common EF most pivotally moderates the effect of reappraisal on life satisfaction is consistent with recent work highlighting the integral role of common EF in various crucial behavioral outcomes, such as behavioral disinhibition (Herd et al., 2014); implicit racial bias (Ito et al., 2015); procrastination (Gustavson, Miyake, Hewitt, & Friedman, 2015); substance abuse (Gustavson et al., 2017); and trait worry (Gustavson et al., 2019). Additionally, apart from EF, we found that intelligence moderated the association between reappraisal and life satisfaction. Specifically, the positive effect of reappraisal on life satisfaction increases with higher levels of intelligence. This could be because more intelligent individuals may recognize the adaptive value of reappraisal and would, therefore, employ reappraisal appropriately and effectively in managing undesired negative emotions, which in turn boosts life satisfaction.

Notably, since we assessed the tendency to adopt emotion regulation strategies, our study focused on the moderating, instead of mediating, role of EF in the relation between emotion regulation and life satisfaction. Given that higher levels of EF are primarily relevant to the success (ability) of emotion regulation strategies and do not necessarily translate to more frequent use of emotion regulation strategies (e.g., reappraisal; Toh, Yang, & Hartanto, 2019; Toh, 2019), a mediation model—specifying that more proficient EF is concomitant with higher tendency to use emotion regulation strategies which, in turn, enhance life satisfaction—is less viable. Moreover, the tendency to employ a specific emotion regulation strategy may be contingent on other factors, such as culture (Butler, Lee, & Gross, 2007) or personality (Gross & John, 2003), in addition to how successful one is in executing the strategy. Thus, mediational associations between EF, emotion regulation, and life satisfaction are plausible if reappraisal strategies are assessed in terms of abilities, because individuals with greater EF abilities may be able to more effectively and successfully implement emotion regulation strategies—which in turn enhances life satisfaction—but they may not necessarily employ these emotion regulation strategies with greater frequency (see also McRae, 2013). Indeed, differentiating the frequency and the success of emotion regulation strategies, and how they would be related to EF and life satisfaction, are promising avenues that future research should pursue.

Apart from the moderation results, we found that reappraisal and suppression positively and negatively predicted life satisfaction, respectively. These results are congruent with the outcomes of past studies based on European American samples (e.g., Butler et al., 2003; Gross & John, 2003). However, given that our participants were East Asians, the negative relation between suppression and life satisfaction is inconsistent with Soto et al.'s (2011) finding that the detrimental effect of suppression on life satisfaction was not evident in participants from East Asian cultures (e.g., Hong Kong), which encourage emotion-expressive suppression—particularly those involving negative emotions—in service of social harmony. A reasonable explanation for this discrepancy could be that our use of the latent variable approach, which affords purer estimates of suppression and life satisfaction, allowed potential relations to be manifested. Indeed, we found that, similar to Soto et al. (2011), the composite scores of suppression and life satisfaction were not significantly related ($r = -.14$, $p = .07$). Another possibility is that our Singaporean sample may hold more individualistic values, which foster emotion-expressive behaviors, than the Hong Kong sample in Soto et al. (2011). Therefore, further studies are needed to clarify the cultural values internalized by participants to better understand how suppression affects life satisfaction.

We also found that inhibitory control negatively predicted life satisfaction. Although satisfactory explanations are not readily available, we propose two possibilities. First, given that inhibitory control is crucial for goal maintenance (Kane & Engle, 2003), individuals with more proficient levels of inhibitory control likely set higher goals and aspirations which may not be easily attained. Given that goal progress and accomplishment are pivotal aspects of life satisfaction, better inhibitory control abilities may stimulate greater disparity in current and ideal selves, thereby negatively predicting life satisfaction, unless inhibitory control enacts adaptive psychological processes such as reappraisal. Second, given that inhibitory control of distractor interference has been shown to be impaired under positive affect (Rowe, Hirsh, & Anderson, 2007), higher inhibitory control could be related to lower positive affect, which has been shown to be concomitant with life satisfaction (Diener et al., 1999). Since these explanations are speculative, uncovering the mechanisms whereby inhibitory control and life satisfaction are related would be a worthy subject for future studies.

