Focusing on Values and Ideals Decreased P3a Amplitude: A Confirmation of the Joint Subsystems Hypothesis

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Approach - avoidance dichotomy can be found in most of the major psychological theories concerned with motivation (Elliot, 1999). However, to date little is known about the effects that the underlying systems have on each other. The joint subsystems hypothesis (JSH), derived from Reinforcement Sensitivity Theory, proposes that under most circumstances the approach (Behavioural Activation System; BAS) and avoidance (Behavioural Inhibition System; BIS) systems behave in a mutually antagonistic fashion (Corr, 2004). To test this hypothesis, I manipulated state BAS by having participants reflect on their ideals (Study 1; n = 65) and core values (Study 2; n = 62). To measure state BIS, I recorded participants' electroencephalogram in response to white noise and pure tones from which P3a amplitude was extracted, a BIS related event-related potential. Reflecting on ideals and core values reduced P3a amplitude, as predicted by the JSH. Results are discussed in the context of the general threat and defense framework (Jonas et al., 2014).

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CHAPTER ONE: INTRODUCTION

Approach-avoidance motivation was first described by Democritus (460 – 370 B.C.E), who saw the pursuit of pleasure and avoidance of pain as an ethical imperative (Elliot, 2006). Bentham similarly proposed this motivational principle as the primary causal force behind all human striving (Bentham, 1996). From its infancy, psychological theory echoed this maxim. William James described pain and pleasure as a "spring of action" and referred to the former as a "tremendous inhibitor" and the latter a "tremendous reinforcer" (James, 1890, pp. 549–559). Freud used the term "Lustprinzip" (English: *pleasure principle*) to describe the instinctual desire to maximize pleasure and minimize pain (Freud & Hubback, 1922). Lewin distinguished between two major groups of "valences" or directions of movement: positive - instigating approach, and negative - instigating avoidance (Lewin, 1935).[1] Similarly, Pavlov, saw behaviour and ultimately personality, as a balance between neural excitation and inhibition (Pavlov, 1927). Inspired by Pavlov's theory, Eysenck argued that personality was reducible to just two dimensions: Extraversion and Neuroticism (reflecting sensitivity to rewarding and aversive experiences respectively; Eysenck, 1967).[2]

More recently, Reinforcement Sensitivity Theory (RST; Corr & McNaughton, 2008; Gray, 1982; Gray & McNaughton, 2003) has similarly asserted that all vertebrate behavior is guided by motivational systems related to approach (behavioural activation system or BAS) and avoidance (behavioral inhibition system or BIS and fight, flight, freeze system or FFFS; Gray, 1982). The first iteration of RST conceived of BAS/approach and BIS/anxious/avoidant activation as independent (cf. Carver & White, 1994). However, the most recent version of RST

[1] He was also the first to formally outline the different types of conflict based on the various configurations of approach and avoidance (i.e. approach-avoidance, approach-approach, avoidance-avoidance; Lewin, 1935).

[2] For a complete historical overview of approach and avoidance motivation see (Elliot, 1999).

(developed by Phillip Corr) holds that approach and avoidance processes are reciprocally active rather than independent (Corr, 2004). More specifically, Corr's joint subsystems hypothesis (JSH) proposes that approach processes downregulate those related to avoidance and anxiety. Increasingly, the interplay between these subsystems has been used to illuminate dynamics of threat and defense (Harmon-Jones, Amodio, & Harmon-Jones, 2009; Hirsh, Mar, & Peterson, 2012; Jonas et al., 2014; Proulx, Inzlicht, & Harmon-Jones, 2012).[3] To date, however, the empirical evidence for the JSH in human studies is sparse; most of the supporting research was carried out with animal subjects, and the little that has been done with humans is correlational (Corr & McNaughton, 2008; Revelle, 2008). To address the lack of research on the topic, I conducted two experiments to examine whether experimentally manipulating approach motivation (or BAS) would downregulate processes related to BIS activation.

Reinforcement Sensitivity Theory

Reinforcement Sensitivity Theory (RST) addresses both the state and trait aspects of approach-avoidance motivation. It describes the interplay between three interrelated systems that guide all human and animal behavior, and also how these momentary processes are related to long-term dispositional tendencies (Corr & McNaughton, 2008; Gray & McNaughton, 2003). RST identifies the following three neural systems and their underlying functions: the Behavioral Activation System (BAS) that propels the organism forward and energizes active pursuit of goals; the Fight-Flight-Freeze System (FFFS) that tunes into threat cues (goal blocks) and gets the organism out of immediate danger; and the Behavioral Inhibition System (BIS) that receives

[3] The general threat and defense framework argues that post threat (e.g. frustration, mortality salience, rejection, failure, ostracism, uncertainty, control loss) behaviours (compensatory enhancement, extremism, conviction, control, worldview defense, angry hostility, etc.) function as levers for activating the BAS in order to downregulate the anxious distress associated with BIS and FFFS activation (Jonas et al., 2014).

input from the BAS and FFFS and resolves the conflict between them.[4] Since most of the situations that people experience in everyday life are not severe enough to cause acute FFFS responses, the focus of this manuscript will be on the relative activation and sensitivities of the BIS and BAS.

At the trait level, RST proposes that the sensitivities of these two systems constitute stable individual differences that predict reactions to diverse classes of stimuli. More specifically, BAS sensitivity constitutes the relative activation of approach tendencies in the presence of appetitive stimuli (rewards), while BIS sensitivity constitutes the magnitude of behavioural inhibition, vigilance, anxious arousal, and risk assessment in the presence of mildly aversive stimuli.

Joint Subsystems Hypothesis

The Joint Subsystems hypothesis was originally put forward to address the growing divide between empirical evidence and the Separable Subsystems hypothesis (SSH) derived from the early iteration of RST (Corr & McNaughton, 2008). The SSH proposes that BIS and BAS are neurally distinct, meaning that the general sensitivities of the two systems predict outcomes independently. In other words, responses to rewarding stimuli are facilitated solely by the BAS (unaffected by the BIS), while responses to aversive stimuli are facilitated solely by the BIS (unaffected by the BAS; Corr, 2004; Gray, 1982). In contrast to the SSH, the JSH states that BIS and BAS are neurally independent at the trait level (i.e., a change in the sensitivity in one system does not affect the sensitivity of the other), but not at the state level, as a change in the activation of one system (in the moment) antagonizes the other (Corr & McNaughton, 2008). Although

[4] BIS activation initially results in behavioral inhibition followed by increased vigilance and environmental scanning (Gray & McNaughton, 2003).

effects in line with SSH are expected under some circumstances (e.g. when appetitive and aversive stimuli are not presented in close temporal proximity to one another), in everyday life and under most laboratory conditions results indicative of the JSH are anticipated (Corr, 2013).

In summary, as it stands today (Corr, 2004), the JSH rests on a single premise: increased BAS activation downregulates BIS activation (and vice versa). For example, during an interview for a desirable job, an interviewee who has a sensitive BIS (scores high on trait BIS) will experience greater BIS activation and consequently anxiety and distress. However, the severity of the anxiety will also depend on the interviewee's BAS sensitivity. More specifically, low BAS sensitivity would not affect anxiety levels, but high BAS would inhibit the BIS (through increased activation in the moment) and associated behaviours (e.g. the interviewee will be less anxious).

