Original Article

How Much We Think of Ourselves and How Little We Think of Others: An Investigation of the Neuronal Signature of Self-Consciousness between Different Personality Traits through an Event-Related Potential Study

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Abstract

***Background*: Previous studies have revealed that self-related tasks (items) receive more attention than non-self-related, and that they elicit event-related potential (ERP) components with larger amplitudes. Since personality has been reported as one of the biological correlates influencing these components, as well as our behavioural differences, it is important to examine how it affects our self-consciousness in relation to tasks of varied relevance and the neurological basis.**

***Methods*: A total of 33 male and female undergraduate Malaysian medical students of Universiti Sains Malaysia (USM) participated in the study. The participants were divided into two groups, Ambivert (*n* = 18) and Extravert (*n* = 15) groups, using the USM personality inventory questionnaire. In the ERP experiment, squares containing standard stimuli of any word other than self and non-self-related nouns (e.g., *Bola*, *Gigi*, *Anak*, etc.; in English: Ball, Teeth, Kids, etc., respectively), those containing self-related pronouns (*Saya*, *Kami* or *Kita*; in English: I, Us or We, respectively), and non-self-related pronouns (*Dia*, *Anda* or *Mereka*; in English: He/She, You or They, respectively), were shown 58%, 21% and 21% of the time, respectively, in a three-stimulus visual oddball paradigm. All words were presented in Bahasa Melayu. The participants were instructed to press 1 for self and 2 for non-self, and ignore standard stimuli.**

***Results*: Comparison of both N200 and P300 amplitudes for self-related and non-self-related pronouns in the Extravert group revealed significant differences at seven electrode sites, with self-related having larger amplitude at anterior electrodes and less at posterior. This was not seen in the Ambivert group.**

***Conclusion*: The present study suggests that self-relevant pronouns are psychologically more important to extraverts than to ambiverts; hence, they have more self-awareness. This may be due to large amount of dopamine in the brains of extraverts, which is more concentrated in the frontal lobe.**

Keywords: *P300 component, N200 evoked potentials, extraversion*

Introduction

The effect of personality on the neuronal basis of self-consciousness is yet to be explored in cognitive neuroscience. Determining the basic neural processes behind complex higher-order cognitive operations and functional domains remains a fundamental goal of this field of study. Therefore, we conducted a study to determine, through event-related potential (ERP), the neuronal signature of the influence of personality on how much we think of ourselves and how little we think of others. The main objective was to explore the effect of personality differences on the level of our self-consciousness in relation to self-related tasks (items) and non-self-related tasks. We also attempted to localise the brain region associated with the processing of self- and non-self-related information in different personality groups. The targeted personality traits were extraverts, characterised as being open, eloquent, vibrant and assertive (1), and ambiverts, characterised as being fairly happy with human company, while, at the same time, comfortable with some private moments; most individuals belong to this latter mixed group (2).

For many decades, self-apprehension has been one of the important issues in philosophy and psychology (3). Self-consciousness can be defined as the ability to become aware of one's own states, especially (but not limited to) mental states, such as perceptions, emotions and attitudes (4). For language competent persons, it is referred to as self-reference, in the case of first-person reference, or indexical reference (3). The processing of self-referential information is closely linked to a particular notion of self in various ways and relates to different stimuli that are believed to be greatly associated with an individual's own persona (4).

Numerous studies have demonstrated the biases in the brain of human beings when dealing with self-related pieces of information when compared to non-self-related ones. According to many behavioural researches, for instance, information of self-relevance attracts more attention than other information (5–7). In addition to behavioural research, a number of neuropsychological (8), neuroimaging (9) and electrophysiological methods (10) have been used in self-processing research over the past several years. ERP has consistently been shown to be an effective measure of cognitive processes; thus, it can be a reliable technique for examining its temporal features (11). As a matter of fact, ERP components have been frequently used to determine the timed changes of attention. For example, the P300 component, identified by an upward deflection occurring nearly 300ms following the stimulus, has amplitude relative to the attentional resources invested in analysing particular information (12). A consistent finding of the studies that used this component is that self-related stimuli, such as name (13), pronouns (14), envy target names (15), faces (16) and self-referential national flags (17), receive more attention than non-self-related stimuli due to their emotional significance.

