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Machiavellianism and early neural responses to others' facial expressions caused by one's own decisions

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ABSTRACT

The processing of social stimuli generated by one's own voluntary behavior is an element of social adaptation. It is known that self-generated stimuli induce attenuated sensory experiences compared with externally generated stimuli. The present study aimed to examine this self-specific attenuation effect on early stimulus processing in the case of others' facial expressions during interpersonal interactions. In addition, this study explored the possibility that the self-specific attenuation effect on social cognition is modulated by antisocial personality traits such as Machiavellianism. We analyzed early components of the event-related brain potential in participants elicited by happy and sad facial expressions of others when the participant's decision was responsible for the others' emotions and when the others' facial expressions were independent of the participant's decision. Compared to the non-responsible condition, the responsible condition showed an attenuated amplitude of the N170 component in response to sad faces. Moreover, Machiavellianism explained individual differences in the self-specific attenuation effect depending on the affective valence of social signals. The present findings support the possibility that the self-specific attenuation effect extends to interpersonal interactions and imply that distorted cognition of others' emotions caused by one's own behavior is associated with personality disorders that promote antisocial behaviors.

1. Introduction

Distorted cognition of positive and negative outcomes of one's own voluntary behaviors has been reported in personality and other mental disorders (Harris et al., 2014; Mezulis et al., 2004). In particular, self-serving biases in the attribution of causality are associated with antisocial behavior and poor self-control (Barriga et al., 2000; Emmons, 1987; Davis, 1990; Rhodewalt and Morf, 1998; Van Leeuwen et al, 2014; Wallinius et al., 2011). These findings imply that the processing of social and affective events caused by one's own behavior is an important aspect of cognition that is related to the adaptive control of behavior.

Causal relationships between one's own voluntary behaviors and events can modulate the early stages of the processing of events. With respect to sensory stimuli, it is known that stimuli that are generated by one's own actions are perceived as less intense than those that are externally generated (Hughes et al., 2013b). This self-specific sensory attenuation has been explained in terms of internal forward models (Blakemore et al., 2000), which are based on the assumption of motor-to-sensory transformations within the central nervous system. According to these models, an efference copy of the motor command is used to simulate sensory consequences in advance. The predicted sensory consequences are compared to the actual feedback. The intensity of the sensory experience in response to the actual feedback is likely to be attenuated when it matches the predicted experience, compared to when they do not match.

Previous studies have provided evidence for the differential neural processing of sensory stimuli depending on whether they are triggered by oneself or externally. Particularly, compared to externally generated tones, those that are self-generated attenuate the amplitude of the auditory N1 component of the event-related potential (ERP) peaking around 100 ms after onset at the vertex electrodes, a neural indicator of early auditory gating (Bäß et al., 2008; Horváth, 2015; Hughes et al., 2013a; Knolle et al., 2013a, 2013b; Sanmiguel et al., 2013; Timm et al.,

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2016). The attenuation of auditory N1 is often accompanied by the attenuation of the amplitude of frontocentral P2, suggesting that there are two different steps in a common chain of processes related to self-generation (Knolle et al., 2013a; Sanmiguel et al., 2013; Sowman et al., 2012; Timm et al., 2016). Most ERP studies on sensory attenuation used auditory stimuli, and there have been few studies in the visual domain (Gentsch and Schütz-Bosbach, 2011; Gentsch et al., 2012; Hughes and Waszak, 2011; Roussel et al., 2013, 2014; Schäfer and Marcus, 1973). Sensory attenuation for visual stimuli might be represented by a reduction of the visual P1 component over occipital sites, but previous studies found either no difference or an increase in the amplitudes of the visual P1 component in response to action-triggered vs. externally triggered visual stimuli (Hughes and Waszak, 2011; Schäfer and Marcus, 1973). Alternatively, the self-specific effect on the processing of visual stimuli has been observed in the attenuation of the visual N1 component peaking around 100 ms after onset over frontocentral sites (Gentsch and Schütz-Bosbach, 2011; Gentsch et al., 2012), later frontocentral and parietal ERP components starting 150 ms after onset (Hughes and Waszak, 2011), and the occipital N1 component peaking from 180–320 ms after onset (Roussel et al., 2014).

While most ERP studies on the self-specific attenuation effect have focused on the processing of simple sensory stimuli, several studies have investigated how one's voluntary actions influence the early processing of social and affective outcomes (Gentsch et al., 2015; Hughes, 2015; Hughes and Waszak, 2014). Hughes (2015) did not observe a self-specific attenuation effect on the occipital visual P1 component in response to both fearful and neutral faces. However, the amplitude of N170 at posterior temporal sites, which is considered to reflect the earliest stage of face recognition (Bentin et al., 1996; Eimer, 2000), was attenuated in response to fearful faces that were predictable based on one's voluntary action compared to those that were unpredictable. Gentsch et al. (2015) revealed that, compared to externally generated social signals (others' happy and angry faces), self-generated signals attenuated the amplitudes of visual N1 and N170. Moreover, the attenuation of N170 in response to angry faces was more evident in individuals who were more likely to attribute the negative outcomes to themselves. This pattern supports other findings suggesting that a self-serving attribution bias can influence perceptual levels of action outcomes (Takahata et al., 2012; Yoshie and Haggard, 2013).