Over the last 15 years, a substantial amount of empirical work has been carried out to test the JSH, with the majority of studies yielding results that support the hypothesis. Trait BIS and BAS have been shown to jointly predict the following phenomena: the evaluation of positive and negative facial expressions (Bocharov & Knyazev, 2011), attention allocation to negatively valenced words (Vilfredo De Pascalis, Strippoli, Riccardi, & Vergari, 2004), reaction time to appetitive cues (Smillie & Jackson, 2005), emotion modulation and inhibition/disinhibition (Corr, 2002), cortical activation to rewarding and aversive stimuli (Knyazev & Slobodskoj-Plusnin, 2007), cognitive processing of emotional information (A. Gomez & Gomez, 2002), attention (V. De Pascalis, Arwari, Matteucci, & Mazzocco, 2005) and activity in the ventral striatum in response to reward cues (Mortensen, Lehn, Evensmoen, & Håberg, 2015). In all these studies, the magnitude of responses to (BIS activating) aversive stimuli was the largest for high BIS and low BAS (as compared to high BIS and high BAS) subjects. This suggests, that in line with the JSH, BAS activity inhibits the BIS.[5] Nonetheless, other studies report results supportive of the SSH under very similar conditions for the following dependent variables: positive and negative mood states (Eddington, Majestic, & Silvia, 2012), behavioural inhibition, activation and skin conductance under aversive and rewarding task conditions (Kambouropoulos & Staiger, 2004; Mardaga, Laloyaux, & Hansenne, 2006) and processing of positive and negative words (A. Gomez & Gomez, 2002, p. 20; R. Gomez, Cooper, McOrmond, & Tatlow, 2004). In these five studies, BIS and BAS predicted responses to aversive and rewarding stimuli/experiences independently (in accordance with the SSH). Although there are more studies in support of the JSH, it is difficult to draw any conclusions due to the substantial variability in the measures used to assess BIS and BAS - they appear to be measuring different but interrelated constructs (Krupic, 2017).

All of the evidence presented above relies on trait measures of BIS and BAS; the downregulation of state BIS by BAS (and vice versa) is simply assumed but never directly tested. The bulk of the supporting evidence comes from animal research, however there is very little work directly examining the hypothesis with human participants (Corr & McNaughton, 2008). To the best of our knowledge, only one publication so far has tested this premise in human subjects, which was done with a correlational design (Nash, Inzlicht, & McGregor, 2012). In that study, left frontal asymmetry (LFA), a neural measure of approach motivation, was found to be negatively associated with error-related negativity (ERN), a neural marker of BIS. With the aim of extending the previous findings, I conducted two experiments with human participants to test the relationship between state BAS and BIS. In both studies, I experimentally focused

[5] Similarly, responses to (BAS activating) appetitive stimuli were the largest for high BAS and low BIS individuals, as compared to high BAS and high BIS.

participants on phenomena that have been linked in the literature to eager, approach motivated states (theoretically linked to increased BAS activation) and then measured patterns of neural activation theoretically related to state BIS. Based on the premise that increased BAS should mute BIS, I hypothesized that the manipulation designed to increase BAS activation should lead to reduced activation of the BIS.[6]

Manipulating BAS Activation by Priming Ideals and Values

To test the JSH (BAS muting BIS activation), I experimentally manipulated self-relevant ideals. Human goals are usually thought to be organized in a hierarchy, differentiated by levels of abstraction (Carver & Scheier, 2001; Vallacher & Wegner, 1989), with abstract system level concepts such as guiding ideals and values at the apex and concrete action sequences at the bottom. An important implication of this view is that the abstract ideals and values are goals that operate according to many of the same motivational processes as more concrete goals. For example, the accessibility of ideals is positively associated with left frontal asymmetry (LFA), a neural marker of approach motivation (Amodio, Shah, Sigelman, Brazy, & Harmon-Jones, 2004). Similarly, priming participants with their idiosyncratic aspire-to goals increases activation of the left prefrontal cortex (Eddington et al., 2012). In addition, affirming a core value increases activity in the Ventral Striatum (VS) and Ventral Medial Prefrontal Cortex (VMPFC; Cascio et al., 2015; Dutcher, 2016) – areas of the brain associated with anticipation of and experience of primary and secondary rewards just as the BAS. Furthermore, abstract narrative representations of the self are particularly important for maintaining effective goal pursuit (Hirsh et al., 2012; Hirsh, Mar, & Peterson, 2013). Finally, in our own unpublished research, I have recently found

[6] To completely validate the JSH, the opposite relationship (state BIS downregulating state BAS) would also need to be established.

that focusing participants on their values and ideals significantly increases state approach motivation (assessed with the adjectives “excited” and “energized”) above baseline levels — importantly, it increased approach motivation to the same extent as focusing directly on something that they wanted to approach (Elnakouri, Sasaki, & McGregor, 2017, unpublished data).[7] In summary, the existing research suggests that the BAS is activated when individuals focus on their values and ideals.

Measuring BIS Activation with P3a Wave

Much of RST theory is based on observation of rodent behaviour (e.g. rearing, scanning, thigmotaxis) in response to a natural predator (e.g. a cat; Corr & McNaughton, 2008; Gray & McNaughton, 2003). To find evidence for similar reactions in humans, I assessed the human orienting response (OR). The OR, first described by Pavlov, is the automatic orienting of attention to a novel stimulus (Bradley, 2009). Novelty, such as unexplored environments, constitutes a potential source of reward and danger simultaneously which in turn activates approach and avoidance tendencies and consequently, the BIS (Gray & McNaughton, 2003). Gray and McNaughton, (2003, p. 53) suggested that the OR is “closely related to the activities of the behavioural inhibition system” because their inputs (novelty) and outputs (behavioural inhibition, increased attention allocation to the novel stimulus) are so similar.

Orienting response. Pavlov’s theorizing about the OR began when attempting to showcase his animal subjects’ learned stimulus response contingencies in front of visiting colleagues (Bradley, 2009). Instead of performing the desired behaviours, his trained animals ignored the presented stimuli and instead focused their attention on the visitors. Pavlov referred

[7] There was no difference in approach motivation strength between the approach (M = 4.1, SD =.72) and values (M = 4.2, SD = .7) conditions, $t(164) = 1.03$, $p = .306$.

to the animals' vigilant investigative reaction to the novel guests as the "novelty reflex", later renamed to OR (Pavlov, 1927). Early OR research focused on understanding the actions of the organism's muscular system to reorient itself to an optimal position for perceiving novel stimuli (Sokolov, 1963). However, later psychophysiological studies also uncovered central, sympathetic, and parasympathetic nervous system reactions associated with the OR (Bradley, 2009).

Central to the OR theory is the concept of the "neuronal model" (Sokolov, 1963). It assumes that at any given moment a mental representation or a schema of the external world is generated in the brain. Since external objects possess diverse properties (e.g. sound can be represented by timbre, pitch, amplitude) their respective "values" are also "encoded" in the model. When any of the major properties of the stimulus change (i.e., are novel) and no longer coincide to the neuronal model, an OR is elicited (Sokolov, 1963). For example, pure tones delivered repeatedly through an audiometer have been shown to reliably elicit the OR (Sokolov, 1963). Habituation is another critical feature of the OR. As the stimulus is presented repeatedly and the novelty factor wears off, the response weakens. Functionally, the OR is a vital adaptation mechanism that allows the organism "to meet chance dangers" (Sokolov, 1963, p. 11).

Orienting and P3a. Neurophysiological research has identified various indices of the OR, including several Event Related Potential (ERP) components: mismatch negativity (MMN), N2b, P300 and late positive potential (Barry, MacDonald, De Blasio, & Steiner, 2013; Bradley, 2009). The P300 is believed to be a by-product of context updating, a process by which working memory mental representations or "schemas" of the external environment are "refreshed" (Polich, 2007). In other words, every time a significant attribute change of an environmental stimulus is detected, working memory "updates" the existing schema to accommodate the change which is almost identical to the neuronal model of the OR. A leading theory is that this updating is what gives rise to the P300 (Polich, 2007). Thus, given the functional similarities between OR and P300 it has been proposed that the two may be closely related (Donchin et al., 1984).

P300 was initially believed to be a unitary phenomenon (Polich, 2007). Later research has suggested that at least two distinct subcomponents can be generated: P3a (or Novelty P300; Simons, Graham, Miles, & Chen, 2001) and P3b (Duncan et al., 2009). P3a is generated in response to rare unattended “novel” stimuli while P3b is generated in response to similarly rare but attended tones (Polich, 2007). Thus, P3a represents involuntary orienting of attention to incidental cues, while P3b represents voluntary attention to integral cues. In one study P3a showed a clear relationship to the OR while P3b did not (Marinkovic, Halgren, & Maltzman, 2001). More recent research also supports the idea that P3a is an important component of the OR (Barry et al., 2013; Rushby, Barry, & Doherty, 2005). Therefore, since P3a as an index of the OR which is a BIS related phenomenon, I used P3a amplitude as a measure of state BIS.