In contrast to inhibitory control, we found that working memory and shifting did not predict life satisfaction. It is notable, however, that a recent study demonstrated that a composite score of EF—based on multiple tasks that loaded on the same (EF) factor—more positively contributes to life satisfaction, through higher sense of control, for older adults than for younger adults (Toh et al., 2019). This finding suggests that the role of EF in life satisfaction may become more prominent with age, especially during late adulthood when cognitive functions rapidly decline. Given that our sample comprised young adults who are typically at their peak cognitive performance, our findings of an absence of direct positive relations between EF (shifting and working memory) and life satisfaction are perhaps not surprising.

Our study is not without limitations. First, its correlational nature restricts causal inferences. For instance, even though we assume that greater reliance on reappraisal engenders life satisfaction, it is possible that greater satisfaction with life encourages one to use reappraisal more frequently to maintain such elevated levels of well-being. Therefore, future research should employ longitudinal designs to ascertain the directionality between emotion regulation strategies and life satisfaction. Second, our research conceptualized inhibitory control as the ability to resist distractor interference. Further work could investigate whether other forms of inhibition, such as prepotent response inhibition (i.e., suppression of dominant responses; Friedman & Miyake, 2004), would similarly moderate the effects of emotion regulation strategies on life satisfaction. Third, given that our study considered only the cognitive component of subjective well-being (i.e., life satisfaction), future studies could extend our findings to other facets of well-being (e.g., affect balance, psychological well-being). Fourth, our findings from young adults may not be generalizable to other age groups. Therefore, more work is needed to replicate our findings for middle-aged and older adults. Lastly, although we found consistent results across multiple analytic approaches (i.e., bin scores, RT difference scores, and Bayesian analysis), our modest effect sizes, coupled with the exploratory nature of our study, indicate that our findings should be interpreted with caution. Moreover, even though our sample size is larger than those from the literature on emotion regulation and EF (*N*s = 30 to 89; e.g., Cohen et al., 2012; McRae et al., 2012), it still lacks statistical power for more complex structural equation models that simultaneously test all interactive terms involving the three EF components with reappraisal and suppression. Nevertheless, it should be noted that the effect sizes in our study are consistent with those from past studies investigating the interactive effects of EF with self-reported and performance-based measures (|β|s =.16 to 34; Hofmann, Friese, & Roefs, 2009; Ito et al., 2015). Future research should employ more reliable methods to minimize biases associated with self-reports (e.g., experience sampling approaches) and replicate our results with larger and more heterogenous samples in order to ascertain how emotion regulation interacts with the unique and shared aspects of EF on life satisfaction.

In conclusion, our study provides an initial demonstration that EF is an important cognitive resource that potentiates the effects of emotion regulation (in particular, reappraisal) on life satisfaction. Notably, the finding that high EF (i.e., common variance across EF constituents) and frequent use of reappraisal afford the best outcomes for life satisfaction holds clinical relevance for interventions that aim to improve anxiety and mood disorders through reappraisal-related skills (Giuliani & Gross, 2009). Critically, given the trainability of EF through consistent practice (Diamond, 2013), improving EF may further enhance the ability of reappraisal to mitigate negative moods and elevate life satisfaction.

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Footnotes

[1] Our data and code are available at https://osf.io/8c5wb/

[2] We thank Dr. Richard Lucas for this suggestion.

[3] We thank Dr. Heather Urry and Dr. Richard Lucas for this suggestion.

Appendix A

Table A1

Latent Variable Correlations

Latent variables	1	2	3	4	5
1. Life satisfaction	**-**				
2. Reappraisal	**.22 (.10)**	**-**			
3. Suppression	**-.19 (.09)**	.15 (.11)	-		
4. Inhibitory control	**-.22 (.09)**	.08 (.10)	-.09 (.11)	-	
5. Working memory	-.04 (.08)	.04 (.09)	-.04 (.10)	**.31 (.10)**	-
6. Shifting	-.10 (.09)	.07 (.10)	.05 (.08)	**.45 (.11)**	**.41 (.09)**

Note. *SE*s are shown in parentheses. Significant results are marked in boldface, $p < .05$.