The aforementioned studies ought to have taken into consideration the factors shown to affect ERP components, such as circadian cycle and other periodic changes (18), exercise, fatigue (19), drugs, IQ, age, gender, handedness and some personality traits (20). Concerning personality traits, the association existing between the P300 and introversion-extraversion dimension of the Eysenck personality model has been noted by many studies due to its reputed biological support (21). Even though personality trait is considered to be one of only two explanations, the introversion-extraversion (IE) personality dimension has since come to be considered as a continuum, with ambiversion located relatively directly in-between (22). A persistent finding of the researches on these traits is that introverts and ambiverts show larger P3 amplitudes when compared to extraverts (23–26). The greater attentional capital that introverts and ambiverts often devote when analysing given information in comparison to extraverts is believed to be behind the P300 amplitude difference seen between the personality groups (27). This difference has been proposed to be due to greater activity in the reticular activating system of the brains (a region that regulates cortical arousal and inhibition) of introverts and ambiverts when compared to extraverts (28).

In contrast to the above, numerous social psychology studies have associated extraverts with subjective well-being and happiness (29). The role of pleasant effects and sensitivity to reward on extraverts has been re-affirmed by cross-cultural studies on large samples (30–31). Reinforcing the findings above are numerous neuroimaging studies. For instance, after many functional magnetic resonance imaging (FMRI) experiments, Canli et al. (2002) discovered that extraverts exhibit increased response to pleasant pictures in their cortical (such as temporal lobes) and subcortical regions (such as amygdala and basal ganglia) (31). Consistent with this, the function of the corticolimbic dopaminergic system, associated with mediated reward motivation, has been revealed to be neurobiologically associated with extraversion (32). In addition to extraverts' emotional sensitivity to pleasant stimuli, they are also closely associated with changes in their valence intensity (33).

Despite being a channel through which variations in human brain activity could be explored (34), personality has been neglected by the studies conducted on self-consciousness. Hence, the present study aimed at exploring the level of self-consciousness among extraverts and ambiverts, as they account for the largest groups in the population.

Method

Ethics

Ethical approval for this study was obtained from the local Human Ethics Committee of Universiti Sains Malaysia, Kelantan, Malaysia – USMKK/PPP/JEPeM (232.3 [8]). After informed consent was obtained, the participants were assured that their data would be kept private and confidential, and that they could withdraw from the study at any time.

Subjects

A total of 33 undergraduate medical students of Universiti Sains Malaysia (USM) consisting of 15 extraverts (21–25 years; M = 23 years, 8 males) and 18 ambiverts (21–24 years; M = 22 years, 8 males) participated in the study. Each of the participants was given an incentive of RM50. The subjects were randomly selected from a large pool of students who completed the USM personality inventory (USMaP-i) (Malay version; internal consistency of 0.723 ($P < 0.001$) Cronbach's alpha coefficient value (35)). It is a 66-item, non-timed questionnaire based on the Big-Five personality factors (Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness) constructed specifically to identify Malaysian students' personalities, based on culture and values. The questionnaire contains behavioural-type questions, with 0–4 rating scales, along with the USMaP-i form for answering purpose. The sum of the scores is divided into high (34–48), average (17–32) and low (0–16) scores. Those that obtained high scores were classified as extraverts, while those with average scores were classed as ambiverts. The participants in both groups reported no history of psychiatric disease, somatic injury, cerebral injury, neurosurgery, abnormal vision, or use of psychoactive agents. Additionally, 80% of the subjects in the Extravert group, and 94.4% of the subjects in the Ambivert group, were right-handed.

Instrumentation

The stimuli were divided into standard (any word in Bahasa Melayu and presented 58 times), self (consisting of the words *Saya*, *Kami* and *Kita* and presented 21 times), and non-self (consisting of the words *Dia*, *Anda* and *Mereka* and presented 21 times). Altogether, 100 squares containing words were randomly presented on the computer screen. Each word appeared for only three seconds and with an interstimulus interval of 3.5 seconds (Figure 1). The participants were instructed to quickly press 1 when they saw a self-related pronoun and 2 for a non-self-related pronoun. However, they were asked not to respond when standard stimuli appeared. The entire experiment was divided into two blocks with each lasting for an average of 2.25 minutes.