Current Research

To test the main premise of the JSH, in two studies, I manipulated state BAS by having participants write about their ideals and aspirations vs. oughts and responsibilities (Study 1) and their most important value vs. least important value (Study 2). I expected participants who wrote about their ideals and most important value to show lower P3a amplitude, in line with the state JSH narrative.

CHAPTER TWO: STUDY 1

In Study 1, I manipulated state BAS by having participants write about either their ideals or duties and obligations (Freitas & Higgins, 2002; Higgins, Roney, Crowe, & Hymes, 1994). I then assessed their BIS activation during an "oddball" procedure by measuring the voltage amplitude of the P3a wave elicited by incidental, white noise tones administered over headphones. If BAS inhibits BIS as proposed by the JSH, writing about ideals should reduce P3a wave amplitude compared to participants who wrote about duties and obligations.

Methods and Materials

Seventy-nine (out of 97) participants consented to have the data they generated as part of an undergraduate psychology class exercise be analyzed for research purposes. Fourteen participants were excluded from the analyses due to missing data (P3a wave amplitude at Time 3). Data from 65 participants (47 female, 1 other, mean age = 21.2, age range: 20-26) were included in the final analyses.

Upon arriving, participants were greeted and then asked to take a seat at one of the computer stations. After introducing the study, participants were fitted with an EEG headset by trained research assistants. Participants were then randomly assigned to either the experimental or control condition. Following the experimental manipulation, I recorded participants' magnitude of electrical brain activity in response to three separate volleys of white noise tones dispersed at random intervals. The first volley was administered immediately after the experimental manipulation (proximal time period). The second, after an intervening task unrelated to the current study (distal time period), and the third was at the end of the experiment, and served to control for individual differences (baseline). The entire study took an average of 60 minutes.[8] At each time point, I averaged the magnitude of the P3a wave after each white noise tone, and used the difference between this magnitude and the magnitude after silence as the measure of BIS activation. I predicted that the ideals manipulation would decrease P3a magnitude.

Ideals manipulation. Participants wrote a short essay about how either their ideals, or their duties and obligations have changed since childhood (adapted from Freitas & Higgins, 2002; Higgins et al., 1994). The instructions read as follows:

> For this task, I would like you to think about how your current <u>hopes and aspirations</u> (duties and obligations) are different now from what they were when you were growing up. In other words, what <u>accomplishments</u> (responsibilities) <u>would you ideally like</u> (do you think you ought) to meet at this point in your life? What <u>accomplishments</u> (responsibilities) <u>did you ideally want</u> (did you think you ought) to meet when you were a child? In the space below, please write a brief essay describing how your <u>hopes and aspirations</u> (duties and obligations) have changed from when you were a child to now."[9]

Although this manipulation has typically been used to induce a promotion-focus in regulatory focus research, past research has also found it to be an effective prime of approach motivation (Amodio et al., 2004; McGregor, Nash, Mann, & Phills, 2010). Given the leverage that abstract goals have for activating systemic motivation in goal systems, I expected that this manipulation should be a powerful way to activate the BAS.

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[8] The current investigation is part of a larger study. For all other measures/manipulations used see Appendix A.

[9] There was no difference in the amount of time (in minutes) spent between conditions (Ideals: $M = 3.46$, $SD = 2.68$; Duties/Obligations: $M = 3.21$, $SD = 2.08$), $t(59) = 0.38$, $p = 0.70$. The amount of time spent writing about duties/aspirations was not recorded for four participants (due to an unexpected software error).

Auditory oddball task and P3a assessment. The P3a wave is typically extracted from a three-stimulus oddball task, comprised of frequent pure tones and infrequent respond-to targets and infrequent distractor tones or noises (Duncan et al., 2009). The distractor elicits a P3a and the target a P3b component. However, a simpler iteration of the oddball task has also been used (Mertens & Polich, 1997). In a single-tone paradigm, subjects passively listen to infrequent pure tones interspersed with periods of silence. This modified version of the oddball task has been shown to yield a robust P3a wave (Mertens & Polich, 1997). The classic oddball Inquisit script was downloaded from the Millisecond website (http://www.millisecond.com/download/library/oddball/). It was then reprogrammed into a single stimulus design. Instead of using pure tones I used white noise as it has been shown to elicit the largest P3a waves (Combs & Polich, 2006).

A total of 300 stimuli were presented in random order for 1 second in immediate succession. Two types of stimuli were used: silence and white noise, presented with probabilities of 0.92 and 0.08, respectively. Participants were instructed to sit still with their eyes closed and avoid large movements. Three sessions of the oddball task were administered: proximally, distally (following the Wise Reasoning Scale[10]), and at the end of the study (baseline measure). Each session lasted for 5 minutes. At the end of the task, participants were told to open their eyes through earphones using pre-recorded instructions.

EEG Apparatus and Software. Experimental materials and stimuli were presented on a computer monitor using Medialab 2012 (Jarvis, 2012) and Inquisit 4 software. An Emotiv EPOC™ EEG headset was used to measure brain activity. The wireless headset contains 16

[10] The current investigation was part of a larger study. For all other measures/manipulations used in the study see Appendix A.

gold-plated electrodes (AF3, F3, F7, FC5, T7, P7, O1, AF4, F4, F8, FC6, T8, P8; CMS and DRL references at P3, P4) arranged according to the 10-20 system. Although less sophisticated in comparison to the full 32-64 electrode EEG cap, the Emotiv EPOC has been validated as an effective research tool (Badcock et al., 2013; Debener, Minow, Emkes, Gandras, & de Vos, 2012; Duvinage et al., 2013; Ekanayake, 2010; Stytsenko, Jablonskis, & Prahm, 2011). The headset was connected to a Dell computer interface through USB using proprietary manufacturer software (TestBench™). The EEG signal was sampled at 128Hz. The impedance values were minimized at the onset of the experiment (the software uses a color system to indicate impedance, "green" color being around 10kΩ). A virtual open-source serial port driver for Windows (com0com, SourceForge.net) relayed stimuli locked markers between the stimuli-presentation software (Medialab 2012; Inquisit 4) and the headset software (TestBench). Most participants brought their own earphones; however, those that forgot were provided a pair along with brand new earphone covers. The volume was set to a comfortable level.

Data Cleaning and Reduction. The raw EEG data were preprocessed offline using Brain Vision Analyzer (Brain Products, Munich, Germany). First, it was subjected to a bandpass filter (0.01Hz – 30 Hz; Luck, 2005) and a notch filter (60Hz; Duncan et al., 2009). An artifact rejection procedure was then applied. Segments that contained: (a) voltage step greater than 35 μV/ms, (b) max-min difference greater than 100mV (within 100 ms), (c) low activity of 0.5 μV/ms in a 100 ms window and (d) max-min amplitude of +75 μV and -75 μV (respectively) were removed (including data 200 ms before and after the event)[11]. The startle and silent tones were extracted from the raw EEG signal, each segment consisting of 200 ms prior to the tone, and 800 ms following it. The segments were baseline corrected using the 200 ms leading up to

[11] Except for max-min amplitude – only 100 ms before and after the event.

the tone. The tones were then averaged together to create an overall average white noise (25 tones) and silent (275 tones) waveforms, from which the P3a component was extracted (mean amplitude within 280 ms – 360 ms[12] of stimulus onset).[13] Since P3a peak amplitude is largest at fronto-central sites (Knight, 1996) I averaged channels F3 and F4 to get the best estimate for the frontal midline site Fz. I then subtracted the mean silence waveform (mean activity in µV for the time window) from the white noise for each channel to calculate the P3a difference wave for each participant.

