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Running Head: *self-efficacy and attentional control*

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Abstract

Self-efficacy (SE) is a modifiable psychosocial factor related to individuals' beliefs in their capabilities to successfully complete courses of action and has been shown to be positively associated with task performance. The authors hypothesized that one means through which SE is related with improved performance is through enhanced task-relevant attentional control during task execution. To assess this hypothesis, we examined the relationships between SE and behavioral and neural indices of task performance and task-relevant attentional control for 76 young adults during the completion of a flanker task. Results showed that greater SE was associated with greater response accuracy and P3b amplitude across task conditions, and faster RT under more difficult task conditions. Additionally, P3b amplitude was found to mediate the relationship between SE and task performance in the difficult condition. These findings suggest that greater attentional allocation to task-relevant processes, including monitoring stimulus-response relationships and focusing attention on working memory operations, may help explain the association between SE and improved task performance.

Key Words: Self-efficacy (SE), Event-Related Brain Potentials (ERPs), Task-Relevant Attentional Control, P3b

Introduction

Self-Efficacy

In the framework of social cognitive theory (Bandura, 1986, 1997), self-efficacy (SE) is the primary variable associated with human agency. SE works within a dual control system that operates both as a proactive agent to institute higher levels of functioning as well as a reactive agent to reduce discrepant outcomes (Bandura, 1991, 2001). Specifically, SE reflects individuals' judgments in their capabilities to successfully execute courses of action (Bandura, 1977) and is theorized to influence effort expenditure and perseverance in response to failure and aversive stimuli (Bandura, 1986).

SE has been positively associated with work-related performance (Stajkovic & Luthans, 1998) and plays an important role in achievement and self-regulatory adjustments during the completion of challenging tasks or task conditions (Bandura & Cervone, 1983; Cervone & Peake, 1986). Further, SE has been positively associated with cognitive task performance (Bandura, 1993; Berry & West, 1993; Bouffard-Bourchard, 1990; Lachman & Jelalian, 1984). This effect of SE on cognitive task performance is believed to exist, in part, because of an increase in cognitive processing during task execution. Individuals with greater SE have been found to expend more effort and persevere longer than individuals with lesser SE (Bandura, 1986). Similarly, Berry (1987) found that individuals who were more confident in their memory capabilities (greater SE) devoted more effort to the cognitive processing of memory tasks. These relationships between SE, effortful cognitive processing, and task performance suggest that SE may affect the underlying mechanisms involved in these processes, especially during challenging tasks or task conditions.

One way to examine underlying cognitive activity during task execution is through electrophysiological means. More specifically, event-related brain potentials (ERPs) are a class of electroencephalographic activity that occurs in response to, or in preparation for, a stimulus or response (Coles, Gratton, & Fabiani, 1990) and provide additional insight into underlying mechanisms that occur during cognitive operations. Research has already shown that ERPs are sensitive to variations in SE (Themanson et al., 2008; Themanson, Pontifex, Hillman, & McAuley, 2011). Specifically, individuals with higher-SE exhibit larger error related negativity (ERN) amplitudes and greater post-error response accuracy compared to lower-SE individuals during the completion of cognitive tasks emphasizing the accuracy of performance. However, this research is limited to self-regulatory cognitive processes that follow error commission, and does not address the potential mechanisms underlying the association between SE and overall task performance, especially during the execution of different tasks or task components. To more broadly and directly address the relations between SE, cognitive processing, and task performance, the current study will examine task-relevant attentional control. The allocation of task-relevant attentional control is a more pervasive cognitive process than self-regulatory action monitoring and has also been associated with patterns of neural activation.

P3b

The way attention is allocated and controlled is an essential part of decision making and task execution. Individuals who show deficits in attentional control and the ability to properly monitor task-relevant stimulus- and response-related processes often cannot efficiently make correct decisions and their performance during task execution suffers (Bestelmeyer, Phillips, Crombiec, Benson, & St.Clair, 2009; Bramon, Croft, Arthur, McDonald, Frangou, & Murray, 2003; Chao & Knight, 1997; Justus, Finn, & Steinmetz, 2001). At times, the control of task-

relevant attention-related processes is simple, such as distinguishing a novel object from other objects. Other attentional control processes can be much more complex and involve attending to several different stimuli and response options at once (Polich, 2007). The more complex processing involves allocating attention to all aspects of the stimulus and response sets in order to fully process the situation.

One ERP component that has been theorized to index task-relevant attentional processing is the P300. The P300 is a component of an endogenous ERP that is characterized as a positive deflection in an ERP that peaks approximately 300-800ms after stimulus onset (Sutton, Braren, Zubin, & John, 1965) and is most positive at central and parietal locations (Fabiani, Sadler, & Wessels, 2000). The P300 is believed to reflect neuronal activity that is involved with basic cognitive functions like memory updating and attentional resource allocation (Brumback, Low, & Gratton, 2005; Donchin, 1981; Polich & Kok, 1995; Polich, 2007). There are two variations of the P300, the novelty P3a and the classical P3b. The current study will be focusing on the P3b, which is elicited in response to task-relevant stimuli (Snyder & Hillyard, 1976; Squires, Squires, & Hillyard, 1975) and can be examined according to its peak amplitude and latency.

The amplitude of the P3b increases in magnitude from frontal to parietal electrode sites (Johnson, 1993; Polich & Kok, 1995), is thought to reflect changes in the neural representation of the task environment, and is proportional to the amount of attentional control needed to engage a given task. The P3b has been identified as either an indicator of inhibitory activity utilized to focus attention on task-relevant processes and appropriate working memory operations (Polich, 2007) or as an index of monitoring processes employed to ensure that stimulus analyses are appropriately linked with the correct behavioral actions (Verleger, Jaśkowski, & Wascher, 2005). Although these theoretical perspectives differ in their specific

functional explanations of the P3b, both suggest that the amplitude of the P3b is sensitive to the allocation of task-relevant attentional control processes (Clayson & Larson, 2011). This functional explanation of the P3b is supported by research findings showing associations between larger (more positive) P3b amplitudes and greater attentional allocation (Polich & Heine, 1996) and faster response time (RT) during task execution (Holm, Ranta-aho, Sallinen, Karjalainen, & Müller, 2006; Koelega, et al., 1992). P3b latency is the time from stimulus onset to the maximum positive amplitude within a specified latency window. Like peak amplitude, peak latency increases from frontal to parietal electrode sites (Polich et al., 1997; Polich & Kok, 1995), and is thought to index classification speed, which is proportional to the time required to detect and evaluate a stimulus and is sensitive to task processing demands and individual differences in cognitive ability (Kutas, McCarthy, & Donchin, 1977; Magliero, Bashore, Coles, & Donchin, 1984; Polich, 2007). Finally, P3b latency has been shown to be related to overall RT, with longer P3b latencies associated with longer RTs (Pfefferbaum, Ford, Johnson, Wenegrat, & Kopell, 1983; for a review see Verleger, 1997).