Appendix B

Table B1

Unstandardized Coefficient Estimates for Latent Moderated Structural Equation Models

	Model 1		Model 2		Model 3		Model 4		Model 5	
	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B
Path coefficients										
Reappraisal	**.30 (0.11)**	**.31 (0.10)**	**.28 (0.11)**	**.29 (0.11)**	**.28 (0.11)**	**.29 (0.11)**	**.31 (0.11)**	**.32 (0.10)**	**.29 (.11)**	**.29 (.11)**
Suppression	**-.27 (0.10)**	**-.25 (0.10)**	**-.25 (0.10)**	**-.27 (0.10)**	**-.24 (0.10)**	**-.25 (0.10)**	**-.27 (0.10)**	**-.29 (0.10)**	**-.24 (.10)**	**-.24 (.10)**
Inhibition	**-.29 (0.11)**	**-.30 (0.11)**	-	-	-	-	**-.29 (0.12)**	**-.32 (0.15)**	-	-
Working memory (WM)	-	-	-.04 (0.12)	-.04 (0.13)	-	-	.03 (0.13)	.06 (0.16)	-	-
Shifting	-	-	-	-	-.10 (0.11)	-.09 (0.12)	-.02 (0.13)	.03 (0.16)	-	-
Common EF	-	-	-	-	-	-	-	-	-.33 (.19)	-.33 (.19)
Intelligence (IQ)	.01 (0.01)	.01 (0.02)	-.01(0.02)	-.00 (0.02)	-.00 (0.02)	-.00 (0.02)	.01 (0.02)	.00 (0.02)	.03 (.03)	.03 (.03)
Interactions										
Inhibition x reappraisal	-	**.26 (.09)**	-	-	-	-	-	**.26 (0.13)**	-	-
Inhibition x suppression	-	-.14 (.09)	-	-	-	-	-	-.22 (0.12)	-	-
WM x reappraisal	-	-	-	**.22 (0.09)**	-	-	-	.10 (0.13)	-	-
WM x suppression	-	-	-	.08 (0.10)	-	-	-	.09 (0.14)	-	-
Shifting x reappraisal	-	-	-	-	-	-.03 (0.14)	-	-.16 (0.12)	-	-
Shifting x suppression	-	-	-	-	-	.14 (0.15)	-	.23 (0.16)	-	-
Common EF x reappraisal	-	-	-	-	-	-	-	-	-	**.23 (.09)**
Common EF x suppression	-	-	-	-	-	-	-	-	-	-.04 (.15)
Residual correlations										
Suppression ↔ reappraisal	.15 (0.11)	.14 (0.11)	.15 (0.11)	.15 (0.11)	.15 (0.11)	.14 (0.11)	.15 (0.11)	.14 (0.11)	.15 (.11)	.14 (.11)
IQ ↔ reappraisal	.52 (0.41)	.53 (0.41)	.52 (0.41)	.52 (0.41)	.52 (0.41)	.51 (0.41)	.52 (0.41)	.52 (0.41)	.52 (.41)	.52 (.41)
IQ ↔ suppression	**-.82 (0.40)**	**-.85 (0.40)**	**-.81 (0.40)**	**-.82 (0.40)**	**-.82 (0.40)**	**-.81 (0.40)**	**-.83 (0.40)**	**-.82 (0.40)**	**-.82 (.40)**	**-.83 (.40)**
Inhibition ↔ IQ	**2.08 (0.7)**	**2.13 (0.69)**	-	-	-	-	**2.13 (0.72)**	**2.18 (0.73)**	-	-