Results

I regressed proximal and distal scores separately on the baseline measure and saved the residuals to control for individual differences.[14] A 2 (ideals vs. duties/obligations) x 2 (proximal

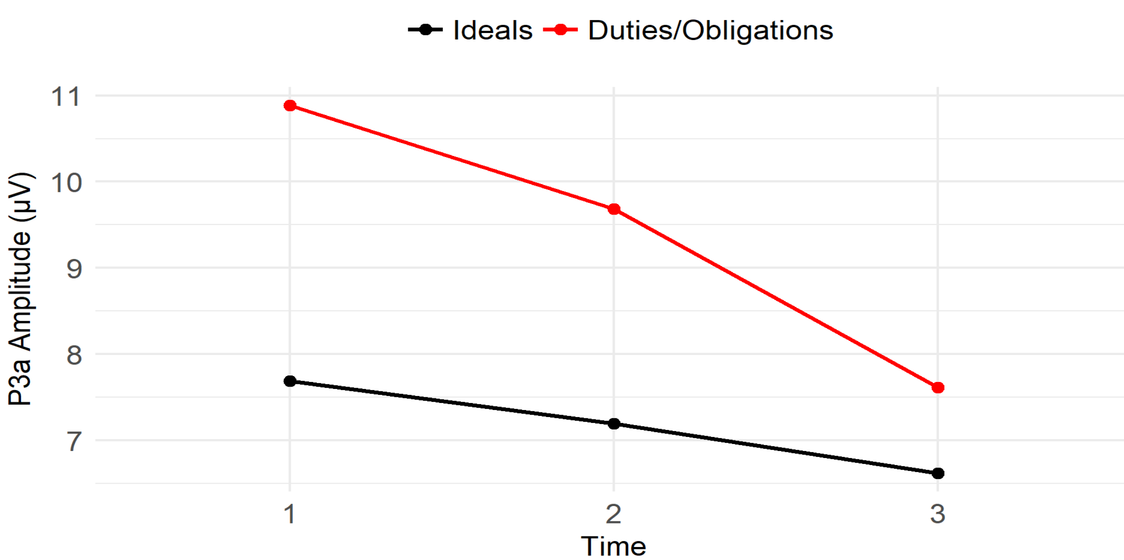

Figure 1. Ideals by Time interaction on P3a amplitude (channels F3 and F4 averaged together; µV) raw means.

[12] This time window was generated by averaging all participant data into a single graph ("grand average" function in Brain Vision Analyzer). Based on our data, it appeared that across all participants the typical peak of the P3a wave occurred within this time frame. To maintain standardization across all participants, we used this same window when extracting the mean activity (µV).
[13] See Figures 4 to 6 in Appendix C for the average ERP waveform.
[14] See Figure 1 for raw means across the three time points by condition.

vs. distal) mixed linear regression analysis did not reveal a significant interaction, nor a main effect of time. However, there was a marginal main effect of condition [$B = 1.99$, $\beta = 0.38$, $t(63) = 1.94$, $p = 0.06$].[15] Participants in the ideals condition ($M = -0.82$, $SD = 4.66$) showed reduced P3a amplitude compared to participants who wrote about their duties and obligations ($M = 1.16$, $SD = 5.72$) across the two time points averaged together (see Figure 2).

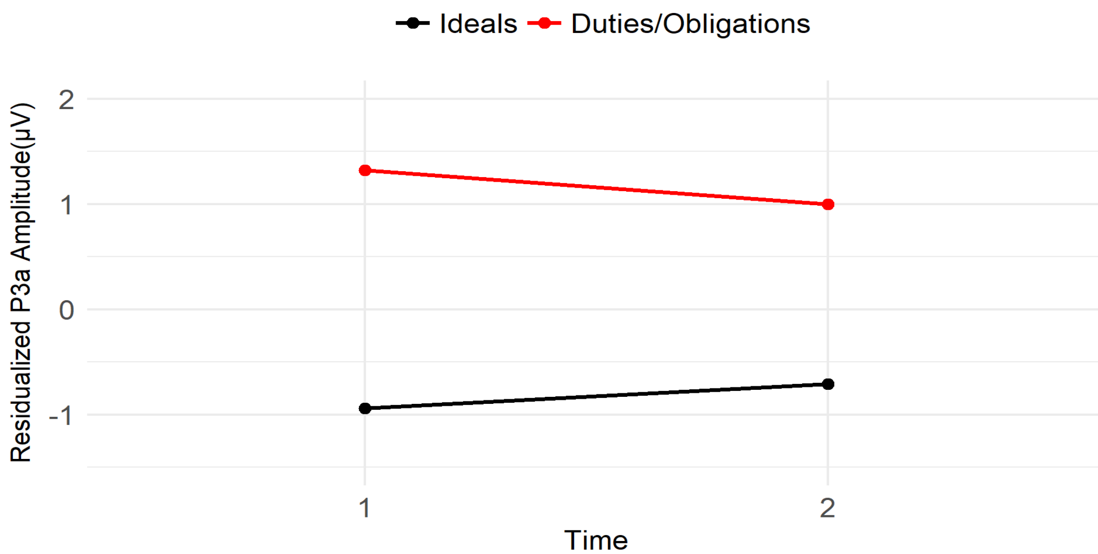

Figure 2. Ideals by Time interaction on P3a Amplitude (channels F3 and F4 averaged together; μV) residualized means.

[15] See Figure 2 for residualized P3a amplitude means by condition and time; independent variable was coded as 1 (duties/obligations) and -1 (ideals).

CHAPTER THREE: STUDY 2

Study 2 was a conceptual replication of Study 1. I manipulated state BAS by having participants write about their highest values instead of their ideals. Aside from this change, the method and data analyses were very similar to Study 1; however, instead of a single stimulus auditory oddball task I used a 2-tone version - 1000 Hz pure tone and white noise, presented with probabilities of .70 and .30, respectively (Squires, Squires, & Hillyard, 1975). Participants were also instructed to look at the middle of the screen while the tones were presented and avoid large movements and excessive blinking (as opposed to keeping their eyes closed in Study 1). Two (as opposed to three) sessions of the oddball task were administered: immediately after the values manipulation (proximal) and one at the end of the experiment (baseline measured used to control for individual differences), just prior to some filler personality questionnaires[16]. Participants were provided a pair of earphones along with noise-reducing earphone covers (as opposed to using their own). The volume was standardized at 30% of the stock volume range (-192dB – 0 dB). A Virtual Serial Port Driver (2013, Eltima Software, Bellevue, WA) relayed stimuli locked markers between the stimuli-presentation software (Inquisit 4) and the headset software (TestBench). The entire study was programmed solely in Inquisit 4.

Methods and Materials

A total of 84 undergraduate psychology students (no demographic information collected; all right-handed) participated for course credit. One participant refused to wear the EEG headset. Another 3 participants were excluded because experimenter error resulted in missing time-locked stimulus markers. An additional 18 participants were dropped from the analyses due to missing

[16] The personality questionnaires were not relevant to the current investigation, however they can be found in Appendix B.

EEG data (from our primary electrodes of interest: F3/4, AF3/4, F7/8, and FC5/6) resulting from poor electrode connection. Consequently, data from a total of 62 participants were included in the statistical analyses.

Values manipulation. Participants were randomly assigned to one of two conditions: a most important value and least important value (control) condition (materials adapted from McGregor et al., 2001). They selected one of six values (that was most/least important to them) from a list and then wrote it down in the space provided. The following value choices were offered: business/economics, social life/relationships, art/music/theatre, social action/helping others, science/pursuit of knowledge and religion/spirituality (adapted from Allport, Vernon, & Lindzey, 1960). In the most important value condition participants wrote about why the value they selected was important to them and how they have acted according to it in the past and plan to in the future. In the control condition, participants selected a value that was least important to them and then wrote about why they find it unimportant, how it might be important to someone else, and how others might act according to it. Following the writing component, a manipulation check for the relative commitment (a central feature of approach motivation, Harmon-Jones et al., 2009) to the selected value was administered (6-item; $\alpha = 0.96$). These included the following statements rated on a 5-point Likert type scale (1 – *very slightly or not at all* to 5 – *extremely*): "This value is of great importance to my life", "This value matters a lot to me", "This value affects my daily behaviour in many ways", "This value is central to my identity", "This value defines me as a person" and "This value makes me who I am".