Flanker Task

The P3b has been shown to be sensitive to a variety of individual difference factors including age, sex, intelligence (IQ), and personality (Ditraglia & Polich, 1991; Houlihan, Stelmack, & Campbell, 1998; Polich, 1996; Polich & Martin, 1992; Stelmack & Houlihan, 1994; van Beijsterveldt, Molenaar, de Geus, & Boomsma, 1998). Additionally, the P3b is influenced by various cognitive demands that occur during task processing, including task difficulty (Kok, 2001; Polich, 2007). More difficult tasks, or task components, have been associated with alterations in the P3b (Kok, 2001; Verleger, 1997), including reduced P3b amplitudes (Kok, 2001). Given that SE has also been theorized to be sensitive to task difficulty, with its strongest

effects exhibited during difficult tasks or task components, any assessment of the relationship between SE and P3b must include variations in task difficulty. One task that varies task difficulty without changing the nature of the task is the Eriksen flanker task (Eriksen & Eriksen, 1974) due to its use of congruent and incongruent flanking stimuli. Specifically, in the arrow version of the flanker task, differences in error rate and response speed are observed between congruent (<<<<< or >>>>>) and incongruent (<<><< or >><>>) conditions with congruent stimuli eliciting faster and more accurate responses compared to the incongruent stimuli (Eriksen & Schultz, 1979). Although performance on the task has been shown to be associated with a number of individual difference variables, including age, IQ, and personality (Hillman et al., 2006; Williams, Suchy, & Rau, 2009), research consistently shows that the incongruent task requires greater amounts of interference control to inhibit task-irrelevant stimuli and execute the correct response (Spencer & Coles, 1999). Specifically, in the incongruent task, the flanking stimuli activate the incorrect response, which competes with the correct response elicited by the centrally placed target stimulus (Spencer & Coles, 1999) and leads to increased performance errors and response delays.

Present Study

Because SE has been shown to be related to task performance as well as neural indices of cognitive processing, we predicted that SE would be related to task performance in the flanker task as well as to the P3b. Specifically, we predicted that individuals with greater SE would show superior task performance (greater accuracy and faster RT) relative to those individuals with lower SE, replicating existing behavioral research, with stronger effects in the incongruent condition of the flanker task compared to the congruent condition. Further, individuals with greater SE would exhibit larger P3b amplitudes and shorter P3b latencies during cognitive task

completion, suggesting enhanced task-relevant attentional control of inhibitory processes and stimulus-response set monitoring during task execution, with stronger effects in the incongruent condition. Finally, we predicted that P3b amplitude would mediate the relationship between SE and indices of task performance, indicating that enhanced task-relevant attentional control may be one mechanism through which SE exhibits its beneficial effects on behavioral outcomes.

Methods

Participants

Eighty-four healthy young adults (18-23 years) were recruited from the undergraduate population at a private university located in the Midwest region of the United States. Participants fulfilled a psychology course requirement in exchange for their participation. Eight participants were excluded due to either excessive artifact in their neuroelectric data ($n = 5$) or not performing the cognitive task at or above 50% accuracy in each task condition ($n = 3$), leaving data from 76 participants (41 females, 35 males) eligible for statistical analyses. The study was approved by the Institutional Review Board at the university.

Cognitive Task

Participants completed a modified version of the Eriksen flanker task (Eriksen & Eriksen, 1974) utilizing symbols that were either congruent (<<<<< or >>>>>), or incongruent (>><>> or <<><<) to the central target stimulus. The central target symbol pointing to the right (“>”) required a right-handed response and the central target symbol pointing to the left (“<”) required a left-handed response. Participants viewed a series of white stimuli on a black background presented focally on a computer monitor at a distance of 1 m and each array of five arrows subtended 13.5° of the horizontal visual angle and 3.4° of the vertical visual angle when presented on the computer monitor. Stimuli were 4 cm in height and were presented for 80 ms with an

inter-trial interval (ITI) varying between either 1000, 1200, or 1400 ms for each trial. The symbols were presented in two task blocks, each block containing 300 trials, with a brief rest period between each block. Congruent and incongruent trials were equiprobable and randomly ordered separately within each task block. Participants were asked to respond as accurately as possible.

Self-efficacy (SE) Assessment

One measure was constructed to assess SE for task performance under conditions that stressed both the accuracy and speed of task performance (McAuley, Morris, & Doerksen, 2005). This measure followed the format recommended by Bandura (1977) for construction of efficacy measures and was composed of a 10-item scale, which reflected beliefs relative to the accurate completion of successively more trials on the flanker task. Specifically, participants were asked to report their degree of confidence in completing trials as accurately and quickly as possible. The first item on the scale was “I believe that I am able to accurately complete 10 out of 100 trials as fast as possible.” Each item on the scale increased by 10 trial increments so that the last item examined beliefs relative to completing 100 out of 100 trials. Each item was scored on a Likert scale from 0% (“not at all confident”) to 100% (“highly confident”). Responses to all 10 items were summed and divided by the total number of items resulting in a SE score with a possible range from 0 to 100. The measure had a high internal consistency, $\alpha = .95$, and has been utilized in previous research studies (Themanson et al., 2008, 2011).

Behavioral Assessment

Behavioral data were collected on response time (i.e., time in ms from the presentation of the stimulus) and response accuracy (i.e., number of correct and error responses) for all trials across task blocks. Average response accuracies (% correct) and response times (ms) were

calculated separately for all incongruent trials and all congruent trials in order to assess the relations between SE, P3b, and task performance in either condition in the flanker task (congruent, incongruent).

Neural Assessment

The electroencephalogram (EEG) was recorded from 64 sintered Ag-AgCl electrodes embedded in a lycra cap arranged in an extended montage based on the International 10-10 system (Chatrain, Lettich, & Nelson, 1985) with a ground electrode (AFz) on the forehead and electrodes placed on each mastoid process for offline re-referencing. The sites were referenced online to a midline electrode placed at the midpoint between Cz and CPz. Vertical and horizontal bipolar electrooculographic activity (EOG) was recorded to monitor eye movements using sintered Ag-AgCl electrodes placed above and below the right orbit and near the outer canthus of each eye. Impedances were kept below 10 kΩ for all electrodes. A Neuroscan Synamps2 bioamplifier (Neuro Inc., El Paso, TX), with a 24 bit A/D converter and +/- 200 millivolt (mV) input range, was used to continuously digitize (500 Hz sampling rate), amplify (gain of 10), and filter (70 Hz low-pass filter, including a 60 Hz notch filter) the raw EEG signal in DC mode (24 nV/bit resolution). EEG activity was recorded using Neuroscan Scan software (v 4.3.1). Stimulus presentation, timing, and measurement of behavioral response time and accuracy were controlled by Neuroscan Stim (v 2.0) software.

Offline EEG processing of the stimulus-locked ERP included: eye blink correction using a spatial filter (Compumedics Neuroscan, 2003), re-referencing to average mastoids, creation of stimulus-locked epochs (-100 to 1000 ms relative to stimulus presentation), baseline removal (100 ms pre-stimulus interval), low-pass filtering (30 Hz; 24dB/octave), and artifact rejection (epochs with signals that exceeded ±75 μV were rejected). P3b amplitude was quantified as the

largest positive-going peak within a 300-700ms latency window following stimulus presentation in each of the average waveforms for congruent trials and incongruent trials at CPz (the site where P3b amplitude was maximal). Amplitudes were measured as a change from the pre-stimulus baseline, and peak latency was defined as the time point of the maximum peak amplitude.

Procedure

The procedure for this study was completed in one testing session. After providing informed consent, participants completed: a brief demographics questionnaire, the Edinburgh handedness inventory (Oldfield, 1971), a 100-item five-factor personality inventory developed from the International Personality Item Pool scale (IPIP; Goldberg, 1999; Goldberg et al., 2006), and the Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990) to assess intelligence quotient (IQ). The K-BIT was administered by a trained research assistant. Participants were then seated in a comfortable chair 1 m in front of a computer screen and prepared for neural measurement in accordance with the guidelines of the Society for Psychophysiological Research (Picton et al., 2000). After acceptable EEG signals were observed, the participant was briefed on the flanker task. The lights were dimmed and the participants were administered 20 practice trials. Following the practice trials, participants completed the SE measure to assess their expectations relative to the subsequent performance of the flanker task. After completing the SE measure, the participants were then given two blocks of 300 trials each, with a brief rest provided in between the task blocks. Following the completion of the last task block, the participants were debriefed on the purpose of the experiment. This session lasted approximately 90 minutes.