To date, few ERP studies have examined the role of voluntary action in the processing of its social outcome. Evidence has been limited to situations where face stimuli are related to non-social behaviors such as the simple choice of which button to press (Hughes, 2015; Hughes and Waszak, 2014), or where facial expressions are used as rewarding and punishing signals for the performance of speeded responses (Gentsch et al., 2015). Although facial expressions contribute to communication in interpersonal interactions, it is unclear whether the self-specific attenuation effect is observed while viewing others' emotional expressions that are meaningfully displayed according to one's voluntary social decisions. Therefore, the present study examined whether ERPs associated with the early processing of others' facial expressions at frontocentral sites (visual N1 and P2), occipital sites (visual P1), and posterior temporal sites (N170) differ depending on causality (responsibility). To this end, we considered participant's responses to the sad and happy faces of others caused by the participant's decision regarding whether or not to sacrifice them for the greater good in a hypothetical situation, and compared them to those faces displayed independently of the participant's decision.

Besides aggressive or mischievous behaviors that are done for emotional or personal reasons, in some cases, behaviors that have adverse impacts on others can be taken for a greater social good (e.g., dismissal of workers as part of corporate restructuring). In such cases, the outcomes of one's behaviors may be perceived differently depending on one's tendency to use any means available to attain one's goal, which is referred to as Machiavellianism (Christie and Geis, 1970). Individuals scoring high on Machiavellianism are characterized as having a cynical worldview, manipulativeness and amorality (Christie and Geis, 1970). Although the concept of Machiavellianism is not defined as a clinical syndrome, Machiavellianism is positively associated with antisocial personality disorder in inmates (Widiger et al., 1996). In a general population, high tendencies in each borderline, paranoid, negativistic and antisocial personality disorders are associated with elevated Machiavellianism scores (McHoskey, 2001). Machiavellianism in adolescents is related to externalizing and delinquent behaviors, thought problems, and reduced empathy (Loftus and Glenwick, 2001). Moreover, because Machiavellianism is correlated with narcissism and psychopathy (Paulhus and Williams, 2002), researchers have claimed that they have a common core as the Dark Triad (Furnham et al., 2013, for a review). Especially in common with psychopathy, Machiavellianism is negatively associated with Agreeableness and Conscientiousness in the five factor model of personality (Paulhus and Williams, 2002), and Honesty/Humility in the HEXACO model (Lee and Ashton, 2005). These findings highlight that Machiavellianism is an analog of antisocial personalities characterized by reduced empathic concern for others.

Individuals with high Machiavellianism scores appear to have deficits in various types of social cognition. According to the findings that they have shown increased utilitarian or selfish behaviors in interpersonal situations (Bartels and Pizarro, 2011; Bereczkei et al., 2013; Spitzer et al., 2007), it is predicted that they have reduced ability to predict and/or read others' emotional reactions. In fact, Machiavellianism is negatively related to empathy (Ali and Chamorro-Premuzic, 2010; Pajevic et al., 2018; Wai and Tiliopoulos, 2012), emotional intelligence (Ali et al., 2009; Austin et al., 2007), and performance in Theory of Mind tasks (Ali and Chamorro-Premuzic, 2010; Lyons et al., 2010). In facial affect recognition tasks, individuals with higher Machiavellianism scores are more likely to evaluate sad faces as being more positive (less negative) and happy or neutral faces as being less positive (more negative), compared with those scoring low on Machiavellianism (Ali et al., 2009; Wai and Tiliopoulos, 2012). However, it is still unclear how Machiavellianism modulates the processing of facial expressions displayed as feedback regarding one's own social decisions. We hypothesized that individuals who scored high on a measure of Machiavellianism are less likely to predict another's distress, even if their goal-directed behavior will result in a bad consequence for the other person. If this is the case, Machiavellianism may moderate the self-specific attenuation effect on the early processing of others' facial expression of, at least, sadness.

2. Methods

2.1. Participants

Twenty Japanese male students, ranging in age from 18 to 23 years ($M = 19.5$, $SD = 1.2$), participated in the present study and received a fee. These participants were randomly recruited from male university students. Although the range of ages was small, it is considered to be adequate for conducting this study because the mean age was not much different from those in previous studies (Hughes, 2015; Hughes and Waszak, 2014). Data obtained from both males and females might facilitate generalization. However, gender modulates both the Machiavellianism score (Ali and Chamorro-Premuzic, 2010; McHoskey, 2001; Nakamura et al., 2012; Paulhus and Williams, 2002) and brain activity in response to social and emotional stimuli (Campanella et al., 2004; Singer et al., 2006), which means that gender can be a confounding factor of the effects of Machiavellianism on ERPs in response to facial expressions. Therefore, to exclude such a confounding factor, the present study collected data only from males. All participants were right-handed and had normal vision. The study was approved by the Keio University Research Ethics Committee (No. 12002). Before participation, written informed consent was obtained from each participant after the nature of the study had been explained.

2.2. Machiavellianism assessment

To assess the Machiavellianism traits of the participants, we used a

Japanese version of the Mach-IV (Christie and Geis, 1970; Nakamura et al., 2012), which is a self-report questionnaire containing 20 items. Participants indicated their degree of agreement with different statements, such as "It's hard to get ahead without cutting corners here and there" and "The best way to deal with people is to tell them what they want to hear," on a five-point scale. The Japanese version of the Mach-IV was developed through the backtranslation of each item and has sufficient internal consistency and test-retest reliability. Moreover, the scale was shown to have correlational validity in terms of the relationships with psychopathic traits and prosocial behavior (Nakamura et al., 2012).