Inhibition ↔ reappraisal	.07 (0.10)	.08 (0.11)	-	-	-	-	.08 (0.10)	.08 (0.11)	-	-
Inhibition ↔ suppression	-.09 (0.11)	-.09 (0.11)	-	-	-	-	-.09 (0.11)	-.07 (0.11)	-	-
WM ↔ IQ	-	-	**3.17 (0.59)**	**3.20 (0.59)**	-	-	**3.13 (0.59)**	**3.14 (0.59)**	**-**	**-**
WM ↔ reappraisal	-	-	.03 (0.10)	.03 (0.10)	-	-	.03 (0.09)	.03 (0.09)	-	-
WM ↔ suppression	-	-	-.03 (0.11)	-.03 (0.11)	-	-	-.04 (0.10)	-.03 (0.11)	-	-
Shifting ↔ IQ	-	-	-	-	**2.45 (0.63)**	**2.44 (0.64)**	**2.45 (0.62)**	**2.44 (0.62)**	-	-
Shifting ↔ reappraisal	-	-	-	-	0.07 (0.10)	0.07 (0.10)	.07 (0.10)	.07 (0.10)	-	-
Shifting ↔ suppression	-	-	-	-	0.05 (0.08)	0.05 (0.09)	.05 (0.08)	.05 (0.08)	-	-
Inhibition ↔ WM	-	-	-	-	-	-	**.33 (0.10)**	**.33 (0.10)**	-	-
Shifting ↔ WM	-	-	-	-	-	-	**.42 (0.09)**	**.42 (0.09)**	-	-
Shifting ↔ inhibition	-	-	-	-	-	-	**.46 (0.12)**	**.46 (0.12)**	-	-
Common EF ↔ IQ	.15 (0.11)	.14 (0.11)	.15 (0.11)	.15 (0.11)	.15 (0.11)	.14 (0.11)	-	-	**4.15 (.58)**	**4.19 (.57)**
Common EF ↔ reappraisal	.52 (0.41)	.53 (0.41)	.52 (0.41)	.52 (0.41)	.52 (0.41)	.51 (0.41)	-	-	.08 (.10)	.10 (.10)
Common EF ↔suppression	**-.82 (0.40)**	**-.85 (0.40)**	**-.81 (0.40)**	**-.82 (0.40)**	**-.82 (0.40)**	**-.81 (0.40)**	-	-	-.03 (.11)	-.04 (.11)

Note. Values reflect standardized coefficient estimates (with *SE*s shown in parentheses). The EF moderators of inhibition (Model 1), working memory (Model 2), and shifting (Model 3) were assessed independently; all moderators were evaluated simultaneously in Model 4, while the common EF moderator was assessed in Model 5. All models were first estimated without interactions (Models A) and interaction terms were added subsequently (Models B). Significant results are marked in boldface, $p < .05$.

Appendix C

Table C1

Latency and Accuracy Scores for Inhibitory Control and Shifting Tasks

	RT (ms)		Accuracy	
	Congruent	Incongruent	Congruent	Incongruent
Inhibition				
Arrow flanker	489.02 (81.77)^a	650.12 (145.67)^b	0.98 (0.07)^a	0.94 (0.11)^b
Color flanker	522.61 (75.15)^a	580.35 (82.33)^b	0.96 (0.05)^a	0.94 (0.07)^b
Eriksen flanker	592.20 (99.63)^a	682.05 (122.33)^b	0.96 (0.08)^a	0.95 (0.06)^b
Shifting	Repeat	Switch	Repeat	Switch
Animacy-locomotion	748.64 (282.16)^a	906.22 (440.91)^b	0.95 (0.08)^a	0.90 (0.09)^b
Color-shape	805.18 (322.66)^a	992.74 (402.09)^b	0.97 (0.05)^a	0.92 (0.08)^b
Magnitude-parity	727.50 (224.06)^a	842.36 (233.11)^b	0.93 (0.10)^a	0.89 (0.10)^b

Note. Values signify means with standard deviations shown in parentheses. Superscripts with different letters indicate that means of congruent and incongruent trials or repeat and switch trials significantly differ from each other, $p < .05$.

Table C2

Latent Moderated Structural Equation Models for Inhibition and Shifting Latency Scores (RT)