Statistical Analyses

Primary analyses were conducted using hierarchical stepwise multiple regression analyses. This multiple regression approach allowed the use of SE as a continuous variable (as measured), rather than forcing an artificial dichotomization of this variable with associated information loss that would be necessary with ANOVA techniques. In addition, these regression analyses facilitated tests of mediation involving our primary neural measure of stimulus processing, P3b. Prior to hypothesis testing, independent samples *t* tests were calculated between the dependent variables, SE, and sex and bivariate Pearson Product Moment correlations were calculated between the dependent variables, SE, personality, and other individual difference factors (i.e., age, IQ). Correlations including personality, age, and IQ and *t* tests including sex were examined due to findings in previous research showing relations between these individual difference variables and SE (Rebok & Balcerak, 1989; Themanson et al., 2008; Thoms, Moore, & Scott, 1996; Zimmerman & Martinez-Pons, 1990), P3b (Ditraglia & Polich, 1991; Houlihan et al., 1998; Polich, 1996; Polich & Martin, 1992; Stelmack & Houlihan, 1994; van Beijsterveldt et al., 1998), or flanker task performance (Hillman et al., 2006; Williams et al., 2009). Separate hierarchical stepwise multiple regression analyses were conducted for each dependent measure (P3b amplitude, P3b latency, response accuracy, RT). Any individual difference factors significantly correlated with the dependent measure were entered in the first step of the analysis (Miller & Chapman, 2001) and independent factors (SE and/or P3b) were added in subsequent steps of the analysis. Goodness-of-fit of the models was considered in terms of variance explained by the variables in the equation, expressed as R^2. The increase in variance explained by the models was tested for significance after each step to establish whether the independent factors accounted for a significant proportion of the variance in the dependent measure. Finally, linear regression analyses (Baron & Kenny, 1986) were conducted to determine if P3b mediated

the relations between SE and task performance (accuracy, RT). The alpha level was set at $p \leq .05$ for each individual analysis and all analyses included every participant in the final sample (n = 76).

Results

Participant Characteristics

Table 1 summarizes participant scores for SE, age, IQ, and five-factor personality. All participants scored within the normal range on IQ, indicating that no participants exhibited signs of abnormal cognitive deficits. Correlations were calculated among participant scores for SE with age, IQ, and five-factor personality. A significant correlation was present between SE and IQ, ($r = .27$, $p = .02$), with higher IQ associated with greater SE. No significant correlations were present between SE and age or any of the five personality factors (*r's* $\leq .16$, *p's* $\geq .16$). Independent samples *t* tests revealed no significant relationships between sex and SE, P3b amplitude, or flanker task response accuracy or response time (*t's* (74) ≤ 1.5, *p's* $\geq .12$).

Flanker Task Performance

Separate two-level (congruency: congruent, incongruent) repeated measures ANOVAs were conducted for response accuracy (% correct) and response time (RT) to verify that these data conformed to the expected effects. Both analyses revealed significant congruency effects as individuals performed significantly more accurately ($F(1, 75) = 275.3$, $p < .001$, partial $\eta^2 = .79$) and more quickly ($F(1, 75) = 764.5$, $p < .001$, partial $\eta^2 = .91$) on congruent trials (M $\pm$ SD = 93% correct $\pm$ 6.1; 377 ms $\pm$ 47.1) compared to incongruent trials (M $\pm$ SD = 84% correct $\pm$ 7.6; 439 ms $\pm$ 53.9).

SE and Flanker Task Performance

Correlation analyses between indices of task performance (congruent and incongruent accuracy and RT) with SE revealed significant correlations for each performance metric with SE (congruent response accuracy: $r = .34$, $p = .002$; incongruent response accuracy: $r = .37$, $p = .001$; congruent RT: $r = -.27$, $p = .02$, incongruent RT: $r = -.31$, $p = .006$), suggesting higher SE is associated with greater task accuracy and faster RT regardless of trial type. Correlation analyses also revealed significant correlations for congruent and incongruent RT with age and IQ and congruent response accuracy (% correct) with IQ. No significant correlations were present between task performance measures and any personality factor. Table 2 provides the correlation coefficients between indices of task performance, P3b, SE, and individual difference factors.

Accordingly, hierarchical stepwise regression analyses were conducted to assess the unique relationships between SE and congruent and incongruent RT by regressing each RT measure on age and IQ entered as covariates in the first step, and SE entered in the second step of the analyses. Both overall regression models were significant (congruent RT: $R^2 = .14$, $F(3,72) = 4.0$, $p = .011$; incongruent RT: $R^2 = .17$, $F(3,72) = 5.0$, $p = .003$) with the expected significant effects for age and IQ in the first step of the analyses. However, in the second step of the analyses, the effect for SE was marginally significant for congruent RT, $\Delta R^2 = .04$, $F(1,72) = 3.6$, $p = .06$, but was significant for incongruent RT, $\Delta R^2 = .06$, $F(1,72) = 4.9$, $p = .03$, suggesting that SE has a slightly stronger association with RT during more difficult (incongruent) task conditions compared to easier (congruent) task conditions above and beyond the relations RT has with both age and IQ. Table 3 provides a summary of these regression analyses (see Steps 1 and 2).

An additional hierarchical stepwise regression analysis was conducted regressing congruent response accuracy on IQ entered as a covariate in the first step and SE entered in the

second step. The overall regression model was significant ($R^2 = .14$, $F(2,73) = 6.1$, $p = .004$) and revealed a significant effect for IQ in the first step and for SE in the second step of the regression, $\Delta R^2 = .08$, $F(1,73) = 7.2$, $p = .009$, suggesting that SE is uniquely associated with congruent response accuracy above and beyond the relation IQ has with congruent response accuracy. Table 4 provides a summary of this regression analysis. Importantly, no regression analysis was conducted between SE and incongruent response accuracy as no individual difference variables were correlated with incongruent response accuracy; leaving the significant zero-order relation between SE and incongruent response accuracy ($r = .37$, $p = .001$) as the most appropriate measure.

P3b

Figure 1 provides grand-averaged stimulus-locked waveforms by congruency (congruent, incongruent). Separate two-level (congruency: congruent, incongruent) repeated measures ANOVAs were conducted for P3b amplitude and P3b latency. As expected, both analyses revealed significant congruency effects as individuals exhibited significantly greater P3b amplitude ($F(1, 75) = 5.0$, $p = .03$, partial $\eta^2 = .06$) and faster P3b latency ($F(1, 75) = 86.9$, $p < .001$, partial $\eta^2 = .54$) on congruent trials (M $\pm$ SD = 10.1 μV $\pm$ 4.6; 382.2 ms $\pm$ 63.4) compared to incongruent trials (M $\pm$ SD = 9.5 μV $\pm$ 4.3; 437.2 ms $\pm$ 60.8).