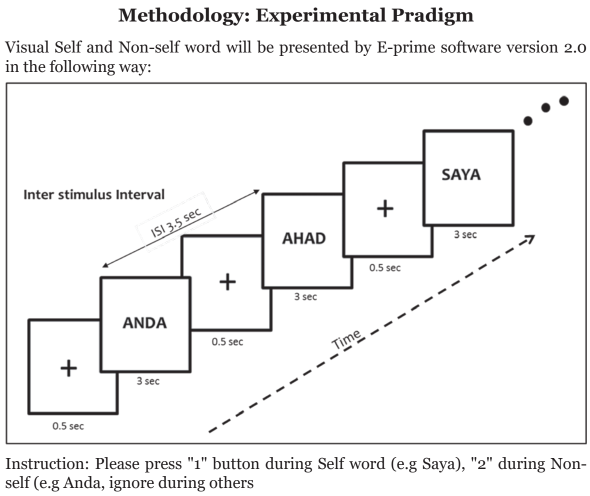

Figure 1. A description of the stimuli, i.e., Self-related (SAYA), Non-self-related (ANDA), and Standard (AHAD), presentation during the experiment. Each stimulus lasted for 3s with 3.5s inter-stimulus interval.

The ERP recording was conducted at the magnetoencephalography (MEG) and event-related potential centre, Department of Neuroscience, Hospital Universiti Sains Malaysia (HUSM). A three-stimulus visual oddball paradigm was used in the experiment. The stimuli were presented by E-prime software version 2.0, and a 128-channel HydroCel Geodesic Sensor Net (HCGSN) with an extended 10-20 system. Brain activity of subjects was recorded while they were seated on a comfortable chair, about 80 cm in front of a computer (LCD monitor screen) in a sound-treated quiet room with dimmed light. Water for injection was used in order to lower the impedance to less than 50Ω and increase the conduction of EEG signals.

After the experiment was completed, the raw data were analysed using Apple's Net Station software. Basically, the analysis included filtration, segmentation, artifact detection, bad channel replacement, averaging, average re-referencing/montage operation, baseline correction, grand averaging and statistical extraction. Only the neural activities found between the frequency ranges of 30 to 40 Hz were selected. This means that all activities that fell within the range of 50 to 60 Hz were recognised as noise and excluded. The grand average ERPs of self-related (blue) and non-self-related (red) stimuli for extraverts are presented in Figure 2 and in Figure 3 for ambiverts. At the end of the analysis, a statistical extraction tool was used in order to obtain the particular values of the ERP components, including N200 and P300. The Mann-Whitney U-test was performed to obtain the latency and amplitude differences of N200 and P300 between the Extravert group and the Ambivert group. The Wilcoxon-signed rank test was used to obtain the latency and amplitude differences of N200 and P300 between self-related stimuli and non-self-related stimuli within both the Extravert and Ambivert groups.

Results

P300 amplitude and latency

The difference in the amplitude of the self-related stimulus between the Ambivert group and the Extravert group was significant only at Pz ($Z = 3.00$, $P = 0.044$), and at FP2 ($Z = 4.65$, $P = 0.027$) for the non-self-related stimulus. The difference of amplitude between the self-related stimulus and the non-self-related stimulus was not significant in any of the electrode sites in the Ambivert group. However, a comparison of the means of the amplitudes of the self-related stimulus and the non-self-related stimulus in the Extravert group revealed significant differences at F3 ($Z = 2.05$, $P = 0.041$), FP2 ($Z = 2.84$, $P = 0.005$), F4 ($Z = 1.99$, $P = 0.047$), Fz ($Z = 2.44$, $P = 0.015$), Pz ($Z = 2.61$, $P = 0.009$), O1 ($Z = 2.61$, $P = 0.009$) and O2 ($Z = 2.84$, $P = 0.005$), as shown in Table 1. Additionally, higher amplitudes at the anterior electrodes and lower amplitudes at the posterior electrodes for self-related stimuli were observed in extraverts, as depicted in Figure 4. There was an unimportant significant difference in the P3 latency of the self-related and non-self-related stimuli between extraverts and ambiverts, and also within each group.

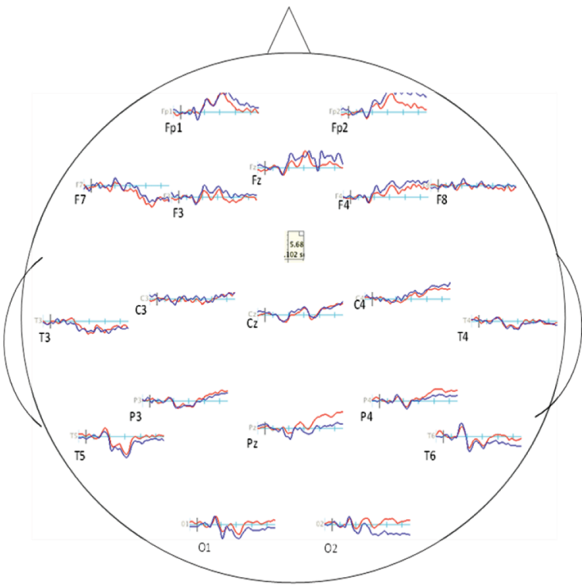

Figure 2. Grand average ERPs of self-related stimuli (blue) and non-self-related stimuli (red) stimuli for extraverts.