2.3. Task procedure

Before the experiment started, participants were instructed to read the following fictional story: "You are the human resources manager in a company. The company is in danger of going bankrupt due to poor business results in recent years and therefore you must select from among your 70 employees who you will retain and who you will dismiss as one element of the restructuring plan. None of the employees want to be fired, and too many firings will affect the maintenance of business and the affairs of the company. Therefore, you are required to reduce the number of employees by nearly half." According to this cover story, participants decided whether or not to dismiss each employee based on the impressions of his/her emotionless face. During this social decision-making task, the dismissal or non-dismissal decision for an employee was linked to their sadness or happiness, respectively. Thus, in this responsible (R) condition, each voluntary decision of the participant was contextually linked to a sad or happy facial expression of another person. In contrast, the non-responsible (NR) condition required participants to simply identify the sex of the employees based on their emotionless faces. Following this judgement, a photograph of the same employee with either a sad or happy face was displayed pseudorandomly at chance level (50%). Accordingly, in the NR condition, the participant's behavior was not related to facial expressions in light of probability and social context.

The experiment consisted of 4 blocks (2 blocks per condition). Participants were seated in a reclining chair in a sound-attenuated room and instructed to focus on the center of a display and minimize any eye movement during the tasks. As shown in Fig. 1, in each trial, after a white-colored cross was displayed for 0.5 s, an emotionless face of a model was shown for 2 s. Once the response cue was displayed, participants pressed the left or right buttons as fast as possible in both the social decision-making and sex judgement tasks. A button press was followed by a blank period for 0.5 s, and then an emotional (sad or happy) face of the same model was presented for 1 s. No behavioral responses were required during the presentation of emotional faces. Pictures of sad, happy and emotionless faces of 70 models (35 males and 35 females) were obtained from Karolinska Directed Emotional Faces (Lundqvist et al., 1998), which is a set of pictures of 70 individuals displaying 7 different emotional expressions. They have a mean age of 25 years, ranging from 20 to 30 years. They have no beards, mustaches, earrings or eyeglasses, and preferably no visible make-up. The size of these pictures was 14.3 cm high by 10.5 cm wide, equaling a visual angle of 10.2 (vertical) 7.5 (horizontal) at a viewing distance of 80 cm. Interface-programming and display software (Presentation version 12.1, Neurobehavioral Systems, Albany, CA) was used to deliver stimuli and record responses.

2.4. Electrophysiological recording and analysis

The electroencephalogram was recorded using a 32-channel Hydrocel Geodesic Sensor Net, Net Amps and Net Station version 4.1.2 software (Electrical Geodesics Inc., Eugene, OR). The impedance of all electrodes was kept below 70 kΩ (Ferree et al., 2011). The signals were referenced to the vertex (Cz) and digitized at a rate of 500 Hz. Off-line analyses were performed using EMSE version 5.5.2 software (Cortech Solutions Inc., Wilmington, NC). Data were re-referenced to the average reference and bandpass-filtered at 0.75–30 Hz. The raw data were subjected to the ocular artifact correction algorithm implemented in EMSE to remove eye movements and blinks. Subsequently, stimulus-locked data epochs were computed (−200 to 800 ms) and baseline-corrected using a 100-ms window before the stimulus. The segmented data were then averaged across trials for 4 categories defined by 2 responsibility conditions (R and NR) and 2 facial expressions (sad and happy) for each participant. In the averaging procedure, epochs in which the signal changes exceeded ± 100 μV on any of the electrodes were omitted.

In this study, the amplitudes of the N1, P1, N170, and P2 components were measured and analyzed (N1 and P1: baseline to peak; P2 and N170: peak to peak). N1 (90–170 ms) and P2 (120–220 ms) were analyzed at frontocentral electrode sites (Fz, FCz and Cz, Fig. 2A); P1 (90–170 ms) was analyzed at occipital electrode sites (Oz, O1 and O2, Fig. 2B); and N170 (120–220 ms) was analyzed at posterior temporal electrode sites (T5 and T6, Fig. 2C). To test the effects of responsibility on the ERPs in response to each positive or negative facial expression, a three-way repeated-measures analysis of variance (ANOVA) on the amplitude of each component was conducted with responsibility, expression, and electrode site as within-subject factors. For violations of the assumption of sphericity, the Greenhouse–Geisser correction was applied and adjusted degrees of freedom were used. Bonferroni's method was used for post-hoc multiple comparisons. We also investigated correlations between Machiavellianism and the self-specific attenuation effect on ERPs. To facilitate understanding of the magnitude of the self-specific attenuation effect, we evaluated the effect values using the NR − R differences in amplitude. The amplitude polarity of the negatively deflected components (N1 and N170) was inverted to convert their magnitudes to positive values. Pearson's correlation coefficients were calculated for only 18 participants because 2 participants did not complete their questionnaires.

3. Results

3.1. Effects of responsibility on ERPs in response to facial expressions

Table 1 shows descriptive statistics for the amplitudes of the selected components in response to sad and happy faces in the responsible and non-responsible conditions. ANOVAs showed a significant three-way interaction of responsibility, expression and electrode site only for N170 ($F(1,19) = 10.55$, $p < 0.01$, $\eta_p^2 = 0.36$). Simple effect tests indicated that the amplitude of N170 at T5 was smaller for sad faces in the R condition than for those in the NR condition ($t(19) = 2.71$, $p < 0.05$, $d = 0.61$, Fig. 3).