SE and P3b

Correlation analyses between P3b (congruent and incongruent P3b amplitude and latency) with SE revealed significant correlations for both congruent ($r = .25$, $p = .03$) and incongruent ($r = .33$, $p = .004$) P3b amplitude with SE, suggesting higher SE is associated with larger P3b amplitude regardless of trial type. No significant correlations were present between SE and P3b latency for either congruency. Correlation analyses also revealed significant

correlations for congruent and incongruent P3b amplitude with IQ (see Table 2). Accordingly, hierarchical stepwise regression analyses were conducted to assess the unique relationships between SE and congruent and incongruent P3b amplitude by regressing each P3b amplitude measure on IQ entered as a covariate in the first step, and SE entered in the second step of the analyses. Both overall regression models were significant (congruent P3b amplitude: $R^2 = .16$, $F(2,73) = 7.2$, $p = .001$; incongruent P3b amplitude: $R^2 = .18$, $F(2,73) = 8.1$, $p = .001$) with the expected significant effects for IQ in the first step of the analyses. However, in the second step of the analyses, the effect for SE was not significant for congruent P3b amplitude, $\Delta R^2 = .02$, $F(1,73) = 2.0$, $p =.16$, but was significant for incongruent P3b amplitude, $\Delta R^2 = .06$, $F(1,73) = 5.3$, $p =.02$, suggesting that SE has a unique association with P3b amplitude above and beyond the relations P3b amplitude has with IQ during more difficult (incongruent) task conditions, but not during easier (congruent) task conditions. Table 5 provides a summary of these regression analyses.

P3b Mediation of Incongruent Performance Effects

Previous analyses demonstrated significant SE effects on incongruent RT and response accuracy in the flanker task, above and beyond the influences of other variables (e.g., age and IQ). Moreover, SE exhibited a significant effect on P3b amplitude for incongruent trials in the flanker task. Therefore, it is possible that incongruent P3b amplitude might mediate the SE effects on incongruent flanker RT and response accuracy. Two hierarchical stepwise regressions were performed to test for P3b amplitude mediation (Baron & Kenny, 1986). For the analysis of the incongruent RT effect, the first and second steps of the stepwise regression reproduce analyses reported above with incongruent RT regressed on age and IQ in the first step and SE in the second step of the analysis. Incongruent P3b amplitude was added to this model in the third

step (see Table 3). A significant effect of P3b amplitude was observed, $\Delta R^2 = .06$, $F(1,71) = 5.0$, $p = .03$, indicating that greater (more positive) P3b amplitude was associated with faster RT on incongruent trials in the flanker task, consistent with the proposed functional significance of P3b amplitude in stimulus processing during task execution (see Figure 2). Further, the addition of P3b amplitude reduced the magnitude of the SE effect, suggesting that P3b amplitude mediated this effect. A one-tailed Sobel (1982) test was conducted to assess the significance of the mediating variable (P3b amplitude) on the strength of the relation between SE and incongruent RT. The test revealed a significant effect $z = 1.7$, $p < .05$, suggesting P3b amplitude does mediate, in part, the relation between SE and incongruent RT as the relationship between SE and incongruent RT was significantly weaker with the inclusion of P3b amplitude in the model. In other words, variation in the activation of attentional control processes indexed by P3b amplitude help to explain the improvement in incongruent RT for those individuals with greater levels of SE.

For the analysis of incongruent response accuracy, the first step of the stepwise regression reproduces the analysis reported above with incongruent response accuracy regressed on SE, with incongruent P3b amplitude added to this model in the second step (see Table 4, right side). No significant effect of P3b amplitude was observed, $\Delta R^2 = .01$, $F(1,73) = .1$, $p = .94$, indicating no unique association between P3b amplitude and response accuracy on incongruent trials in the flanker task. Importantly, the analysis also revealed no significant zero-order correlation was present between P3b amplitude and response accuracy in incongruent trials, $r = .12$, $p = .30$, possibly due to the ceiling effect associated with the very high level of response accuracy among the participants.

P3b Mean Amplitude Analyses

Recent research examining the P3b during flanker task execution has focused on measures of mean amplitude rather than peak amplitude (Clayson & Larson, 2011; Nelson, Patrick, & Bernat, 2011). Further, the utility of mean amplitude measures for ERP studies has been well-explained (Luck, 2005). To allow for better comparisons with other research on the P3b during the flanker task, we conducted all P3b analyses again using a mean amplitude measure for the P3b. For these analyses, P3b amplitude was quantified as the average amplitude within a 300-500 ms latency window following stimulus presentation in each of the average waveforms for congruent trials and incongruent trials at CPz (the site where P3b amplitude was maximal). As expected, the pattern of findings is consistent with the previously-reported findings for peak P3b amplitude. Specifically, both congruent ($r = .24$, $p = .04$) and incongruent ($r = .33$, $p = .003$) mean P3b amplitude was significantly corrected with SE. Further, regression analyses showed that incongruent mean P3b amplitude had a significant unique association with SE above and beyond the relationship P3b amplitude has with IQ during, , $\Delta R^2 = .06$, $F(1,73) = 5.6$, $p = .02$. Finally, mediation analyses revealed a significant effect of mean P3b amplitude on incongruent RT, $\Delta R^2 = .05$, $F(1,71) = 4.5$, $p = .04$, and the addition of P3b significantly reduced the magnitude of the SE effect on incongruent RT, $z = 2.2$, $p = .01$. Similar to the findings for peak P3b amplitude, these findings suggest that P3b amplitude does mediate the relationship between SE and incongruent RT.

Discussion

Consistent with results observed by Bandura (1977, 1986, 1991), higher SE was found to be associated with greater response accuracy during task execution and faster RT during difficult task conditions. These relationships are consistent with the social cognitive theory (Bandura, 1986), which states that higher SE will have a beneficial effect on task performance and that

effect will be more powerful when task difficulty is greater. Additionally, SE was associated with enhanced P3b amplitude, a neural index of the allocation of task-relevant attentional control and the monitoring of stimulus-response relationships. Finally, findings suggest that P3b amplitude mediated the relationship between SE and RT on incongruent (difficult) trials of the cognitive task, indicating that the task-relevant attentional control activation indexed by P3b amplitude may help explain the faster RT on difficult trials exhibited by individuals with greater SE.

Many researchers have explored the relationship between SE and cognitive behavior for a number of years (Bandura, 1977, 1986, 1991; Berry & West, 1993; Bouffard-Bourchard, 1990; Lachman & Jelalian, 1984; Stajkovic & Luthans, 1998) and have detailed SE influences on effort and motivation during task performance (Bandura, 1993; Bandura & Cervone, 1983; Bandura, & Locke, 2003). However, there has been little focus on how the impact of SE on psychological constructs like “effort” and “motivation” is implemented through patterns of neural activation during task execution (Themanson et al., 2008, 2011). Adaptations in one’s effort or motivation during a task should be reflected through alterations in one’s neural processes that underlie the execution of the task.

The current findings corroborate previous research in showing SE as a factor that is beneficially related with task performance, with a positive relationship between SE and response accuracy in easy and difficult task conditions (greater SE associated with greater response accuracy) and a negative relationship between SE and difficult task RT (greater SE associated with faster/shorter RT). These relationships were independent of any relations between task performance and other individual difference factors, including age, sex, IQ, and personality. Additionally, our data show a positive relationship between SE and P3b amplitude during task

execution, with individuals possessing greater SE exhibiting greater (more positive) P3b amplitudes. This finding extends the behavioral findings described above to include neural measures of processes utilized during task execution and provides details into how the benefits of SE on task behavior are manifested.

The P3b is a consciousness-dependent ERP component that is sensitive to task difficulty, as well as the subjective probability of task stimuli or conditions. The amplitude of the P3b has been theorized to index the allocation of task-relevant attentional control resources to either the monitoring of the proper linkage between stimulus analysis and response implementation (Verleger et al., 2005) or the inhibition of task-extraneous processes to focus attention more appropriately on task-relevant process and working memory operations (Polich, 2007). Given this role as an indicator of task-relevant attentional control processing, the present findings suggest that SE is associated with enhanced attentional control during task execution. This may provide some quantification of the “enhanced effort” findings described in previous behavioral research on SE and task performance (Bandura, 1986; Berry, 1987) and also detail a specific process underlying the beneficial effects of SE on goal-directed behavior.