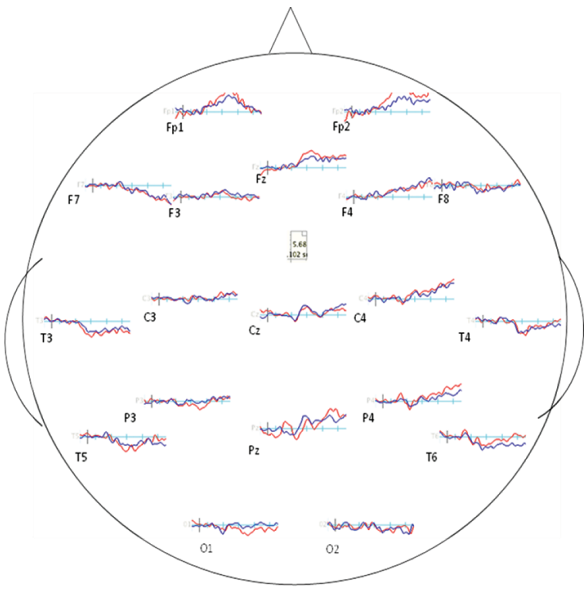

Figure 3. Grand average ERPs of self-related stimuli (blue) and non-self-related stimuli (red) stimuli for ambiverts.

Table 1. P300 amplitudes and latencies in extravert

Electrode	Self-related	Pronouns	Non-self-related	Pronouns
	Amplitude Mean (SD)	Latency Mean (SD)	Amplitude Mean (SD)	Latency Mean (SD)
FP1	6.29 (3.38)	456.00 (162.69)	4.67 (4.13)	480.27 (170.74)
F3	3.56 (3.37)	473.87 (140.24)	2.42 (2.39)*	497.60 (137.04)
F7	1.55 (3.42)	429.87 (128.71)	0.58 (3.04)	472.00 (146.83)
FP2	8.11 (3.44)	495.47 (155.11)	4.75 (4.75)*	494.40 (172.91)
F4	5.36 (1.59)	466.67 (122.77)	4.17 (2.72)*	490.13 (139.98)
F8	3.11 (2.39)	517.07 (158.71)	3.24 (3.24)	536.53 (155.39)
C3	3.08 (1.99)	509.87 (110.13)	2.86 (1.87)	482.67 (126.40)
C4	4.75 (3.37)	508.00 (129.92)	3.71 (2.57)	479.73 (139.18)
Fz	6.10 (3.63)	477.60 (145.65)	3.44 (2.75)*	463.73 (146.72)
Cz	4.53 (2.24)	517.87 (129.18)	4.37 (2.91)	460.00 (120.99)*
Pz	3.03 (2.71)	527.73 (127.65)	4.93 (3.31)*	496.53 (098.80)
T3	0.76 (2.26)	433.87 (104.32)	1.13 (2.19)	449.07 (121.77)
T4	1.37 (1.37)	454.67 (125.18)	1.81 (2.92)	435.20 (145.87)
T5	0.90 (2.67)	461.07 (119.50)	1.86 (2.60)	407.73 (114.01)
T6	1.00 (2.83)	409.60 (118.73)	2.07 (2.07)	407.47 (139.89)
P3	2.82 (2.20)	487.73 (112.43)	3.68 (1.84)	489.87 (107.61)
P4	2.81 (2.15)	428.53 (124.15)	3.97 (2.70)	475.47 (122.22)
O1	1.68 (3.32)	479.47 (155.88)	3.06 (4.06)*	480.27 (114.79)
O2	0.92 (3.91)	441.07 (137.22)	3.12 (4.00)*	443.20 (122.64)

Note: Amplitudes values are in microvolts (SD). Latencies are in milliseconds (SD).
* = Significance ($P < .05$)