While the three-way interaction for P1 amplitude was almost significant ($F(2,38) = 3.16$, $p = 0.054$, $\eta_p^2 = 0.14$), post hoc tests did not show any significant effects of responsibility ($ts < 1.60$, $ps > 0.125$, $ds < 0.36$). For the other components, there was no significant effect or interaction involved with responsibility (for omnibus results of ANOVAs, see Table 2).

3.2. Correlations between the self-specific ERP attenuation and Machiavellianism

According to Pearson's correlation coefficients between Machiavellianism score and the self-specific attenuation effect on each ERP component, Machiavellianism was negatively correlated with the self-specific attenuation effects on the amplitudes of N1 and P2 at FCz, especially for a model's sad face (N1: $r = -0.47$, $p < 0.05$; P2: $r = -0.51$, $p < 0.05$, Fig. 4A). In contrast, Machiavellianism was positively related to the attenuation effects of responsibility on the amplitudes of P1 at O2 and P2 at Fz for other's happiness (P1: $r = 0.49$, $p < 0.05$; P2: $r = 0.64$, $p < 0.01$, Fig. 4B). Furthermore, in participants with a high level of Machiavellianism, the left temporal N170 was more negatively deflected for sad faces ($r = -0.45$, $p < 0.10$), but the

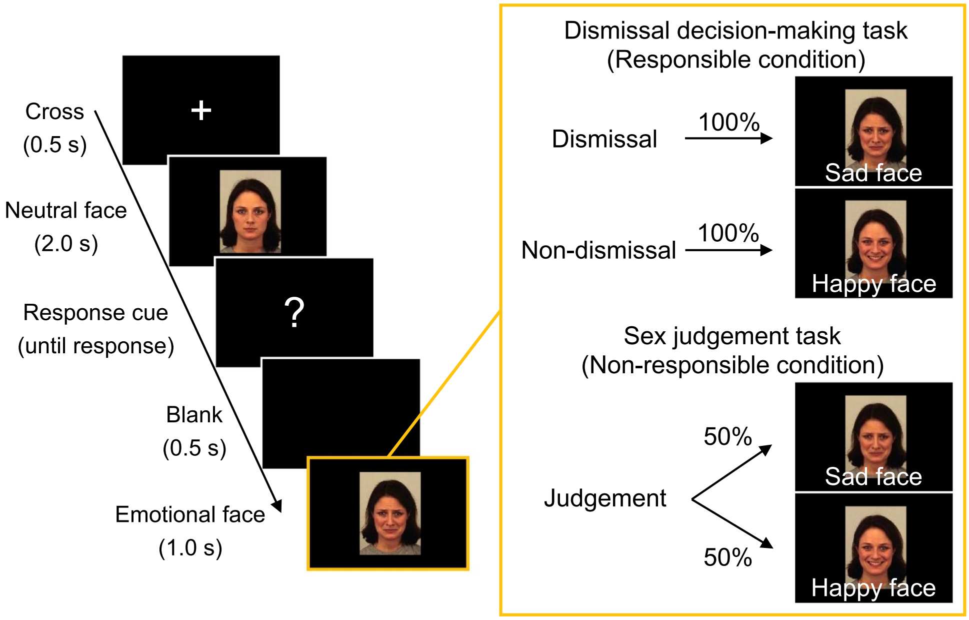

Fig. 1. Timeline for a single trial of the tasks used in the present study and the relationship between the participant's behavior and the model's facial expressions in each task.

amplitude of right temporal N170 was more attenuated for happy faces ($r = 0.42$, $p < 0.10$), albeit these results were not statistically significant (for omnibus results of correlation analyses, see Table 3).

4. Discussion

Distorted cognition of social and affective events caused by one's own behavior is predicted to be intimately associated with psychiatric disorders characterized by disinhibition of socially maladaptive behaviors, but little is known about how it can be represented in information processing. To obtain evidence regarding neural responses specifically corresponding to the processing of social effects of one's behaviors, the present study examined whether the early components of the ERP in response to facial expressions would be attenuated depending on responsibility (whether others' emotional expressions were affected by one's decisions) according to the model of the self-specific sensory attenuation. Moreover, we explored how Machiavellianism, as a subclinical analog of antisocial personality, would modulate the effect of responsibility on ERPs in response to facial expressions.

Previous studies using visual stimuli have reported self-specific ERP attenuation, not for the visual P1 component, but for later components (Hughes and Waszak, 2011; Roussel et al., 2014). Importantly, face stimuli generated by one's voluntary actions have been associated with attenuation of the face-specific N170 component (Gentsch et al., 2015; Hughes, 2015). In line with these findings, the present study showed that responsibility was effective for attenuating the amplitude of the N170 component in response to facial expressions, especially for sad faces. Thus, our findings support the notion that the prediction of behavioral consequences based on forward models can extend to the context of social cognition. According to the theoretical account that sensory attenuation results from the match between the sensory consequences simulated based on an efference copy of the motor command and the actual feedback (Blakemore et al., 2000), the fact that the model's facial expression of sadness predicted based on the participant's behavior matched the actual sad face of the model is thought to have attenuated perceptional processing of the face stimuli represented by the N170 component.