Attentional control is vital to the successful completion of cognitive tasks, with those individuals exhibiting deficient task-relevant attentional control capabilities showing severe decrements in task performance (Bestelmeyer et al., 2009; Bramon et al., 2003; Chao & Knight, 1997; Justus et al., 2001). The present findings suggest that individuals with greater SE engage a task with greater task-relevant attentional control, resulting in enhanced performance. This notion gains further support from evidence showing that the relationship between SE and RT on incongruent trials was mediated by P3b amplitude on incongruent trials, indicating that processes indexed by P3b amplitude help explain the faster incongruent RT exhibited by individuals with

greater SE. Thus, the current study provides more information on how SE, P3b, and RT are related, with the intervening effects SE has on P3b as well as those P3b has on incongruent RT, providing insight into one important mechanism through which SE is related with improvements in behavior during more difficult, or challenging, tasks and task components. It is important to note that the P3b mediation of the relationship between SE and incongruent RT was not complete. A relationship between SE and incongruent RT was still present, though significantly weaker, once the effect of P3b was included in the regression model; suggesting partial mediation (Baron & Kenny, 1986). One can then conclude that processes indexed by the P3b may not be the only cognitive component responsible for the improvements in task performance associated with greater SE. Consistent with this conclusion, research has detailed SE influences on other cognitive processes related to overall task performance, including self-regulatory action monitoring (Themanson et al., 2008, 2011), indicating that P3b-related processes may just be one of many components involved in a larger network of processes responsible for the beneficial relationship between SE and task performance.

Limitations and Future Directions

Although our analyses were able to determine the extent to which SE was independently associated with task performance and P3b amplitude, it is important to clarify that no causal relationships or temporal models are being proposed. The cross-sectional nature of the study, as well as the lack of random assignment to levels of SE, limits the strength of the findings, as seen in the small effect sizes, because the effects may be attributable to other factors. However, multiple individual difference factors were assessed (sex, age, IQ, five-factor personality), which helps to reduce these variables as potential influences on the SE findings and allows for an examination of the unique or independent associations SE has with the neural and behavioral

variables of interest. Future examinations employing experimental designs to manipulate SE are warranted as are studies examining other key variables that may moderate or mediate SE effects on neural and behavioral indices of task performance and attentional control. Finally, future research should implement a broader array of cognitive measures with greater levels of difficulty and complexity to more completely assess the relationships between SE and indices of task-relevant attentional control and test the theorized relationships between SE and task performance under challenging task conditions (Bandura, 1977, 1986).

Conclusions

In conclusion, the relationships between SE, attentional control, and task performance were examined in healthy young adults. As predicted, we found significant relationships present between SE, P3b amplitude, and indices of task performance during more difficult task conditions, with greater SE associated with larger P3b amplitudes and faster RT on incongruent trials of the cognitive task. This pattern of findings is consistent with social cognitive theory (Bandura, 1977, 1986), which suggests that SE exhibits a more powerful effect on performance when task difficulty is greater. Further, we found that P3b amplitude mediated the relationships between SE and RT on incongruent trials of the flanker task. These findings provide evidence that improved task-relevant attentional control, indexed by P3b amplitude, may be one mechanism through which SE improves task performance. Although the observed relationship between SE and attentional control is intriguing, further exploration is required to delve into the exact role that SE plays in improving attentional control, and how crucial the involvement of enhanced attentional control processing is in the larger relationship between SE and improved task performance.

References

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191-215. doi:10.1037/0033-295X.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ, Prentice-Hall.

Bandura, A. (1991). Self-regulation of motivation through anticipatory and self-regulatory mechanisms. In R. A. Dienstbier (Ed.), *Perspectives on motivation: Nebraska symposium on motivation* (Vol. 38, pp. 69-164). Lincoln: University of Nebraska Press.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*, 117-148. doi:10.1207/s15326985ep2802_3

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52,* 1-26. doi:10.1146/annurev.psych.52.1.1

Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology, 45,* 1017-1028. doi:10.1037/0022-3514.45.5.1017

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology, 88,* 87-99. doi:10.1037/0021-9010.88.1.87

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182. doi:10.1037/0022-3514.51.6.1173

Berry, J. M. (1987, August). A self-efficacy model of memory performance. Paper presented at the 95th annual convention of the American Psychological Association, New York.

Berry, J. M., & West, R. L. (1993). Cognitive self-efficacy in relation to personal mastery and goal setting across the life span. *International Journal of Behavioral Development*, *16*, 351-379. doi:10.1177/016502549301600213

Bestelmeyer, P. E. G., Phillips, L. H., Crombie, C., Benson, P., & St.Clair, D. (2009). The P300 as a possible endophenotype for schizophrenia and bipolar disorder: Evidence from twin and patient studies. *Psychiatry Research, 169(3),* 212-219. doi:10.1016/j.psychres.2008.06.035

Bouffard-Bouchard, T. (1990). Influence of self-efficacy on performance in a cognitive task. *Journal of Social Psychology, 130*, 353-363. doi:10.1080/00224545.1990.9924591

Bramon, E., Croft, R. J., Arthur, M., McDonald, C., Frangou, S., & Murray, R. M. (2003). The P300 wave in schizophrenia: A family study. *Schizophrenia Research, 60(1)*, 248. doi:10.1016/S0920-9964(03)81266-5

Brumback, C. R., Low, K. A., & Gratton, G. (2005). Putting things into perspective - Individual differences in working-memory span and the integration of information. *Experimental Psychology, 52(1),* 21-30**.** doi:10.1027/1618-3169.52.1.21

Cervone, D., & Peake, P. K. (1986). Anchoring, efficacy, and action: The influence of judgmental heuristics on self-efficacy judgments and behavior. *Journal of Personality and Social Psychology*, *50*, 492-501. doi:10.1037/0022-3514.50.3.492

Chatrain, G. E., Lettich, E., & Nelson, P. L. (1985). Ten percent electrode system for topographic studies of spontaneous and evoked EEG activity. *American Journal of EEG Technology, 25,* 83-92.

Chao, L. L., & Knight, R. T. (1997). Prefrontal deficits in attention and inhibitory control with aging. *Cerebral Cortex, 7*, 63-69. doi:10.1093/cercor/7.1.63

Clayson, P. E., & Larson, M. J. (2011). Effects of repetition priming on electrophysiological and behavioral indices of conflict adaptation and cognitive control. *Psychophysiology, 48*, 1621-1630. doi:10.1111/j.1469-8986.2011.01265.x

Coles, M. G. H., Gratton, G., & Fabiani, M. (1990). Event-related brain potentials. In J. T. Cacioppo & L. G. Tassinary (Eds.), Principles of psychophysiology (pp. 413-455). New York: Cambridge University Press.

Compumedics Neuroscan (2003). *Offline analysis of acquired data (SCAN 4.3 – Vol. II, EDIT 4.3)*. [Software Manual]. El Paso, TX: Author.