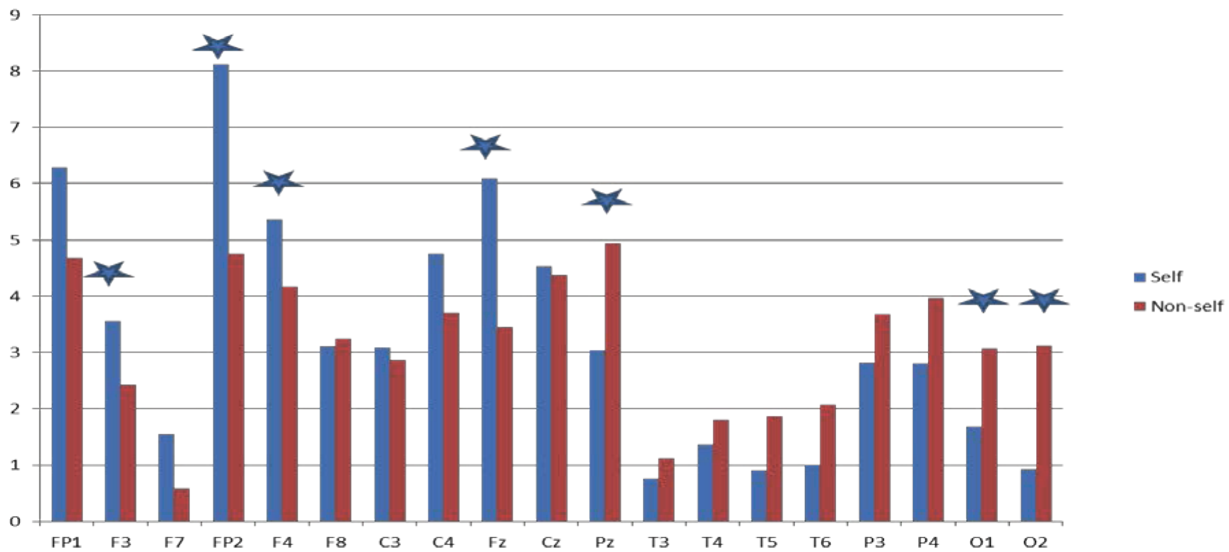

Figure 4. Histogram of P300 amplitudes of self-related stimuli (blue) and non-self-related stimuli (red) at each electrode site in extraverts.

N200 amplitude and latency

We obtained a significant difference in the amplitude for the self-related stimulus between the Ambivert group and the Extravert group at O1 (Z = 1.99, *P* = 0.048), and at FP2 (Z = 3.99, *P* = 0.027) for the non-self-related stimulus. Comparison of the means of amplitude for the self-related stimulus and non-self-related stimulus in the Ambivert group indicated a significant difference only at FP2 (Z = 2.82, *P* = 0.005). However, a similar comparison in the Extravert group demonstrated a significant difference at F3 (Z = 2.44, *P* = 0.015), F4 (Z = 2.22, *P* = 0.027), Fz (Z = 2.44, *P* = 0.015), Pz (Z = 2.56, *P* = 0.011), T5 (Z = 1.99, *P* = 0.047), O1 (Z = 2.44, *P* = 0.015) and O2 (Z = 2.10, *P* = 0.036), as shown in Table 2. Furthermore, higher amplitudes were observed for self-related stimuli at the anterior electrodes and lower at the posterior electrodes in extraverts, as illustrated in Figure 5. No important significance difference in the N2 latency of self- and non-self-related stimuli was seen between the extraverts and ambiverts, or within each group.

Discussion

The findings of this study indicated no significant difference in the N2 latency of self-related and non-self-related pronouns between ambiverts and extraverts, or within the groups. A similar finding was obtained for the P3 latency of self-related and non-self-related pronouns between and within the two groups. The N2 latency reflects the amount of time taken to detect a deviation of the eliciting stimuli from the previously formed template (36). In other words, N2 latency indicates the timing of mental access to properties of stimulus. Based on the above, our findings indicated that both ambiverts and extraverts took an equal amount of time to update their memory of the properties of self-related and non-self-related pronouns.