The present findings were obtained under a condition where subjects could entirely predict others' emotional expressions that would be induced by specific decisions. However, in real life, the actual consequences of specific actions are not always congruent with the predicted consequences. In the auditory domain, the N1-attenuation effect was reduced when the type of self-triggered stimuli was unpredictable in terms of frequency (Bäß et al., 2008), and when self-triggered sounds were of infrequent deviant pitch (Knolle et al., 2013b). Furthermore, a significant auditory N1-attenuation was observed when the identity of self-triggered tones was congruent with the prediction based on behavioral choices, but not when it was incongruent (Hughes et al., 2013a). According to these findings, a specific prediction may play an important role in the self-specific attenuation of N170 for facial expressions.

An earlier study reported that N170-attenuation was enhanced for happy faces signaling successful outcomes of one's behavioral performance, compared to angry faces signaling unsuccessful outcomes in a speeded response task (Gentsch et al., 2015). The authors explained this finding with the classical view that forward models are often biased to predict the success of intentional actions to promote the adaptive control of actions (Blakemore et al., 1999; 1998). In the decision-making task used in the present study, on the other hand, each presentation of a sad or happy face meant that the specific decision had been successfully executed. In that respect, it is reasonable that an N170-attenuation effect was found for sad faces. In contrast, it is puzzling that a self-specific attenuation effect was not found for N170 in response to happy faces. This null result for happy faces might be the result of chance fluctuations due to a small sample size. However, despite using the same samples, we observed a significant effect of responsibility on N170 amplitude for sad faces. These opposite results imply the presence of factors that produce a specific effect on the processing of negative social feedback for the participants' decisions. One potential factor is our decision-making task. Because the goal of the task was to reduce the number of employees in a hypothetical company as part of restructuring plans, sad faces, but not happy faces, could serve to signal the accomplishment of the goal. Accordingly, our results do not rule out the possibility that the context that defines the goal modulates the self-specific attenuation effect.

However, another possibility is that the results reflected the difference in emotional saliency between others' sadness and happiness in our decision-making task. One previous study reported that accurate action–outcome prediction effectively attenuated the amplitude of N170 in response to fearful faces, but not neutral faces, which suggests

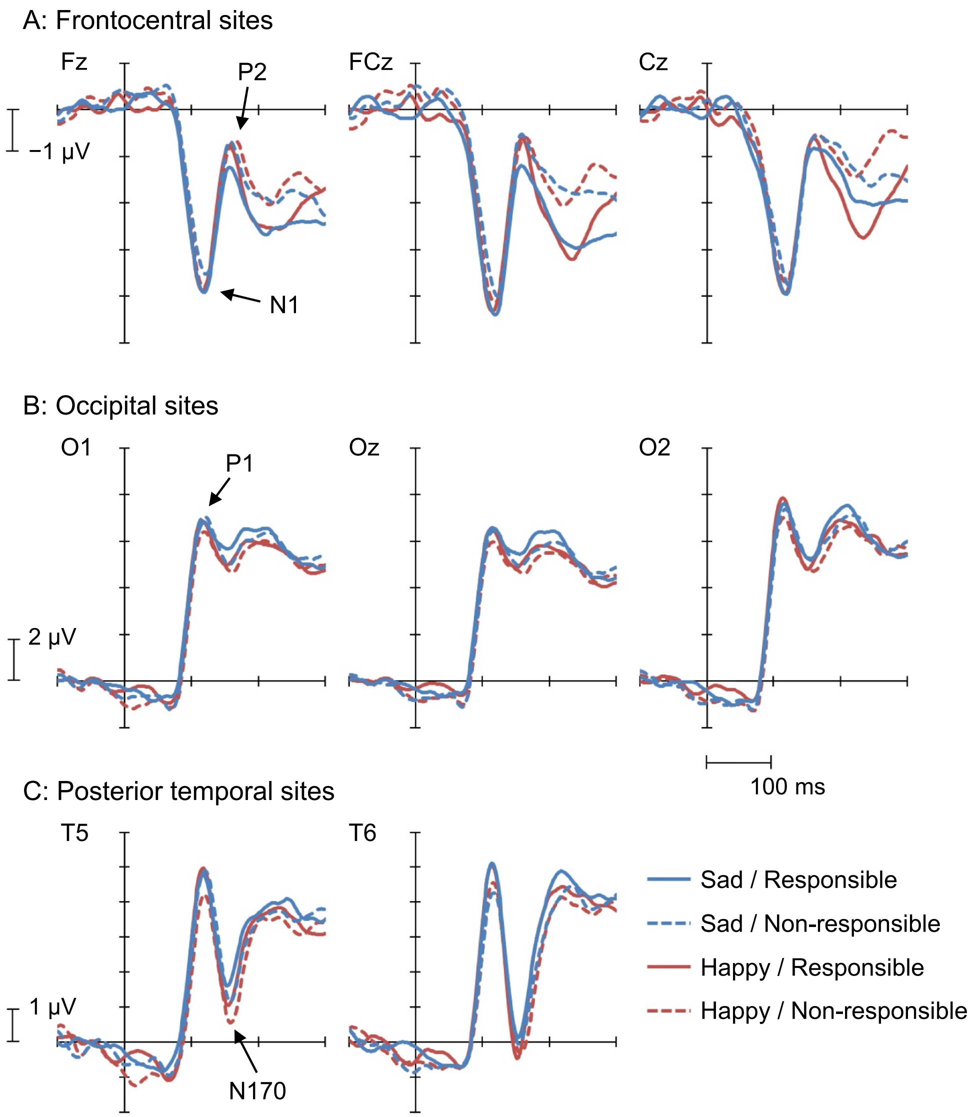

Fig. 2. ERP waves depicting the responsibility effect for sad and happy faces at selected electrodes at (A) frontocentral, (B) occipital, and (C) posterior temporal sites.