Ditraglia, G. M., & Polich, J. (1991). P300 and introverted/extroverted personality types. *Psychophysiology, 28*, 177-184. doi:10.1111/j.1469-8986.1991.tb00410.x

Donchin, E. (1981). Surprise!…Surprise? *Psychophysiology***,** 18**(**5), 493-513**.** doi:10.1111/j.1469-8986.1981.tb01815.x

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonresearch task. *Perception and Psychophysics, 16*, 143-149. doi: 10.3758/BF03203267

Eriksen, C. W. & Schultz, D. W. (1979). Information processing in visual search: A continuous flow conception and experimental results. *Perception and Psychophysics, 25*, 249-263. doi:10.3758/BF03198804

Fabiani, M., Sadler, M. A., & Wessels, P. M. (2000). True but not false memories produce a sensory signature in human lateralized brain potentials. *Journal of Cognitive Neuroscience, 12(6).*941-949**.** doi:10.1162/089892900051137486

Goldberg, L. R. (1999). A broad-bandwidth, public-domain, personality inventory measuring the lower-level facets of several five-factor models. In I. Mervielde, I. Deary, F. De Fruyt, &

F. Ostendorf (Eds.), *Personality Psychology in Europe, Vol. 7* (pp. 7-28). Tilburg, The Netherlands: Tilburg University Press.

Goldberg, L. R., Johnson, J. A., Eber, H. W., Hogan, R., Ashton, M. C., Cloninger, C. R., & Gough, H. G. (2006). The international personality item pool and the future of public-domain personality measures. *Journal of Research in Personality, 40*, 84-96. doi:10.1016/j.jrp.2005.08.007

Hillman, C. H., Motl, R. W., Pontifex, M. B., Posthuma, D., Stubbe, J. H., Boomsma, D. I., & de Geus, E. J. C. (2006). Physical activity and cognitive function in a cross-section of younger and older community-dwelling individuals. *Health Psychology, 25*, 678-687. doi:10.1037/0278-6133.25.6.678

Holm, A., Ranta-aho, P. O., Sallinen, M., Karjalainen, P. A., & Müller, K. (2006). Relationship of P300 single-trial responses with reaction time and preceding stimulus sequence. *International Journal of Psychophysiology, 61*, 244-252. doi:10.1016/j.ijpsycho.2005.10.015

Houlihan, M., Stelmack, R. & Campbell, K. (1998). Intelligence and the effects of perceptual processing demands, task difficulty and processing speed on P300, reaction time and movement time. *Intelligence, 26*, 9-25. doi:10.1016/S0160-2896(99)80049-X

Johnson, R. (1993). On the neural generators of the P300 component of the event-related potential. *Psychophysiology, 30*, 90-97. doi:10.1111/j.1469-8986.1993.tb03208.x

Justus, A. N., Finn, P. R., & Steinmetz, J. E. (2001). P300, Disinhibited personality, and early-onset alcohol problems. *Alchoholism: Clinical & Experimental Research, 25(10)*, 1457-1466. doi:10.1111/j.1530-0277.2001.tb02147.x

Kaufman, A. S., & Kaufman, N. L. (1990). *Kaufman Brief Intelligence Test manual*. Circle Pines, MN: American Guidance Service.

Koelega, H. S., Verbaten, M. N., van Leeuwen, T. H., Kenemans, J. L., Kemner, C., & Sjouw, W. (1982). Time effects on event-related brain potentials and vigilance performance. *Biological Psychology, 34,* 59-86. doi:10.1016/0301-0511(92)90024-O

Kok, A. (2001). On the utility of P3 amplitude as a measure of processing capacity. *Psychophysiology, 38*, 557-577. doi:10.1017/S0048577201990559

Kutas, K., McCarthy, G., & Donchin, E. (1977). Augmenting mental chronometry: P300 as a measure of stimulus evaluation time. *Science*, *197*, 792-795.

Lachman, M. E., & Jelalian, E. (1984). Self-efficacy and attributions for intellectual performance in young and elderly adults. *Journal of Gerontology, 39*, 577-582. doi:10.1093/geronj/39.5.577

Luck, S. J. (2005). *An introduction to the event-related potential technique*. Cambridge, MA: The MIT Press.

Magliero, A., Bashore, T. R., Coles, M. G. H., & Donchin, E. (1984). On the dependence of P300 latency on stimulus evaluation processes. *Psychophysiological*, *21*, 171-186.

McAuley, E., Morris, K. S., & Doerksen, S. E. (2005). *Measures of cognitive self-efficacy*. Unpublished manuscript, Exercise Psychology Laboratory, Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign.

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology, 110,* 40-48. doi:10.1037/0021-843X.110.1.40

Nelson, L. D., Patrick, C. J., & Bernat, E. M. (2011). Operationalizing proneness to externalizing psychopathology as a multivariate psychophysiological phenotype. *Psychophysiology, 48,* 64-73. doi: 10.1111/j.1469-8986.2010.01047.x

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97-113. doi: 10.1016/0028-3932(71)90067-4

Pfefferbaum, A., Ford, J., Johnson, R. Wenegrat, B., & Kopell, B. S. (1983). Manipulation of P3 latency: Speed vs. accuracy instructions. *Electroencephalography and Clinical Neurophysiology, 55*, 188-197.

Picton, T. W., Bentin, S., Berg, P., Donchin, E., Hillyard, S. A., Johnson Jr., R., Miller, G. A., Ritter, W., Ruchkin, D. S., Rugg, M. D., & Taylor, M. J. (2000). Guidelines for using human event-related-potentials to study cognition: Recording standards and publication criteria. *Psychophysiology, 37*, 127-152. doi: 10.1111/1469-8986.3720127

Polich, J. (1996). Meta-analysis of P300 normative aging studies. *Psychophysiology, 33*, 334-353. doi:10.1111/j.1469-8986.1996.tb01058.x

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*, 2128-2148. doi:10.1016/j.clinph.2007.04.019

Polich, J., Alexander, J. E., Bauer, L. O., Kuperman, S., Rohrbaugh, J., & Mozarati, S. (1997). P300 topography of amplitude/latency correlations. *Brain Topography, 9,* 275-282.

Polich, J., & Heine, M. R. D. (1996). P300 topography and modality effects from a single stimulus paradigm. *Psychophysiology, 33,* 747-752. doi:10.1111/j.1469-8986.1996.tb02371.x

Polich, J., & Kok, A. (1995). Cognitive and biological determinants of P300: An integrative review. *Biological Psychology, 41*, 103-146. doi:10.1016/0301-0511(95)05130-9

Polich, J., & Martin, S. (1992). P300, cognitive capability, and personality: a correlational study of university undergraduates. *Personality and Individual Differences*, *13*, 533-543. doi:10.1016/0191-8869(92)90194-T

Rebok, G. W., & Balcerak, L. J. (1989). Memory self-efficacy and performance differences between younger and older adults: Effects of mnemonic training. *Developmental Psychology, 25*, 714-721. doi:10.1037/0012-1649.25.5.714

Snyder, E., & Hillyard, S. (1976). Long-latency evoked potentials to irrelevant, deviant stimuli. *Behavioral Biology, 16*, 319-331. doi:10.1016/S0091-6773(76)91447-4

Sobel, M. E. (1982). Asymptotic intervals for indirect effects in structural equation models. In S. Leinhart (Ed.). *Sociological methodology 1982, Vol. 13*. (pp. 290-312) San Francisco: Jossey-Bass.

Spencer, K. M., & Coles, M. G. H. (1999). The lateralized readiness potential: Relationship between human data and response activation in a connectionist model. *Psychophysiology, 36*, 364-370. doi:10.1017/S0048577299970749

Squires, N., Squires, K., & Hillyard, S. (1975). Two varieties of long-latency positive waves evoked by unpredictable auditory stimuli in man. *Electroencephalography Clinical Neurophysiology, 38*, 387-401. doi:10.1016/0013-4694(75)90263-1

Stajkovic, A. D., & Luthans, F. (1998). Self-efficacy and work related performance: A meta-analysis. *Psychological Bulletin, 124*, 240-261. doi:10.1037/0033-2909.124.2.240

Stelmack, R. M., & Houlihan, M. (1994). Event related potentials, personality, and intelligence: Concepts, issues, and evidence. In D. H. Saklofske, & M. Zaidner, (Eds), *International handbook of personality and intelligence* (pp. 349-365). New York: Plenum Press.