Data cleaning and reduction. A total of 300 tones were presented from which the P3a component was extracted (265ms – 350ms)[17,18]. As in the first study I subtracted the mean standard tone wave from the startle to calculate the P3a difference wave.

Results

The composite six-item manipulation check revealed that participants were more committed to the important (M = 4.05, SD = 0.69) than the unimportant values (M = 2.02, SD = 0.79; [B = -2.03, β = -1.61, $t(60)$ = -10.82, p < .001]. As in Study 1, we used the average of channels F3 and F4 as an estimate for the midline Fz site. Similarly, we regressed the proximal P3a amplitude on the baseline measure and saved the residuals. A linear regression yielded a significant effect of condition, [B = 3.34, β = 0.57, $t(60)$ = 2.34, p = 0.02]. [19,20] As shown in Figure 3, participants in the most important value condition (M = -1.67, SD = 5.72) exhibited reduced P3a amplitude compared to participants in the control condition (M = 1.67, SD = 5.51).

[17] As in Study 1, based on a grand average of all participants it appeared that this time window best represented the peak of the P3a wave. We therefore used this time window to export the mean activity data (µV) for all participants.
[18] See Figures 7 and 8 in Appendix C for the average ERP waveform.
[19] See Figure 3 for raw means across the two time points by condition.
[20] Independent variable was coded as 1 (control) and 0 (affirmation).

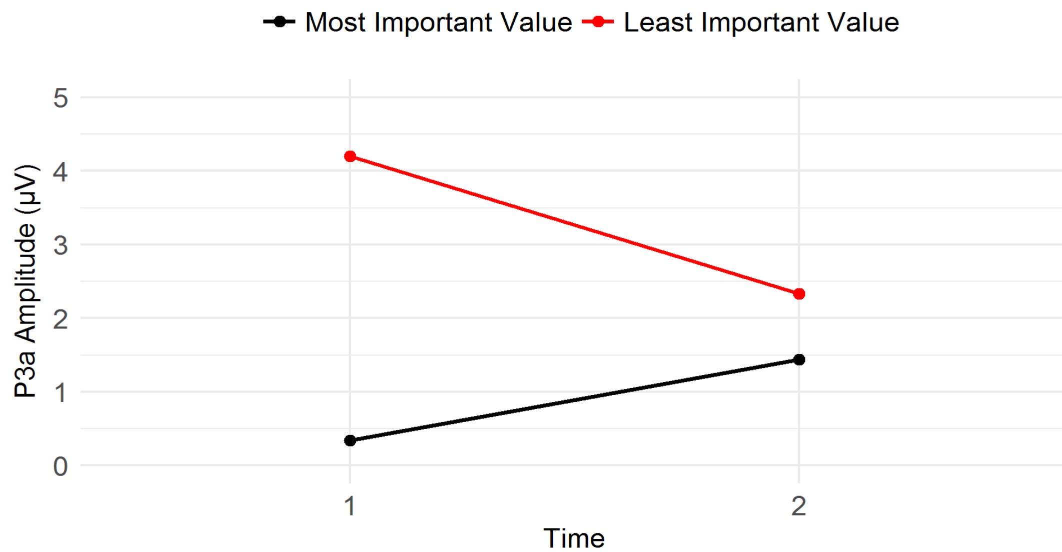

Figure 3. Values by Time interaction on P3a amplitude (channels F3 and F4 averaged together; μV) raw means.

CHAPTER FOUR: GENERAL DISCUSSION

In two studies, I tested the JSH (Corr, 2004) derived postulate that activation of state BAS should reduce subsequent state BIS activation. For the experimental manipulation of state BAS in Study 1, participants wrote about their ideals; in Study 2 they reflected on their most important value in life. Across both studies, after the experimental manipulation I used P3a amplitude to measure state BIS. Results supported our JSH derived postulate: writing about ideals or values muted the marker of BIS activation (P3a magnitude).

In Study 1, participants in the control condition reflected on their current as well as childhood duties and obligations. Thinking about duties and obligations can trigger a vigilant state, that is also characteristic of BIS activation (Gray & McNaughton, 2003; Scholer & Higgins, 2011). As a result, it is possible that the effects observed in Study 1 were driven by increased BIS (control condition) as opposed to the hypothesized BAS activation (experimental condition). However, the fact that I found a significant effect in Study 2 using a completely neutral control manipulation, suggests that it was increased BAS activation that drove the effects in Study 1.

Stress induction research largely corroborates our findings. In two studies, writing about a most important value reduced threat induced spike in cortisol (Creswell et al., 2005; Sherman, Bunyan, Creswell, & Jaremka, 2009). Cortisol has been found to be positively associated with the BIS, although this study was conducted with a sample of depressed pregnant women (Field et al., 2006). Our studies are the first to test the JSH using an experimental method in humans and to thereby support the postulate that state BAS activation in one domain can mute state BIS activation in another.

Limitations

One limitation of our studies is that despite similar power in the two studies, the expected effect was only marginally significant in Study 1. This may be because the Study 1 manipulation asked participants to focus on ideals that had been important to them in the past as well as the present, as opposed to only presently important values in Study 2. Priming past and present priorities (Study 1) may be a less powerful activator of BAS than priming present priorities only (Study 2). The convergence across methods is nonetheless encouraging, and a meta-analysis of the main effect across the two studies yielded an overall significance of $p = 0.003$ (Stouffer's z trend method; Whitlock, 2005).

Another limitation of the present research is that I did not include a direct measure of BAS activation during the period when participants were writing about their hopes or values. I merely relied on past research showing that these writing manipulations could prime approach motivated states characteristic of BAS activation (Amodio et al., 2004; Dutcher, 2016; Elnakouri et al., 2017). However, in Study 2 I did include a manipulation check of commitment as a proxy for approach motivation (based on Harmon-Jones et al., 2009). However, future research should directly measure a neural measure of approach motivation during the experimental manipulations as a manipulation check and mediator of the effect on muted BIS activation (as in Nash et al., 2012).

Methodological Implications

One methodological implication of the present research is that it provides preliminary support for the viability of priming abstract goals as a way to activate BAS and approach motivated states. Current manipulations of approach motivation tend to rely on anger, which simultaneously activates negative affect (Carver, 2004; Harmon-Jones & Allen, 1998). Priming approach motivation by reminding people about their ideals and values would provide a complementary way to activate approach motivation that does not involve negative affect.

An important methodological advancement of the present work is that it validates the use of P3a as an unobtrusive measure of BIS activation. This is important because past research on neural correlates of BIS has tended to rely on error-related negativity (ERN), an ERP that is generated when people make errors on a focal task (e.g. Stroop, flanker, etc; Yeung, Botvinick, & Cohen, 2004). Using P3a as opposed to ERN wave is more advantageous procedurally for the following reasons: 1) Time - ERN wave typically requires upwards of 350 trials, which take an average of 10-15 minutes (in contrast to just five for P3a; Hajcak, 2016), 2) Cognitive load – participants need to constantly stay focused on a boring task which may in turn lead to depletion (Hagger, Wood, Stiff, & Chatzisarantis, 2010) and affect post task responses (whereas our version of the oddball does not require focal attention), and 3) Muscle potential artifacts – having to keep eyes open and press keys throughout the task increases the noise in the collected signal (Luck, 2005). In addition, although the ERN has been linked to anxiety (Hajcak, 2012), its functional definition is complicated by its dual status as an error/conflict detection signals and as a marker of motivation for error-correction and self-control (Inzlicht, Bartholow, & Hirsh, 2015; Inzlicht & Schmeichel, 2012; Yeung et al., 2004). Given these advantages P3a wave can be a promising measure of BIS activation.