Table 1
Means and standard deviations for the amplitude of the early components of event-related potentials in response to sad and happy faces in the responsible and non-responsible conditions (μV).

		Sad faces				Happy faces			
		R		NR		R		NR	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Frontocentral sites									
N1 (90–170 ms)	Fz	−4.46	1.78	−4.14	1.29	−4.60	1.97	−4.50	1.67
	FCz	−5.06	1.95	−4.67	1.51	−5.12	2.08	−4.92	1.88
	Cz	−4.73	1.89	−4.44	1.70	−4.70	1.64	−4.41	1.76
P2 (120–220 ms)	Fz	3.82	1.75	4.19	1.90	4.50	1.77	4.53	1.87
	FCz	4.72	2.00	5.07	2.11	5.15	2.03	5.09	2.01
	Cz	5.08	1.97	5.22	1.80	4.95	1.92	4.93	1.80
Occipital sites									
P1 (90–170 ms)	Oz	8.00	3.33	7.86	3.35	8.10	3.55	7.70	3.67
	O1	8.01	2.80	8.34	3.19	8.38	3.13	7.84	3.48
	O2	9.13	4.13	9.12	3.73	9.46	3.94	8.89	4.32
Posterior temporal sites									
N170 (120–220 ms)	T5	−4.68	3.86	−5.66	4.25	−6.19	3.97	−5.58	4.45
	T6	−6.38	4.70	−6.32	4.58	−7.01	4.33	−7.03	4.71

Note. R = responsible condition; NR = non-responsible condition.

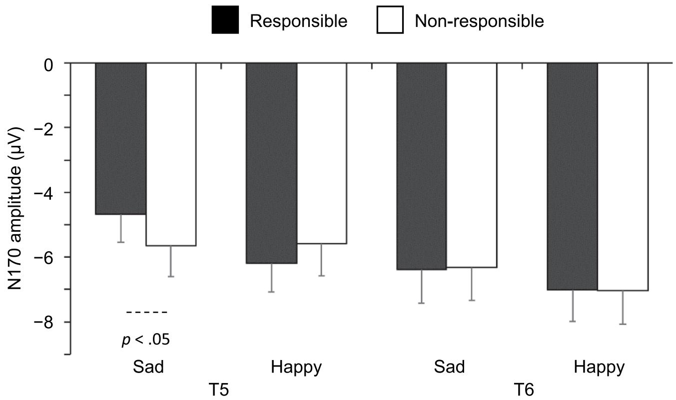

Fig. 3. Mean amplitudes of N170 at T5 and T6 electrodes in response to sad and happy faces in the responsible and non-responsible conditions. Error bars represent standard errors.

that emotional stimuli are subject to greater attenuation than non-emotional stimuli (Hughes, 2015). In our decision-making task, an employee's social position was greatly affected by a decision for dismissal, and maintained by a decision for non-dismissal. In this sense, the employees' sad faces caused by the participant's dismissal decision might be more salient than their happy faces caused by a non-dismissal decision. In addition, our decision-making task created a moral dilemma of whether or not participants should directly affect other individuals to sacrifice them for the greater good. Previous studies using moral dilemma tasks have indicated that utilitarian decisions that have a direct adverse impact on others are higher in emotional saliency and less likely to be endorsed than those that have an indirect impact on others (Greene et al., 2001; Koenigs et al., 2007). Furthermore, it has been suggested that such rational, but emotionally aversive, decisions are prompted by cognitive control (Greene et al., 2008). Hence, it is conceivable that the sense of self-control plays a greater role in decisions that will have a negative effect on others than in decisions that have a positive effect, which might result in the N170-attenuation effect for sad faces, but not for happy faces.

These possibilities are only speculative because, unfortunately, we did not evaluate whether the goal of the current decision-making task varied the intentions of dismissal and non-dismissal decisions and/or the impacts of sad and happy faces. In addition, if these factors are keys to explain the present results, different goals of decision-making would modulate the attenuation of N170 amplitude depending on the type of facial expression. For instance, instead of the scenario in the present study that required participants to make decisions that caused others distress (firing employees who wish not to be fired), some other scenario that encouraged participants to make decisions that would give pleasure to others (e.g., hiring employees among job seekers) might attenuate the amplitude of N170, especially for happy faces.

We did not find any effects of responsibility on the amplitudes of ERPs other than N170, which suggests that there may be considerable differences between individual participants. To interpret individual differences in the self-specific attenuation effect on the processing of facial expressions, we hypothesized that the prediction that one's goal-directed behavior has an adverse impact on others is inhibited by Machiavellianism, an antisocial personality trait. Supporting this hypothesis, Machiavellianism, as measured by the self-report questionnaire, moderated the attenuation effects of responsibility on the visual N1 and P2 components, especially for a model's sad face. The N1 and P2 components have been analyzed as neural markers of the sensory attenuation of self-generated stimuli (for a review, see Horváth, 2015; Hughes et al., 2013), but several studies have demonstrated that the N1- and P2-attenuation effects can be functionally dissociated. Some findings highlight that N1-attenuation reflects the attenuation of automatic responses to self-generated stimuli, while P2-attenuation involves the more conscious detection of these stimuli (Knolle et al., 2013a; Sanmiguel et al., 2013). According to this view, the present findings suggest that Machiavellianism negatively influences the lower-level processing of the effect of one's own harsh behavior on others, which extends to higher-level processing. Especially, several studies have indicated that there is a relationship between P2 and the sense of agency (Timm et al., 2016; Weller et al., 2017). Therefore, although we did not assess the sense of self-attribution in the present tasks, Machiavellians might have a greater tendency to attribute others' sad expressions to factors other than their own decision regarding dismissal such as the company's circumstances.

