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The Influence of Social Rejection on Cognitive Control

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Abstract

Social exclusion has a broad effect on individuals, including basic cognitive function, emotion and behaviour. Studies using the Cyberball game showed that social exclusion influenced executive control. However, the effects of different paradigms on subjects are different. The present study aimed to explore the effect of social exclusion through the life-alone paradigm. Participants were required to complete a questionnaire, and then they randomly received fake feedback (lonely or happy) about their future social lives. To test the cognitive control of the two groups, event related potential (ERP) was recorded when participants completed a letter flanker task. The results showed that compared with included subjects, excluded subjects had a larger congruency effect and showed a smaller N2 component in both congruent and incongruent trials; additionally, they did not show a larger P3 effect in incongruent compared to congruent trials. These results indicated that social exclusion decreased subjects' cognitive control ability, including conflict detection and response inhibition. Time-frequency results found that ERSP magnitudes of the alpha band were significantly smaller in incongruent than congruent trials for included participants, but this was not the case for excluded subjects. This finding suggested that excluded subjects might have no available resources to resolve conflict in incongruent trials. Further, compared to the ostracism paradigm, future rejection led to a decline in conflict detection ability.

Keywords

Social Rejection, Executive Function, Conflict Detection, N2, P3, Alpha Band

1. Introduction

Social exclusion refers to the process in which an individual is rejected by others or other organizations, and the individual's need to belong or relatedness is blocked (Twenge, Catanese, & Baumeister, 2002). Almost everyone has had the experience of being refused. For example, one has been refused during physical activities or received a rejection letter from an editor. Numerous studies have found that social exclusion can lead to aggression and impulsive behaviour (Leary, Twenge & Quinlivan, 2006). For example, when given a chance, an excluded individual would make innocent people eat more chili sauce (Warburton, Williams, & Cairns, 2006) or make them listen to longer and louder sounds (Twenge, Baumeister, Tice, & Stucke, 2001). Excluded adolescents also showed greater behavioural risk-taking if they had a low ability to resist peer influence (Peake, Dishion, Stormshak, Moore, & Pfeifer, 2013). In addition, social exclusion damaged self-regulation skills (Baumeister, DeWall, Ciarocco, & Twenge, 2005) and overall cognitive function (Baumeister, Twenge, & Nuss, 2002). For example, excluded individuals ate more cookies and could not focus on a frustrating task (Baumeister et al., 2005). Excluded individuals also showed decreased logical thinking (Campbell et al., 2006). Executive function modulates this behaviour and thinking. Executive function is also called cognitive control, and it is used to accomplish goal-directed behaviours by monitoring interference or response conflict and dynamically adjusting performance (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Egner, 2011). Thus, researchers inferred that aggression- and impulsive behaviour-induced social exclusion is linked to the decline of executive function (Otten & Jonas, 2013).

Researchers then began to explore the effect of social exclusion on executive function and made some progress. Jamieson, Harkins, and Williams (2010) used the antisaccade task and measured the response inhibition ability of rejected and accepted individuals; the results showed that inhibition ability was lower for the rejected individuals. Otten and Jonas (2013), using event-related potential (ERP) technology to measure electrical activity when the subjects completed the Go/No Go task, found that there was no difference in behaviour between excluded and included subjects, but in the ERP component, excluded subjects showed a stronger response in conflict monitoring and a worse response in inhibition ability. Another study with magnetoencephalography (MEG) found that compared with control subjects, the social exclusion group showed decreased activities in the parietal and right prefrontal lobes, which are the vital brain regions in executive function (Campbell et al., 2006). All of these studies showed that social exclusion influenced executive control.

It is worth noting that all of these studies used the Cyberball game, which is categorized as an ostracism paradigm (Gerber & Wheeler, 2009). Gerber and Wheeler (2009) classified the social exclusion paradigms into four types: ostracism, demarcated rejection, future rejection, and reliving rejection. These different paradigms have different effects on participants. For example, through a meta-analysis of 88 studies, Gerber and Wheeler (2009) found that the ostracism paradigm increased individuals' arousal level, but the other three types of exclusion paradigms did not impact the arousal level. The arousal level might influence subjects' executive function, especially conflict monitoring. The ACC, which acts as a conflict monitor, has been shown to be involved in alertness-related modulation (Yanaka, Saito, Uchiyama, & Sadato, 2010), and phasic alertness can modulate conflict adaptation and feature integration in the flanker task (Liu, Yang, Chen, Huang, & Chen, 2013). Therefore, the influence of social exclusion on participants' conflict detection ability might be different when adopting other social exclusion paradigms. Thus, we use the life-alone paradigm (Twenge et al., 2001), which is categorized as the future rejection paradigm, to explore the effect of social exclusion on executive function.