Theoretical and Practical Implications

Our findings have direct implications for the general threat and defense framework (Jonas et al., 2014). This meta theory which subsumes a wide-ranging family of theories (e.g. cognitive dissonance, uncertainty reduction, social identity, terror management, reactive approach motivation, meaning maintenance model, etc.; see Jonas et al., 2014), argues for the JSH as the unifying process that elucidates the motivational underpinnings of threat induced compensatory behaviour. However, this framework only has indirect evidence that BAS mutes BIS activation (Jonas et al., 2014). The present work provides causal support of the JSH-derived postulate that BAS mutes BIS.

Our results also have implications for theory and research on the effects of value-affirmation. To date there is little consensus on the nature of the mediating mechanism responsible for these effects (Sherman & Cohen, 2006). Potential mechanisms have been suggested: increases in (non-conscious) positive affect, and state and collective self-esteem (Fein & Spencer, 1997; Koole, Smeets, Van Knippenberg, & Dijksterhuis, 1999; Sherman & Kim, 2005). Our findings suggest that reduced BIS activation may be another viable candidate, as it is consistent with all of the interpretations above. Reduced BIS activation should reduce the need for defensiveness in the wake of a threatening experience, because most defenses are levers for BAS activation for relief from BIS (Jonas et al., 2014).

Our evidence that BAS mutes BIS also suggests a possible parsimonious account for the motivational basis of frustration induced aggression. Evolutionary theory proposes that aggression is an evolved mechanism for addressing social problems (see Buss & Shackelford, 1997). However, most human aggression and violence is irrational and runs contrary to personal and evolutionary self-interest (Baumeister, Smart, & Boden, 1996). This “hostile” (as opposed to instrumental) form of aggression is primarily motivated by the desire to inflict harm upon another person/object and appears to be pointless and self-defeating from the perpetrator’s perspective (Baumeister et al., 1996; Berkowitz, 1989). What motivates people to engage in such self-defeating behaviours? If state BAS mutes state BIS, then hostile aggression may be self-reinforcing largely due to its anxiolytic properties. Anger is an approach oriented emotion aimed at removing an aversive stimulus by its destruction or injury (Berkowitz, 2012; Carver & Harmon-Jones, 2009; Harmon-Jones & Allen, 1997; Harmon-Jones & Sigelman, 2001). Therefore, anger and hostility may sometimes be levers for activating approach states, to downregulate the BIS and associated anxiety.

Finally, our results may also shed light on the potential mechanism responsible for adaptive change in psychotherapy. Clinical research suggests that personality can change significantly over the course of treatment (Bagby, Gralnick, Al-Dajani, & Uliaszek, 2016). For example, group cognitive behaviour therapy (CBT) for social anxiety disorder has been shown to increase extraversion and decrease neuroticism (Glinski & Page, 2010). Similarly, antidepressant and therapy treatments for major depressive disorder (MDD) have been consistently shown to have the same effect (Costa, Bagby, Herbst, & McCrae, 2005; De Fruyt, Van Leeuwen, Bagby, Rolland, & Rouillon, 2006; Santor, Bagby, & Joffe, 1997). Trait measures of BIS and BAS have been consistently linked to neuroticism and extraversion (Heubeck, Wilkinson, & Cologon, 1998; Jorm et al., 1998; Smits & Boeck, 2006). Thus, it is possible that at least for depression and social anxiety, some of the gains made in treatment can be attributed to increased BAS and decreased BIS sensitivities. Since the two systems interact at the behavioural level, this change would result in substantial net increase in approach motivation which is in turn positively associated with life satisfaction (Updegraff, Gable, & Taylor, 2004). Future psychotherapy process studies could incorporate personality measures of BIS and BAS to measure absolute and relative change in the sensitivities of these systems and whether this can account for the reduction in symptoms.

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Appendix A – Extended Methods and Materials (Study 1)

After reading over the informed consent, participants filled out the Regulatory Focus Questionnaire (RFQ; Higgins et al., 2001) and were randomly assigned to one of two conditions (ideals vs. duties/obligations). Following the main manipulation, participants' left frontal asymmetry (Coan & Allen, 2003; Harmon-Jones & Allen, 1997) and P3a wave were recorded. They then wrote about a friend's close relationship that was not going very well, provided circumstantial details, and filled out the Wise Reasoning Scale (WRS; Huynh, Oakes, Shay, & McGregor, 2017). Subsequently, subjects were assigned to either the depletion or no depletion manipulation (adapted from Muraven, Tice, & Baumeister, 1998). Second LFA and P3a wave recording sessions followed. Afterwards, participants were instructed to solve as many five letter word anagrams as they could (out of 50), followed by the third and last LFA and P3a wave recording segment.

Depletion Manipulation

During the experiment, participants were instructed to take a copy of the materials for the next task from either a blue or a red folder (control and depletion respectfully). Paper materials consisted of two parts: A (practice block – same across conditions) and B (manipulation). Subjects were told to cross out the letter "e" (adapted from Muraven et al., 1998) in a difficult passage about obsessive compulsive disorder (1 page in length). In the depletion condition, the instructions for part B were altered, such that subjects had to cross out the letter "e" only if it was preceded by a vowel or if the vowel came two letters before the "e". In the control condition, e-crossing rules remained the same as in part A. In both conditions, part B was a continuation of the passage from part A (around 1 page in length).

The depletion manipulation was intended to test additional hypotheses that are not the focus of the current paper. The manipulation occurred after our key dependent variable, the Time 1 oddball task P3a measure. It also showed no effect on the baseline P3a scores at Time 3, $B = 2.59$, $\beta = 0.36$, $F(1, 62) = 2.03$, $p = 0.16$.

Appendix B – Extended Methods and Materials (Study 2)

After reading over the information letter participants' baseline LFA was recorded (Coan & Allen, 2003; Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997). Subjects then filled out a 1-item self-esteem scale (Robins, Hendin, & Trzesniewski, 2001), and were randomly assigned to one of two condition (most versus least important value). After picking a value from a list of six, they were told that they would soon describe and rate how important the value is to them, which was followed by another LFA segment. Following the value affirmation manipulation, participants rated their chosen value on importance. Then, a 3rd LFA segment was recorded followed by a 5-minute oddball task and a 4th LFA segment. Thereafter, participants read a favorable and an unfavorable essay (presented in random order) ostensibly written by recent exchange students about their experience in Canada and then rated the authors' intelligence. Subsequently, they filled out a personal projects measure (Little, 1983). The essays and personal projects were presented randomly. Thereafter, participants' LFA was recorded again, followed by another 5-minute oddball task and a final LFA segment.

Next, participants filled out a battery of personality scales conceptually related to BAS and BIS. These included: Meaning in Life Questionnaire (Steger, Frazier, Kaler, & Oishi, 2006), General Self-Efficacy Scale (Schwarzer & Jerusalem, 2010), Adult Hope Scale (Snyder et al., 1991), General Regulatory Focus Measure (Lockwood, Jordan, & Kunda, 2002), Horizontal Collectivism and Individualism subscales (Singelis, Triandis, Bhawuk, & Gelfand, 1995), Uncertainty Response Scale (Greco & Roger, 2001), BAS Drive (Carver & White, 1994), Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003), Behavior Identification Form (Vallacher & Wegner, 1989) and Rosenberg Self-Esteem Scale (Rosenberg, 1965). Finally, participants were asked about their religious identification, given a suspicion check, and debriefed.