Table 2. N200 amplitudes and latencies in extravert

Electrode	Self-related	Pronouns	Non-self-related	Pronouns
	Amplitude Mean (SD)	Latency Mean (SD)	Amplitude Mean (SD)	Latency Mean (SD)
FP1	6.14 (3.10)	292.53 (94.69)	5.17 (3.98)	314.13 (82.46)
F3	3.81 (2.97)	327.73 (70.27)	2.56 (1.00)*	292.00 (60.96)
F7	2.39 (2.42)	334.40 (73.38)	1.30 (2.41)	328.53 (69.41)
FP2	7.04 (3.57)	252.53 (68.98)	4.88 (4.12)	272.53 (88.10)
F4	5.18 (2.33)	274.93 (46.66)	3.78 (2.35)*	265.33 (57.54)
F8	2.13 (1.69)	300.80 (70.40)	1.88 (2.00)	300.53 (77.93)
C3	2.13 (2.06)	296.00 (66.33)	1.70 (1.63)	277.33 (62.15)
C4	3.95 (1.96)	276.80 (72.53)	3.04 (2.32)	240.00 (45.73)
Fz	5.82 (3.24)	274.13 (78.03)	4.16 (3.17)*	283.47 (72.27)
Cz	3.39 (1.40)	298.40 (47.15)	3.16 (2.74)	295.20 (53.35)
Pz	2.18 (2.98)	280.53 (66.23)	3.90 (3.14)*	251.47 (55.01)
T3	0.55 (1.80)	292.27 (56.27)	0.23 (1.74)	291.20 (68.21)
T4	1.22 (1.79)	254.40 (50.75)	1.52 (2.37)	256.53 (53.73)
T5	0.33 (2.79)	250.93 (22.85)	1.25 (2.67)*	247.20 (24.76)
T6	1.39 (2.96)	290.93 (63.10)	2.08 (3.34)	268.00 (58.79)
P3	1.55 (2.12)	252.80 (46.80)	2.19 (1.45)	230.20 (23.67)
P4	2.81 (1.72)	271.73 (78.33)	3.42 (2.70)	252.00 (59.64)
O1	1.00 (3.23)	261.33 (48.40)	2.38 (3.91)*	261.33 (48.58)
O2	1.93 (3.01)	300.80 (70.82)	3.21 (3.53)*	274.93 (61.01)

Note: Amplitudes values are in microvolts (SD). Latencies are in milliseconds (SD).
* = Significance ($P < .05$)

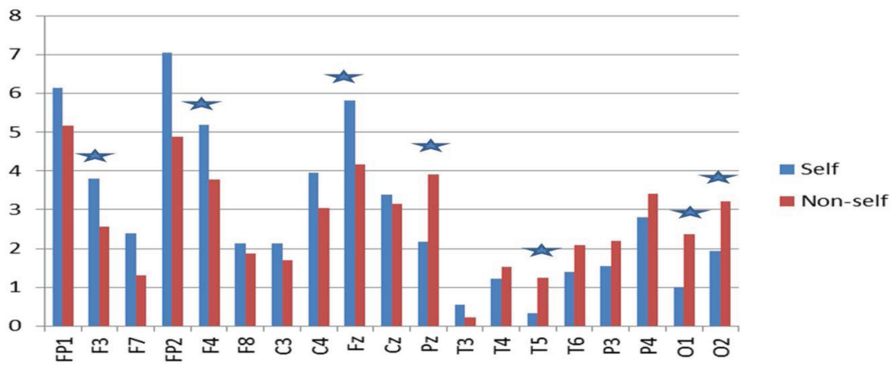

Figure 5. Histogram of N200 amplitudes of self-related stimuli (blue) and non-self-related stimuli (red) at each electrode site in extraverts.

The P3 latency reflects stimulus evaluation and categorisation time (37). This means that the time taken by ambiverts and extraverts to identify and differentiate self-related pronouns from non-self-related pronouns was approximately the same.

One possible explanation for the above findings may be that the quality of relevance of self-related pronouns used in this study was not strong enough to impact the duration of stimulus categorisation in the paradigm (38). Nevertheless, the duration of the P3 latencies obtained in this study have shown that the effects of self-related pronouns appeared at higher-order stages of cortical response. This is because classifying and differentiating these stimuli from non-self-related pronouns first demanded an analysis of semantic meaning which likely would have increased P3 latency (39).

For N2 amplitude, a significant difference was observed between self-related pronouns, '*Saya*, *Kami* and *Kita*', and non-self-related pronouns, '*Dia*, *Anda* and *Mereka*', at F3, F4, Fz, Pz, T5, O1 and O2 electrodes in extraverts. However, a significant difference was seen only at the FP2 electrode in ambiverts. Since the magnitude of N2 amplitude has been shown to correlate positively with the degree of variations between standard and target stimuli (40), and also indexes biologically important stimuli (41–42), the findings of this study indicated that, compared to ambiverts, extraverts are more responsive to the differences between self-related and non-self-related pronouns due to their positive emotional significance. In agreement with this observation is a recent study by Lou et al. (2015), which had the aim of determining whether neuroticism modulates the impact of extraversion on attention orientation to pleasant and unpleasant pictures of diverse emotional intensities (42). They reported increased N2 amplitude for highly pleasant (HP) and mildly pleasant (MP) stimuli, compared to neutral stimuli, which was absent in ambiverts.