In contrast, Machiavellianism was related to an enhanced self-specific attenuation effect on the amplitudes of occipital P1 and frontal P2 for other's happiness. The self-specific attenuation effect on the amplitude of visual P1 has not been reported previously (Hughes, 2015; Hughes and Waszak, 2011; Schäfer and Marcus, 1973), but predictable affective images have been shown to reduce the activity of the occipital visual cortex at around 120 ms compared to unpredictable images (Onoda et al., 2006). Accordingly, Machiavellianism may enhance the short-cutting of the early processing of happy faces that can be predicted by one's own behaviors. Furthermore, Machiavellianism was mildly correlated to the attenuation effect of responsibility on N170, negatively for sad faces, but positively for happy faces. The change in correlational patterns depending on affective valence resembles the previous finding of the effect of a self-serving attribution bias for ERPs in response to positive and negative outcomes (Gentsch et al., 2015). Previous studies have indicated that there are relationships between self-serving attributions and narcissism (Rhodewalt and Morf, 1998) and the callous-unemotional elements of psychopathy (Van Leeuwen et al., 2014). Machiavellianism is regarded as a member of the Dark Triad, along with narcissism and psychopathy, and they share a conceptual resemblance (Paulhus and Williams, 2002). Our findings support the relationship between such socially undesirable personality traits and self-serving attribution biases.

However, because the sample size for our correlation analyses (n = 18) was not large enough to obtain reliable results, several non-significant results have a high possibility of Type II error. In particular,

Table 2
Results of analysis of variance for the amplitude of the early components of event-related potentials.

	Frontocentral sites N1 (90–170 ms)			P2 (120–220 ms)			Occipital sites P1 (90–170 ms)			Posterior temporal sites N170 (120–220 ms)		
	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
Responsibility	1.03	0.32	0.05	0.76	0.39	0.04	1.49	0.24	0.07	0.16	0.69	0.01
Facial expression	0.56	0.46	0.03	1.17	0.29	0.06	< 0.01	0.96	< 0.01	**8.53**	**0.01**	**0.31**
Electrode	2.44	0.12	0.11	**9.68**	**< 0.01**	**0.34**	**5.54**	**0.01**	**0.23**	0.96	0.34	0.05
Responsibility × Facial expression	0.12	0.74	0.01	0.91	0.35	0.05	2.16	0.16	0.10	3.98	0.06	0.17
Responsibility × Electrode	0.09	0.91	< 0.01	0.37	0.62	0.02	0.35	0.61	0.02	0.20	0.66	0.01
Facial expression × Electrode	1.14	0.33	0.06	**18.08**	**< 0.01**	**0.49**	0.27	0.77	0.01	0.02	0.89	< 0.01
Responsibility × Facial expression × Electrode	0.22	0.80	0.01	0.18	0.75	0.01	**3.16**	**0.05**	**0.14**	**10.55**	**< 0.01**	**0.36**

Note. Significant effects are indicated in bold.