Sutton, S., Braren, M., Zubin, J., & John, E. (1965). Evoked potential correlates of stimulus uncertainty. *Science, 150*, 1187-1188. doi:10.1126/science.150.3700.1187

Themanson, J. R., Hillman, C. H., McAuley, E., Buck, S. M., Doerksen, S. E., Morris, K. S., & Pontifex, M. B. (2008). Self-efficacy effects on neuroelectric and behavioral indices of action monitoring in older adults. *Neurobiology of Aging, 29*, 1111-1122. doi:10.1016/j.neurobiolaging.2007.01.004

Themanson, J. R, Pontifex, M. B., Hillman, C. H., & McAuley, E. (2011). The relation of self-efficacy and error-related self-regulation. *International Journal of Psychophysiology, 80*, 1-10. doi:10.1016/j.ijpsycho.2011.01.005

Thoms, P., Moore, K. S., & Scott, K. S. (1996). The relationship between self-efficacy for participating in self-managed work groups and the big five personality dimensions. *Journal of Organizational Behavior, 17*, 349-362. doi:10.1002/(SICI)1099-1379(199607)

van Beijsterveldt, C. E. M., Molenaar, P. C. M., de Geus, E. J. C., & Boomsma, D. I. (1998). Individual differences in P300 amplitude: A genetic study in adolescent twins. *Biological Psychology, 47*, 97-120. doi:10.1016/S0301-0511(97)00025-2

Verleger, R. (1997). On the utility of P3 latency as an index of mental chronometry. *Psychophysiology, 34*, 131-156. doi:10.1111/j.1469-8986.1997.tb02125.x

Verleger, R., Jaśkowski, P., & Wascher, E. (2005). Evidence for an integrative role of P3b in linking reaction to perception. *Journal of Psychophysiology, 19*, 165-181. doi:10.1027/0269-8803.19.3.165

Williams, P. G., Suchy, Y., & Rau, H. K. (2009). Individual differences in executive functioning: Implications for stress regulation. *Annals of Behavioral Medicine, 37*, 126-140. doi:10.1007/s12160-009-9100-0

Zimmerman, B. L., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology, 82*, 51-59. doi:10.1037/0022-0663.82.1.51

Table 1. *Means (SD) and Minimum and Maximum Values for SE, Age, IQ, and Five-Factor Personality.*

Variable	M (SD)	Min. – Max.
SE	73.2 (15.4)	28 – 98
Age (years)	19.2 (1.2)	18 – 23
IQ	106.9 (7.0)	88 – 120
F-I	66.3 (12.7)	39 – 89
F-II	78.5 (9.4)	48 – 96
F-III	72.5 (11.7)	35 – 95
F-IV	64.1 (14.3)	25 – 92
F-V	74.6 (8.7)	56 – 98

Note. SE – Self-efficacy; IQ = K-BIT Composite Score; F-I = Extraversion; F-II = Agreeableness; F-III = Conscientiousness; F-IV = Emotional Stability; F-V = Intellect.

Table 2. *Correlations of Individual Difference Variables (Sex, Age, IQ, Five-Factor Personality) with Flanker Task Performance (Congruent and Incongruent Response Accuracy and Response Time), Self-Efficacy, and Congruent and Incongruent P3b Amplitude and Latency.*

Variable	Sex	Age	IQ	F-I	F-II	F-III	F-IV	F-V
1. Congruent PC	.11	.06	.24*	.06	.04	.08	.03	.02
2. Incongruent PC	.01	.01	.16	.03	.01	.08	-.01	.01
3. Congruent RT	-.02	-.24*	-.27*	-.09	.11	-.13	-.01	-.16
4. Incongruent RT	-.06	-.23*	-.31**	-.06	.09	-.14	.02	-.17
5. SE	.18	.06	.27*	.15	-.08	-.06	.04	.16
6. Congruent P3b-A	-.13	.12	.38**	.07	.01	.13	.08	.21
7. Incongruent P3b-A	.01	.09	.35**	.01	.01	.09	.05	.18
8. Congruent P3b-L	.20	-.22	-.18	-.22	-.03	-.32**	-.14	-.30**
9. Incongruent P3b-L	.17	-.27*	-.15	-.20	-.05	-.23*	-.17	-.16

Note. F-I = Extraversion; F-II = Agreeableness; F-III = Conscientiousness; F-IV = Emotional Stability; F-V = Intellect; Sex: 0 = male, 1 = female; IQ = K-BIT Composite score; PC = percentage correct (response accuracy); RT = response time; SE = self-efficacy; P3b-A = P3b amplitude; P3b-L = P3b latency.

* $p < .05$; ** $p < .01$

Table 3. *Summary of Regression Analyses for a) Variables Predicting Congruent RT (left) and b) Variables Predicting Incongruent RT (right).*

a) Congruent RT				b) Incongruent RT			
Variables	B	SE B	β	Variables	B	SE B	β
Step 1				**Step 1**			
Age	-6.88	4.67	-.17	Age	-6.69	5.29	-.14
IQ	-1.53	.77	-.23*	IQ	-2.12	.87	-.28*
Step 2				**Step 2**			
Age	-6.91	4.59	-.17	Age	-6.73	5.15	-.14
IQ	-1.13	.79	-.17	IQ	-1.61	.88	-.21
SE	-.66	.35	-.21	*SE*	*-.87*	*.39*	*-.25**
				Step 3			
				Age	-6.73	5.01	-.14
				IQ	-1.05	.89	-.14
				SE	*-.64*	*.39*	*-.18*
				P3b	*-3.25*	*1.45*	*-.26**

Note. RT = response time; IQ = K-BIT Composite score; SE = self-efficacy; P3b = P3b Amplitude at CPz.

* $p < .05$

Table 4. *Summary of the Regression Analysis for a) Variables Predicting Congruent Response Accuracy (% Correct; left) and b) Variables Predicting Incongruent Response Accuracy (% Correct; right).*

a) Congruent % Correct				b) Incongruent % Correct			
Variables	B	SE B	β	Variables	B	SE B	β
Step 1				**Step 1**			
IQ	.21	.10	.24*	*SE*	*.18*	*.05*	*.37***
Step 2				**Step 2**			
IQ	.14	.10	.16	*SE*	*.18*	*.06*	*.37***
SE	*.12*	*.04*	*.30***	P3b	.01	.19	.01

Note. IQ = K-BIT Composite score; SE = self-efficacy; P3b = P3b amplitude.

* $p < .05$; ** $p < .01$

Table 5. *Summary of Regression Analyses for a) Variables Predicting Congruent P3b Amplitude (left) and b) Variables Predicting Incongruent P3b Ampltude (right).*

a) Congruent P3b Amplitude				b) Incongruent P3b Amplitude			
Variables	B	SE B	β	Variables	B	SE B	β
Step 1				**Step 1**			
IQ	.25	.07	.38**	IQ	.21	.07	.35**
Step 2				**Step 2**			
IQ	.22	.07	.33**	IQ	.17	.07	.28*
SE	.05	.03	.16	*SE*	*.07*	*.03*	*.25**

Note. RT = response time; IQ = K-BIT Composite score; SE = self-efficacy; P3b = P3b Amplitude at CPz.