Concerning P3 amplitude, a significant difference was seen in extraverts at the F3, FP2, F4, Fz, Pz, O1 and O2 electrodes. However, no significant difference was obtained in ambiverts. In support of these findings, a study by Yuan et al. (2012), investigating the neural mechanisms behind the subjective well-being in extraverts using pictures of different emotional intensities, found that highly positive (HP) and moderately positive (MP) pictures elicited P3 of higher amplitude in extraverts as compared to ambiverts (43). Given the fact that P3 amplitude reflects the amount of attentional resources invested in processing a given stimulus (12), and also that Johnston, Miller and Burleson (1986) proposed that the P3 amplitude is proportional to the emotional value of the eliciting stimuli, the present study, therefore, found extraverts to allocate more attention to self-related pronouns due to their emotional significance (44). According to Yuan et al. (2012), this can possibly be explained by extraverts' lower threshold for pleasant emotion and higher threshold for unpleasant emotion, while ambiverts have a high threshold for pleasant emotion and a low threshold for unpleasant emotion (43). Extraverts are responsive to emotionally pleasant stimuli irrespective of its emotional valence (30). Hence, an effect was detected in this study when only first-person and third-person pronouns were used.

The responsiveness of extraverts to pleasant stimuli of low intensity is believed to be the basis of the subjective well-being and personal happiness seen in this group (43–45). Extraverts are also reported to be sensitive to reward signals, both in social and unsocial situations (46–47). The positive feelings and reward motivation associated with trait extraversion are mediated by a neurotransmitter called dopamine (48). This is the main mediator in the reticulo-limbic circuit, which is one of the modulators of behavioral differences between extraverts, introverts and ambiverts (49).

ERP components have been used to explore reward pathways, as in a study by Foti and Hajcak in which they used feedback negativity and P3 to prove that reduction in sensitivity to rewards is a fundamental feature of depression by tracking phasic changes in midbrain dopamine levels (1, 50). To further strengthen the feasibility of using ERP components in understanding the dopaminergic system, studies have revealed neurons in these regions to be the actual source of components such as P300 (51). There are three ascending dopamine (DA) projection systems from the ventral tegmental area (VTA) of the brainstem (Figure 6), namely: nigrostriatal, projecting to dorsal striatum; mesocortical, projecting to multiple cortical areas; and mesolimbic pathways, projecting to ventral striatum. The last two, especially the mesolimbic system, are particularly important for the reward system (52).

Consistent with the above, an interesting observation was made in this study. The amplitudes of both N2 and P3 for self-related pronouns were found to be larger than that of non-self-related pronouns at the frontal and central electrodes in extraverts (Figures 4 and Figure 5), while being less than that of the latter at the temporal, parietal and occipital electrodes. This may be due to a reduction in the concentration of dopamine along the fronto-occipital axis, resulting in the highest concentration in the pre-frontal cortex and the lowest concentration in the occipital visual areas (53–55). This indicated that the processing of self-related pronouns occurs only in the anterior regions of the brain (frontal lobe) and is associated with the limbic system.

Concerning self-consciousness, a distinction must be made between 'being self' and 'being aware of being self', which are related to pre-reflective self-awareness and reflective self-awareness, respectively (56–57). While pre-reflective self-awareness implies being aware of oneself as a 'subject', reflective self-awareness means thinking of oneself as an 'object' (explicit self-representation). Many of the previous studies adopted explicit self-representations, such as name, face, objects, trait adjectives and autobiographical information (14). These studies were interested more in the ability to think of

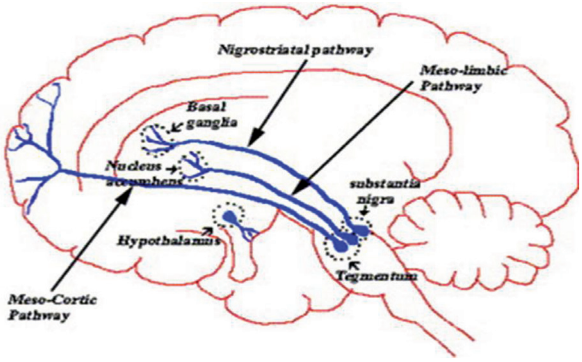

Figure 6. A description of the dopaminergic pathways (nigrostriatal, mesocortical, and mesolimbic) in the brain.

oneself as an 'object', while neglecting the core awareness of 'being self' (58). Thinking about oneself as a 'subject' is related to the first-person mode, and thinking about oneself as an 'object' is related to the third-person mode. The present study adopted the first-person mode in the form of self-related pronouns, '*Saya*, *Kami* and *Kita*', in contrast to the third-person mode, '*Dia*, *Anda* and *Mereka*', because a first-person perspective is the true representation of self and is immune to error through misidentification (59).