	Inhibition		Shifting	
	A	B	A	B
Path coefficients				
Reappraisal	**.31 (.10)**	**.32 (.09)**	**.26 (.09)**	.03 (.16)
Suppression	**-.24 (.09)**	**-.24 (.09)**	**-.24 (.09)**	-.03 (.18)
Inhibition	-.14 (.12)	-.06 (.12)	-	-
Shifting	-	-	.06 (.09)	.04 (.09)
Intelligence	-.06 (.07)	-.04 (.07)	-.06 (.07)	-.04 (.07)
Interactions				
Inhibition x reappraisal	**-**	**.18 (.08)**	-	-
Inhibition x suppression	-	.04 (.07)	-	-
Shifting x reappraisal	-	-	-	-.17 (.09)†
Shifting x suppression	-	-	-	.15 (.12)
Residual correlations				
Suppression ↔ reappraisal	.15 (.11)	.15 (.11)	.15 (.11)	.15 (.11)
Intelligence ↔ reappraisal	.09 (.07)	.09 (.07)	.09 (.07)	.09 (.07)
Intelligence↔ suppression	**-.14 (.07)**	**-.14 (.07)**	**-.14 (.07)**	**-.15 (.07)**
Inhibition ↔ intelligence	.01 (.13)	.02 (.13)	-	-
Inhibition ↔ reappraisal	**.33 (.13)**	**.32 (.13)**	-	-
Inhibition ↔ suppression	.04 (.16)	.05 (.14)	-	-
Shifting ↔ intelligence	-	-	.06 (.07)	.06 (.07)
Shifting ↔ reappraisal	-	-	-.03 (.08)	-.03 (.08)
Shifting ↔ suppression	-	-	-.07 (.08)	-.06 (.08)

Note. Values reflect standardized coefficient estimates (with *SE*s shown in parentheses). Given that the measurement model revealed nonsignificant factor loadings for the shifting latent variable, we used a single composite score, based on the mean of all three switch costs, instead. Flanker effect and switch costs were reversed-scored (by multiplying by -1) such that higher values reflect better inhibition and shifting performance, respectively. All models were first estimated without interactions (Models A) and interaction terms were added subsequently (Models B). Significant results are marked in boldface; $p < .05$, $^{\dagger} p < .10$.

Appendix D

Table D1

Standardized Coefficient Estimates for Bayesian Latent Moderated Structural Equation Models

	Model 1		Model 2		Model 3		Model 4		Model 5	
	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B
Path coefficients										
Reappraisal	**.28** **[.11, .43]**	**.27** **[.10, .43]**	**.26** **[.09,.41]**	**.27** **[.10,.43]**	**.26** **[.09,.42]**	**.27** **[.11,.42]**	**.30** **[.15,.45]**	**.27** **[.10,.43]**	**.27** **[.10,.43]**	**.28** **[.09,.45]**
Suppression	**-.25** **[-.41, -.07]**	**-.22** **[-.39, -.04]**	**-.23** **[-.39,-.05]**	**-.25** **[-.41,-.06]**	**-.22** **[-.39,-.05]**	**-.23** **[-.40,-.05]**	**-.25** **[-.44,-.07]**	**-.26** **[-.44,-.08]**	**-.21** **[-.38,-.03]**	-.18 [-.36,.01]
Inhibition	**-.26 (.09)** **[-.46, -.06]**	**-.26** **[-.47, -.04]**	-	-	-	-	**-.28** **[-.60,-.03]**	**-.29** **[-.54,-.01]**	-	-
Working memory (WM)	-	-	-0.05 [-.24,.21]	-0.02 [-.27,.20]	-	-	.03 [-.20,.24]	.09 [-.16,.37]	-	-
Shifting	-	-	-	-	-0.12 [-.28,.06]	-.09 [-.30,.12]	-.01 [-.23,.27]	.05 [-.21,.31]	-	-
Common EF	-	-	-	-	-	-	-	-	-.31 [-.70,.04]	-.39 [-.77,.06]
Intelligence (IQ)	.04 [-.10,.16]	.05 [-.11,.23]	-.01 [-.21,.18]	-.03 [-.20,.21]	.01 [-.09,.12]	.01 [-.20,.20]	.04 [-.02,.13]	-.04 [-.28,.17]	.18 [-.11,.53]	.29 [-.07,.61]
Interactions										
Inhibition x reappraisal	-	**.24** **[.05,.41]**	-	-	-	-	-	.25 [-.03,.51]	-	-
Inhibition x suppression	-	-.13 [-.34,.09]	-	-	-	-	-	-.22 [-.51,.06]	-	-
WM x reappraisal	-	-	-	**.21** **[.02,.40]**	-	-	-	.09 [-.16,.33]	-	-
WM x suppression	-	-	-	.07 [-.15,.28]	-	-	-	.09 [-.16,.33]	-	-
Shifting x reappraisal	-	-	-	-	-	-.03 [-.23,.18]	-	-.17 [-.43,.06]	-	-
Shifting x suppression	-	-	-	-	-	.14 [-.13,.40]	-	.22 [-.06,.54]	-	-
Common EF x reappraisal	-	-	-	-	-	-	-	-	-	**.21** **[.02,.41]**