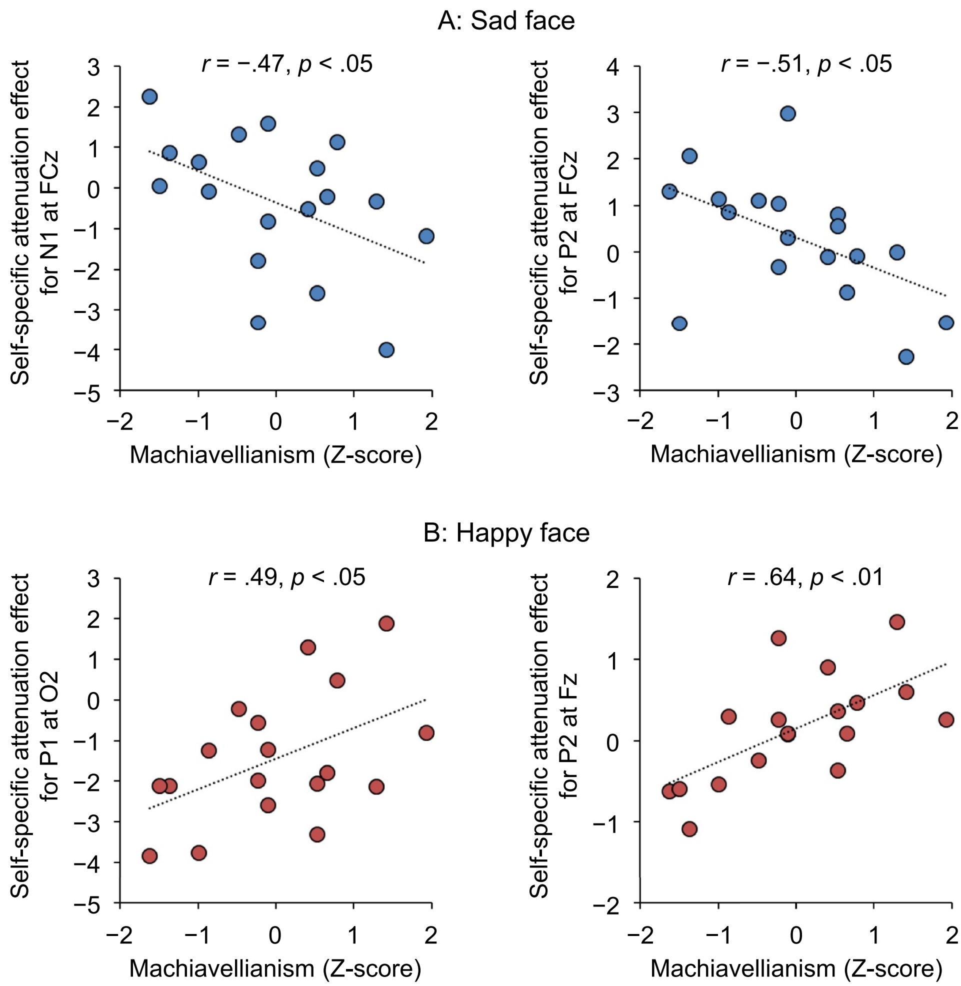

Fig. 4. Scatter plots depicting the significant correlations between Machiavellianism and the magnitudes of the self-specific attenuation effect for (A) sad and (B) happy faces. The polarity of the value is not equal to that of the ERP components. More positive values indicate greater magnitudes of attenuation in the responsible relative to the non-responsible condition.

Table 3
Pearson's correlation coefficients between Machiavellianism and the magnitude of the self-specific attenuation effect on the early components of event-related potentials in response to sad and happy faces.

		Sad faces			Happy faces		
		r	*p*	95% CI (Lower, Upper)	*r*	*p*	95% CI (Lower, Upper)
Frontocentral sites							
N1	Fz	−0.44	0.07	−0.75, 0.03	0.44	0.07	−0.04, 0.75
	FCz	**−0.47**	**0.05**	**−0.77, −0.00**	0.23	0.35	−0.26, 0.63
	Cz	−0.43	0.07	−0.75, 0.04	0.05	0.83	−0.42, 0.51
P2	Fz	−0.19	0.45	−0.60, 0.30	**0.64**	**< 0.01**	**0.25, 0.85**
	FCz	**−0.51**	**0.03**	**−0.79, −0.05**	0.26	0.29	−0.23, 0.65
	Cz	−0.31	0.22	−0.68, 0.19	0.14	0.59	−0.35, 0.57
Occipital sites							
P1	Oz	−0.22	0.39	−0.62, 0.28	0.38	0.12	−0.10, 0.72
	O1	−0.03	0.90	−0.49, 0.44	0.40	0.10	−0.09, 0.73
	O2	−0.24	0.35	−0.63, 0.26	**0.49**	**0.04**	**0.02, 0.78**
Posterior temporal sites							
N170	T5	−0.45	0.06	−0.76, 0.02	0.20	0.44	−0.30, 0.61
	T6	−0.10	0.69	−0.54, 0.38	0.42	0.08	−0.05, 0.74

Note. Positive and negative correlations indicate that high levels of Machiavellianism are associated with increased and decreased attenuation of the ERP components, respectively. Significant correlations are indicated in bold.

the correlations between Machiavellianism and N170-attenuation effects for sad faces and happy faces were not statistically significant. For these correlations, the coefficient of statistical power $(1-\beta)$ was 0.49 for sad faces (T5) and 0.43 for happy faces (T6). These values are clearly less than 0.80, a recommended power value (Cohen, 1988). Such ambiguous results for correlations due to the small sample size are an important limitation. The use of larger samples might reveal divergent relationships between Machiavellianism and self-specific attenuation effect for sad and happy faces.

Other limitations should be noted. First, due to the absence of subjective reports on the sense of responsibility or self-attribution, interpretations of the results are speculative. Second, we used a cover story to add context to the presentation of other's facial expressions and to emphasize responsibility for other's emotions, but hypothetical situations may not have as much of an impact as real events. Third, although the present study provides biological evidence for a distorted cognition related to antisocial personality, Machiavellianism is just one sort of antisocial personality trait. Moreover, since we recruited participants from a subclinical population, it is unclear whether our findings can be applied to clinical or criminal populations. Subclinical analogs of psychiatric disorders are helpful for enhancing our understanding of these disorders, but data from subclinical populations may have less of an effect than those from psychiatric populations. The self-specific attenuation effects on the early ERPs in response to social stimuli may be more explicitly modulated by antisocial personality in psychiatric or criminal populations. Further studies will be needed to clarify the details of the cognitive abnormality in individuals with an antisocial personality.

Despite these limitations, the present study provides ERP evidence for the attenuation of the early processing of social stimuli, especially for the case of others' emotional feedback regarding one's social decision-making. Our findings support the possibility that the self-specific attenuation effect is apparent not only for simple sensory outcomes, but also for meaningful feedback from others. Action–outcome prediction based on internal forward models would play an important role in adaptive interpersonal interactions. In addition, we provided an important implication for the neural representation of an underlying cognitive bias of antisocial personality. To assemble further evidence, future studies should investigate the relationship between the self-specific attenuation effect and various patterns of attribution error for social and emotional events that are specific to patients with personality and other mental disorders.

Conflict of interest

No potential conflict of interest was reported by the authors.

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