When the neural correlates of self-awareness are considered, it was observed in this study that first-person pronouns elicited, in extraverts, P300 of larger amplitude at the frontal regions of the brain when compared to the third-person pronouns (and vice versa) at the posterior regions. This has clearly associated the processing of first-person pronouns with the structures in frontal lobe and other related subcortical structures (e.g., the basal ganglia, amygdala and nucleus accumbens). A good number of neuroimaging studies have implicated these regions in the processing of pleasant emotions and its interaction with extraversion (47, 60–61). Specifically, the posterior cingulate cortex (PCC), a limbic structure located between neocortices (e.g., temporal and orbitofrontal cortices) with subcortical structures and neural projections with these areas, has been shown to be important in emotional processing (62–64). In line with the above data, Yuan et al. (2012), in an attempt to investigate the neural mechanisms that underlie the higher levels of subjective well-being in extraverts, reported that the PCC might mediate the extravert-specific emotion effect for pleasant stimuli (41).

Despite the above evidence regarding the association of PCC with the processing of emotion in extraverts, we cannot ascertain whether it is the sole actor in the processing of self-related pronouns. This is because several cortical midline structures, such as the ventral medial pre-frontal cortex (vMPFC), the dorsal medial pre-frontal cortex (dMPFC), and the parietal/posterior cingulate cortex (PCC), as well as the anterior CMS (e.g., anterior cingulate cortex), have been implicated by neuroimaging studies in self-related processing (4, 62, 65–69). These structures seem to overlap due to an inability to control self-relatedness and self-specificity (56). The self-specificity is based on personal familiarity with a place, person, or other stimulus that normally elicits autobiographical memories or emotional reactions (70). Self-relatedness, on the other hand, involves evaluative judgement processes enabling identification, attribution and reflection upon a subject not different from other subjects (71). However, a recent meta-analysis by Qin and Northoff with the aim of identifying 'the relationship between brain activity related to the processing of self-specific, personally familiar, and other (non-self and non-familiar) stimuli', has been able to control the two (72). As in previous studies, this research also demonstrated an overlap in several regions of CMS (MPFC and PCC in particular) that process self-related, other related and familiar stimuli. However, the study discovered that the perigenual anterior cingulate cortex (PACC) is activated in the processing of self-related stimuli, as well as during resting state conditions. This result indicated the involvement of CMS (particularly PACC) in the processing of self-related stimuli. Since this study adopted self-related stimuli (pronouns) to test implicit self-awareness, which we believe to be the true self-consciousness, it is safer to identify PACC as the location of self in extraverts.

Conclusion

Our results demonstrated that N200 and P300 amplitudes were augmented for the self-related pronouns, '*Saya*, *Kami* and *Kita*', relative to the non-self-related pronouns, '*Dia*, *Anda* and *Mereka*', mainly in the frontal and central regions of the brain. This difference was observed in the Extravert, but not in the Ambivert, group. The larger N200 and P300 amplitudes were interpreted to reflect a processing bias toward the self-related pronouns, '*Saya*, *Kami* and *Kita*', as compared with the non-self-related pronouns, '*Dia*, *Anda* and *Mereka*'. We suggest that extraverts are more aware of themselves due to their low threshold for pleasant emotions. However, because of the peculiar limitation of ERP of relying on brain signals picked up by scalp superficial EEG, the results of this study should be taken as provisional. Modern techniques with greater localisation, such as functional MRI or dipole source analysis, are needed to explore the neural bases that underlie the enhanced self-awareness in extraverts as opposed to other traits, such as ambiversion, and also verify the claims made by previous studies that the perigenual anterior cingulate cortex is the location of self in extraverts.

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Conflict of Interest

None

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Authors' Contribution

Conception and design: ABH, MFR
Analysis and interpretation of the data: ABH, TB, MFR
Drafting of the article: ABH
Critical revision of the article for important intellectual content: NY, MFR
Final approval of the article: NY
Provision of study materials or patients: TB
Statistical expertise: MFR
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