Common EF x suppression	-	-	-	-	-	-	-	-	-	-.06 [-.31,.21]
Residual correlations										
Suppression ↔ reappraisal	.14 [-.04,.31]	.14 [-.03,.31]	.14 [-.04,.31]	.14 [-.04,.32]	.14 [-.04,.28]	.14 [-.04,.32]	.13 [-.03,.29]	14 [-.04,.32]	.15 [-.03,.31]	.14 [-.04,.31]
IQ ↔ reappraisal	.09 [-.07,.25]	.09 [-.07,.24]	.09 [-.07,.25]	.09 [-.07,.25]	.09 [-.06,.24]	.09 [-.08,.24]	.08 [-.07,.25]	0.09 [-.08,.26]	.09 [-.07,.25]	.09 [-.07,.24]
IQ ↔ suppression	-.15 [-.31,.03]	-.15 [-.31,.02]	-.14 [-.31,.03]	-.14 [-.31,.02]	**-.14** **[-.30,.04]**	**-.14** **[-.31,.03]**	-.14 [-.32,.03]	-.15 [-.31,.03]	-.14 [-.31,.03]	-.15 [-.31,.02]
Inhibition ↔ IQ	**.36** **[.17,.53]**	**.37** **[.18,.54]**	-	-	-	-	**.38** **[.19,.55]**	**.39** **[.19,.56]**	-	-
Inhibition ↔ reappraisal	.07 [-.13,.27]	.08 [-.12,.28]	-	-	-	-	.08 [-.14,.30]	.08 [-.11,.27]	-	-
Inhibition ↔ suppression	-.09 [-.30,.12]	-.09 [-.30,.12]	-	-	-	-	-.08 [-.30,.14]	-.06 [-.28,.16]	-	-
WM ↔ IQ	-	-	**.55** **[.37,.68]**	**.56** **[.42,.69]**	-	-	**.53** **[.38,.66]**	**.55** **[.41,.68]**	-	-
WM ↔ reappraisal	-	-	.02 [-.17,.20]	.03 [-.16,.22]	-	-	.04 [-.17,.22]	.03 [-.16,.22]	-	-
WM ↔ suppression	-	-	-.04 [-.24,.16]	-.04 [-.24,.17]	-	-	-.03 [-.25,.15]	-.03 [-.23,.16]	-	-
Shifting ↔ IQ	-	-	-	-	**.41** **[.26,.57]**	**.42** **[.26,.57]**	**.43** **[.25,.56]**	**.43** **[.27,.57]**	-	-
Shifting ↔ reappraisal	-	-	-	-	.06 [-.11,.23]	.07 [-.11,.25]	.07 [-.10,.25]	.07 [-.12,.25]	-	-
Shifting ↔ suppression	-	-	-	-	.06 [-.14,.24]	.05 [-.14,.24]	.05 [-.14,.24]	.05 [-.16,.23]	-	-
Inhibition ↔ WM	-	-	-	-	-	-	**.33** **[.07,.52]**	**.35** **[.12,.56]**	-	-
Shifting ↔ WM	-	-	-	-	-	-	**.41** **[.02,.58]**	**.43** **[.23,.60]**	-	-
Shifting ↔ inhibition	-	-	-	-	-	-	**.46** **[.25,.69]**	**.49** **[.27,.71]**	-	-
Common EF ↔ IQ	-	-	-	-	-	-	-	-	**.73** **[.57,.87]**	**.75** **[.54,.88]**
Common EF ↔ reappraisal	-	-	-	-	-	-	-	-	.09 [-.13,30]	.10 [-.12,.31]
Common EF ↔suppression	-	-	-	-	-	-	-	-	-.03 [-.27,.20]	-.04 [-.27,.19]

Note. *SE*s are shown in parentheses. The EF moderators of inhibition (Model 1), working memory (Model 2), and shifting (Model 3) were assessed independently; all moderators were evaluated simultaneously in Model 4, while the common EF moderator was assessed in Model 5.

All models were first estimated without interactions (Models A) and interaction terms were added subsequently (Models B). Significant results are marked in boldface, $p < .05$.