* *p* < .05; ** p < .01

Figure Captions

Figure 1. Grand-averaged stimulus-locked waveforms by trial type (congruent, incongruent) at the Fz, FCz, Cz, CPz, and Pz electrode sites.

Figure 2. Self-efficacy (SE), P3b, and RT results for incongruent trials during the flanker task. (**a**) Scatter plot for the relationship between residuals for SE and incongruent RT after controlling for the influences of age and IQ. (**b**) Scatter plot for the relationship between residuals for SE and P3b amplitude on incongruent trials after controlling for the influence of IQ. (**c**) Scatter plot for the relationship between P3b amplitude and RT on incongruent trials after controlling for the influences of age, IQ, and SE.

Figure 1.

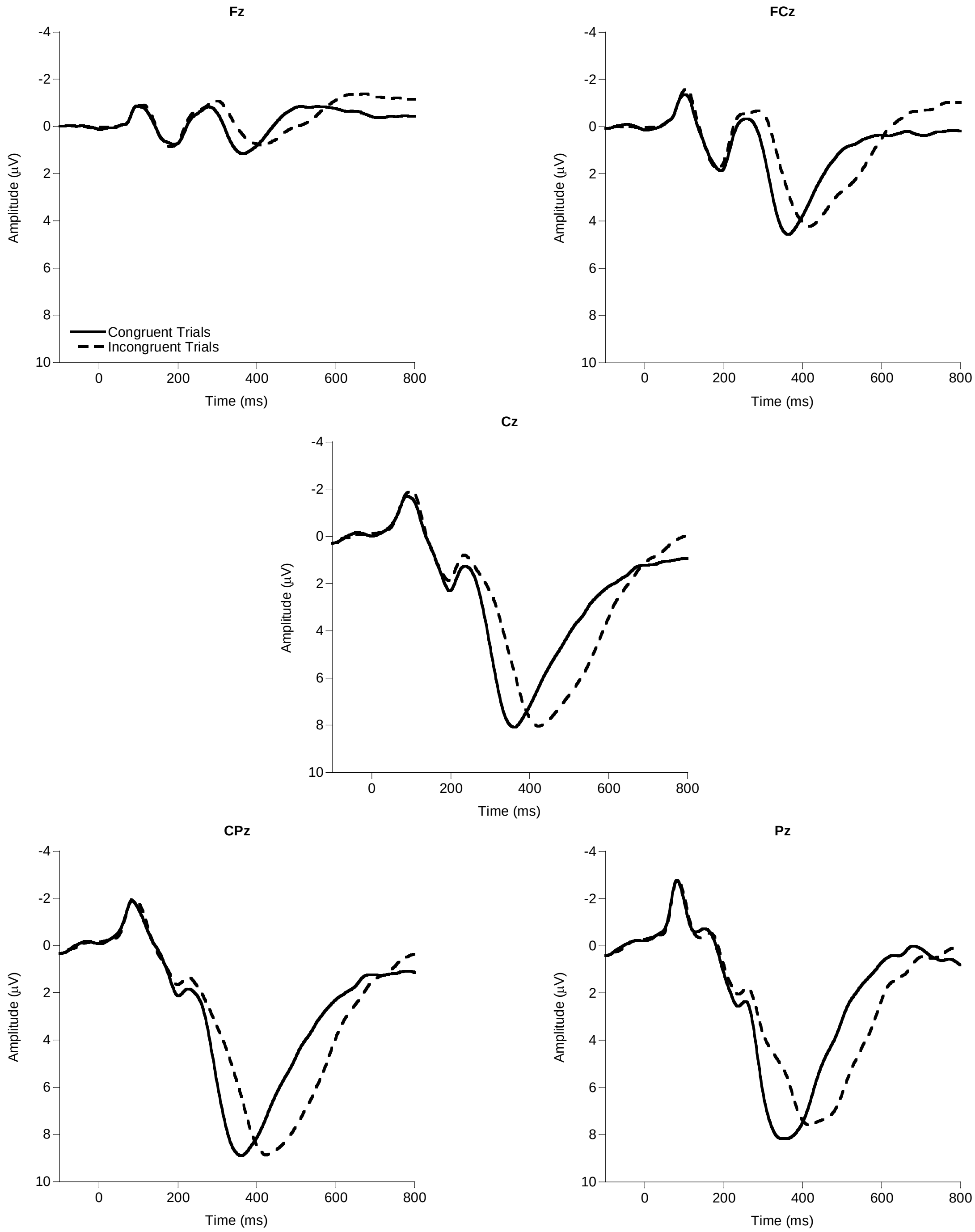
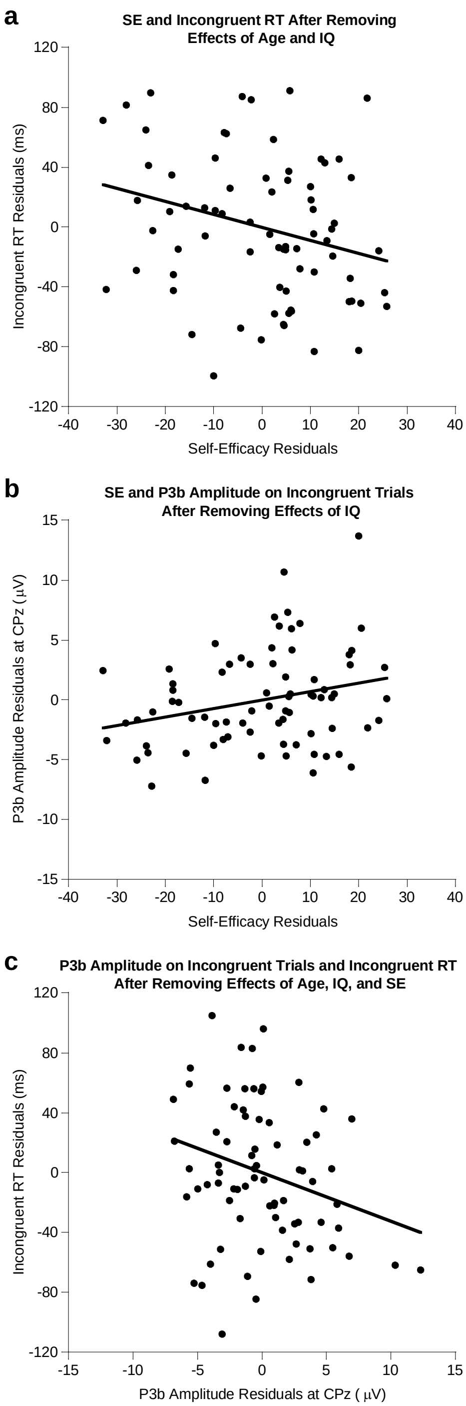

Fz
FCz
Cz
CPz
Pz
Amplitude (μV)
Time (ms)
Congruent Trials
Incongruent Trials
-4
-2
0
2
4
6
8
10
0
200
400
600
800

Figure 2.


a
SE and Incongruent RT After Removing Effects of Age and IQ
Incongruent RT Residuals (ms)
Self-Efficacy Residuals
120
80
40
0
-40
-80
-120
-40
-30
-20
-10
0
10
20
30
40
b
SE and P3b Amplitude on Incongruent Trials After Removing Effects of IQ
P3b Amplitude Residuals at CPz (μV)
Self-Efficacy Residuals
15
10
5
0
-5
-10
-15
c
P3b Amplitude on Incongruent Trials and Incongruent RT After Removing Effects of Age, IQ, and SE
Incongruent RT Residuals (ms)
P3b Amplitude Residuals at CPz (μV)
-15
-10
-5
0
5
10
15