Appendix C – P3a Wave Time Window Extraction

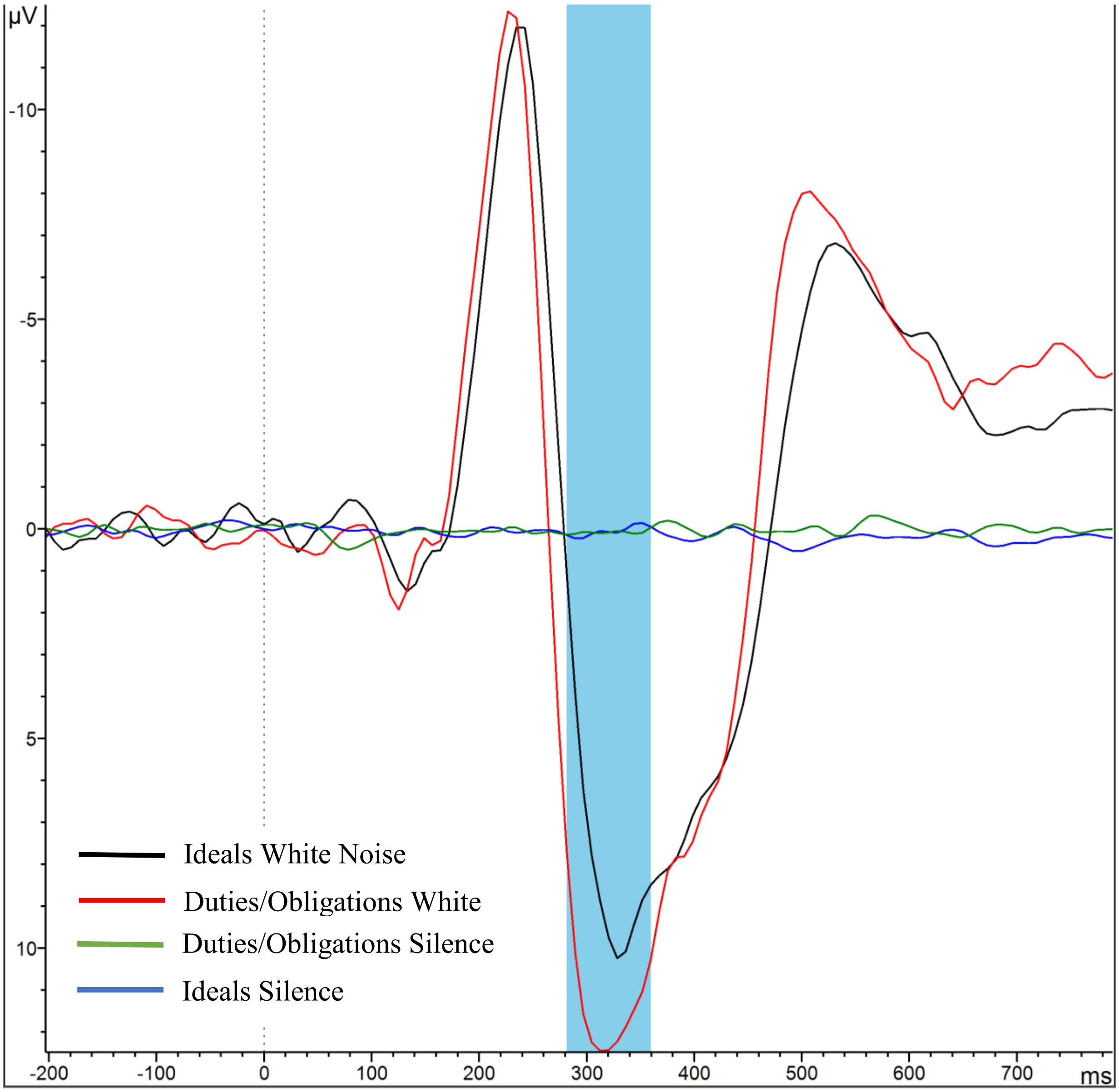

Figure 4. Average waveform for white noise tones and periods of silence for channels F3 and F4 pooled together by condition at Time 1 (X axis – milliseconds; Y-axis - μV). The blue area under the curve was exported for analyses.

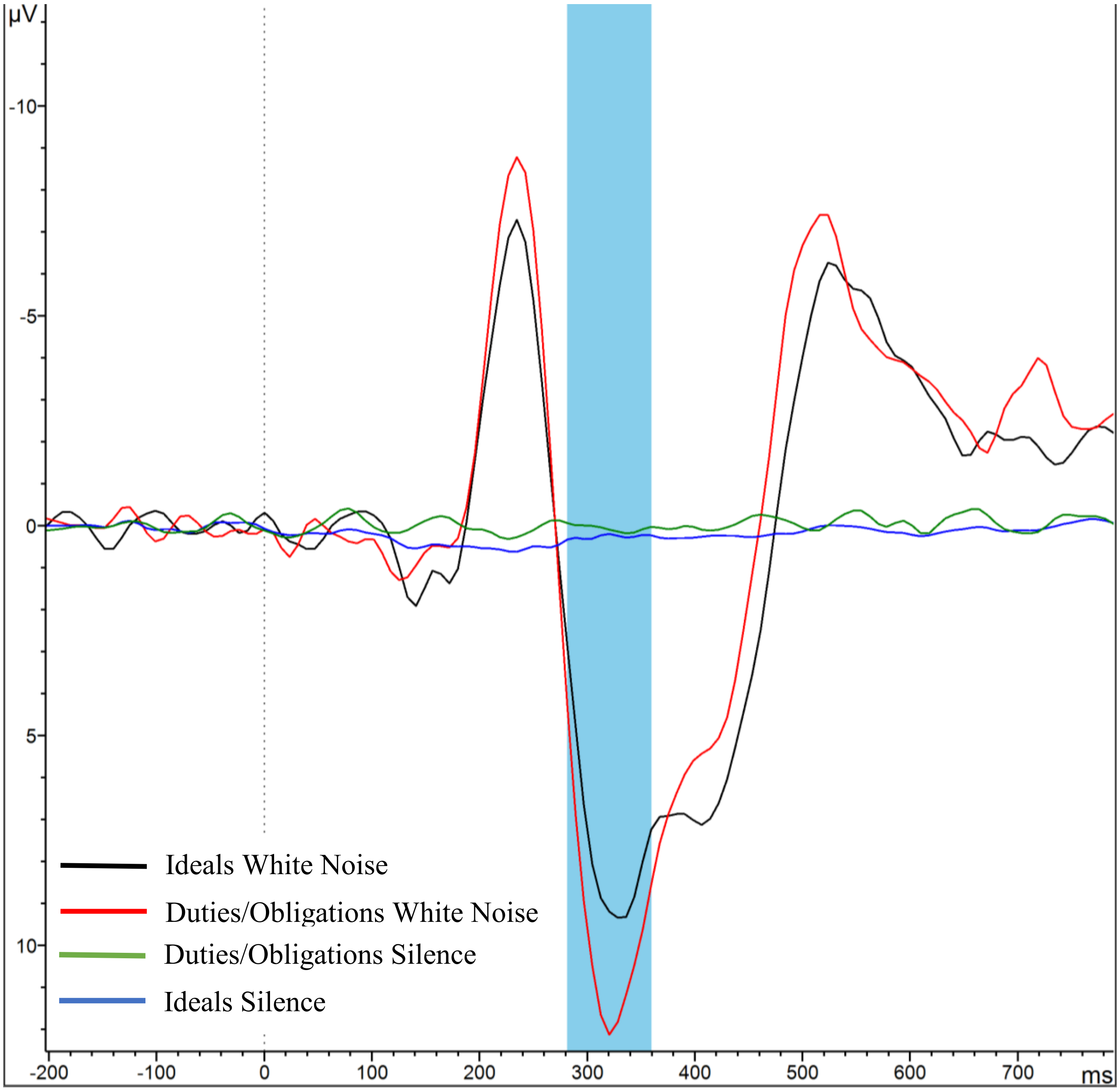

Figure 5. Average waveform for white noise tones and periods of silence for channels F3 and F4 pooled together by condition at Time 2 (X axis – milliseconds; Y-axis - µV). The blue area under the curve was exported for analyses.

Figure 6. Average waveform for white noise tones and periods of silence for channels F3 and F4 pooled together by condition at Time 3 (baseline; X axis – milliseconds; Y-axis - µV). The blue area under the curve was exported for analyses.

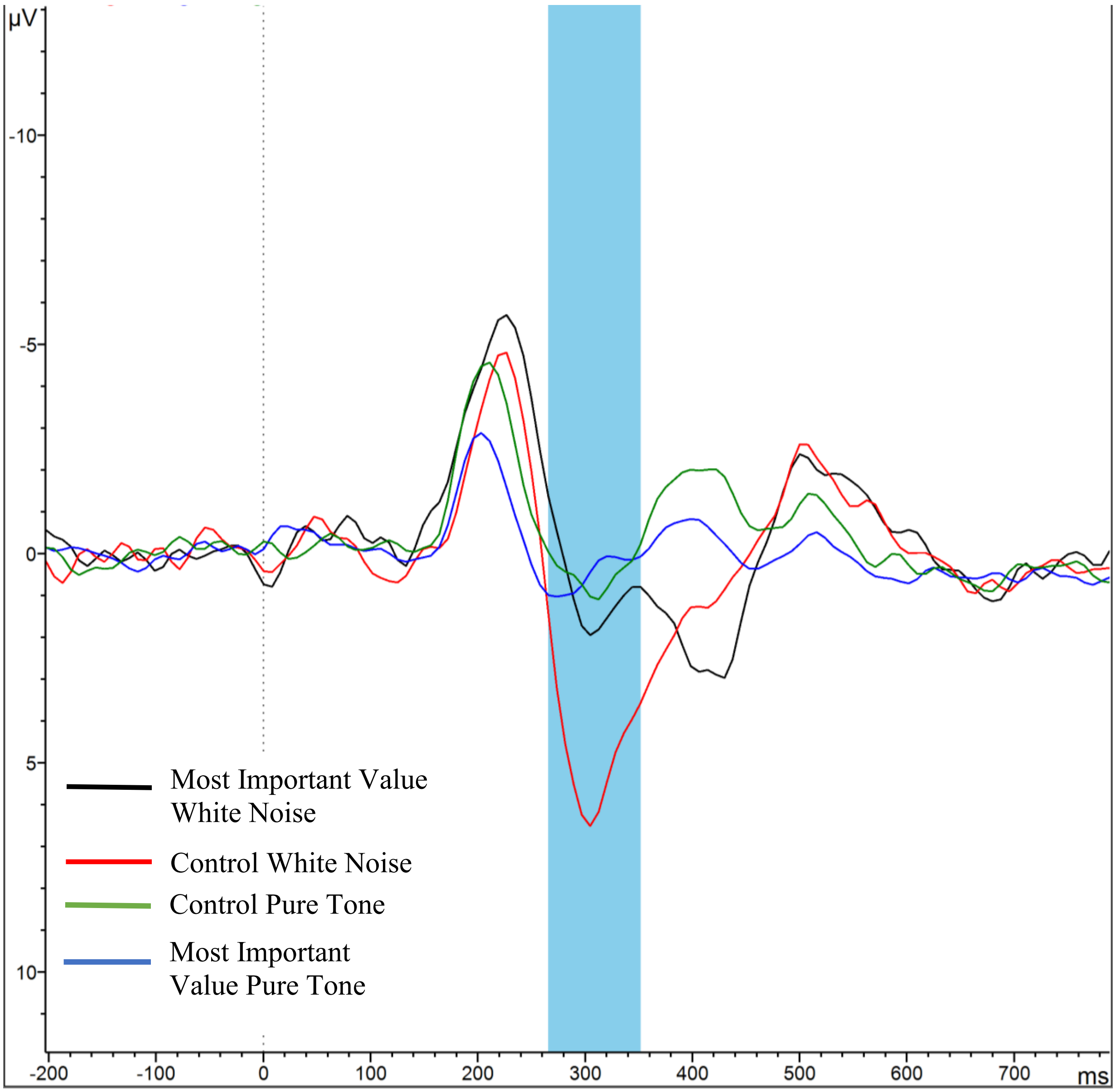

Figure 7. Average waveform for white noise and (1000 Hz) pure tones for channels F3 and F4 pooled together by condition at Time 1 (X axis – milliseconds; Y-axis - µV). The blue area under the curve was exported for analyses.

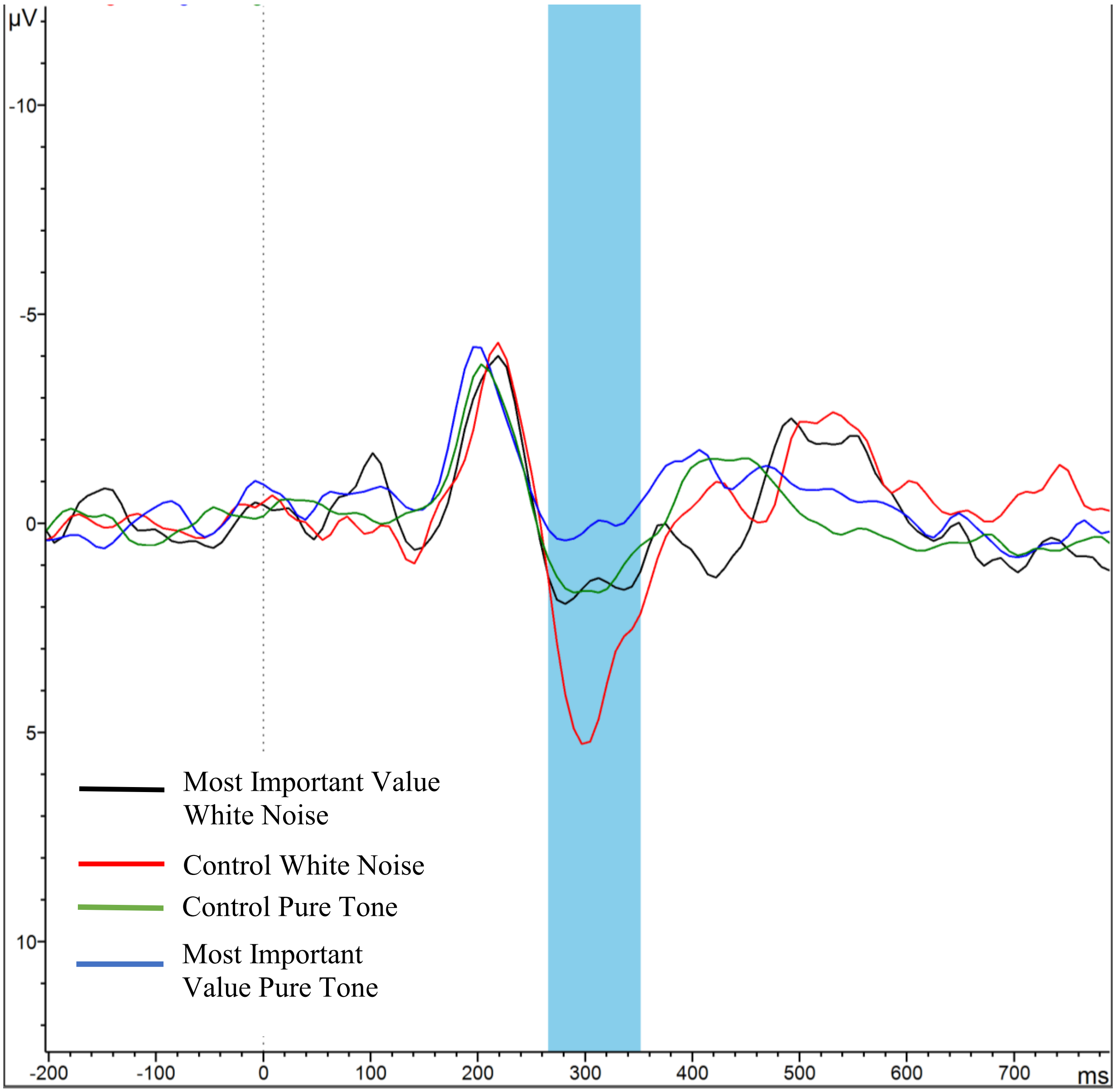

Figure 8. Average waveform for white noise and (1000 Hz) pure tones for channels F3 and F4 pooled together by condition at Time 2 (baseline; X axis – milliseconds; Y-axis - µV). The blue area under the curve was exported for analyses.