Additionally, we used a letter flanker task to measure the cognitive control of participants. In the flanker task, subjects typically respond more slowly to incongruent than to congruent trials, which reflects the level of cognitive control (Wang et al., 2014). Previous ERP studies have revealed the following two processes of cognitive control: conflict detection and the response inhibitory processes. The conflict detection process is represented by the fronto-central N2 component (van Veen & Carter, 2002), which is a negative potential that peaks at approximately 200 ms after stimuli onset and is larger in incongruent trials than in congruent trials (Folstein & Van Petten, 2008; Yeung, Botvinick, & Cohen, 2004). The response inhibitory process is represented by the P3 component (Nee, Wager, & Jonides, 2007), which is a positive potential at approximately 300 ms and is also larger in incongruent trials than in congruent trials (Fruhholz, Godde, Finke, & Herrmann, 2011).

The ERP approach has utility in detecting scalp evoked activities, which are time- and phase-locked to experimental events (e.g., presenting a visual stimulus). However, there are also induced activities that are time- but not phase-locked to the onset of a stimulus or a response (Makeig, Debener, Onton, & Delorme, 2004). These activities can be detected via spectral analysis methods, which exhibit rhythmic oscillations within different frequency bands (L. Wang et al., 2015). Different EEG frequency bands are thought to underlie a particular cognitive process (Pandey et al., 2016). For instance, the alpha band has been shown to be linked with relaxed or mentally drowsy states, so it can serve as an inverse neural indicator of mental alertness or arousal (Carp & Compton, 2009). Additionally, studies have shown that the alpha band reflects modulation to attention demand allocation (Pandey et al., 2016) and attention orienting (van Ede, de Lange, Jensen, & Maris, 2011).

We therefore recorded the EEG when participants were completing a letter flanker task to explore how exclusion affects cognitive control. The amplitude differences in N2 and P3 components between included and excluded subjects will reflect the influences of social exclusion on the two stages of the cognitive control process. More precisely, if social exclusion affects the conflict detection process, there will be a difference in the N2 component between excluded and included participants; if social exclusion influences the response inhibitory process, the P3 component will show a difference between the two groups. We also adopted the time-frequency analysis approach, which is a data-driven method, to explore the differences in neural oscillation between excluded and included subjects when they were completing the flanker task.

2. Material and Methods

2.1. Subjects

Thirty paid volunteers (16 women, 14 men) aged 18 - 22 years (mean age, 19.6 years) participated in the experiment. They were undergraduate students from a university in China. All participants were right-handed and had normal or corrected-to-normal vision.

2.2. Stimuli and Procedures

Participants first completed the Revised Eysenck Personality Questionnaire Short Scale for Chinese (EPQ-RSC), which is a Chinese version of the Eysenck Personality Questionnaire (Qian, Wu, Zhu, & Zhang, 2000). To obtain credibility, the experimenter provided accurate feedback in response to the questionnaires. Then, the social exclusion was manipulated by providing participants bogus feedback about their future social lives. For the included condition, the participant was told, "You're the type who has rewarding relationships throughout life. You're likely to have a long and stable marriage and have friendships that will last into your later years. The odds are that you'll always have friends and people who care about you" (Twenge et al., 2001). In contrast, people in the excluded condition were told, "You're the type who will end up alone later in life. You may have friends and relationships now, but by your mid-20s most of these will have drifted away. You may even marry or have several marriages, but these are likely to be short-lived and not continue into your 30s. Relationships don't last, and when you're past the age where people are constantly forming new relationships, the odds are you'll end up being alone more and more." (Twenge et al., 2001).

After the feedback about the future, participants completed a flanker task, during which brain electrical activity was recorded. In each trial, five letters were presented in a line: the central one was the target, and the remaining letters were the flankers. Four letters (S, H, N and P) were employed in the task, and each letter could be a target or a flanker. In the congruent trials, the flankers were identical to the target (for example, SSSSS), and in the incongruent trials, the flankers were mapped onto a different response hand to the target stimulus (for example, SSNSS). Participants were instructed to press the key that corresponded to the central letter. Responses were made with one of four different fingers (left middle finger, left index finger, right index finger and right middle finger). The four responses corresponding to each letter were counterbalanced across the subjects.

The flanker task consisted of 3 blocks, and each block comprised 97 trials. Stimuli were presented in a random order in which the number of congruent and incongruent trials was counterbalanced. A trial began with a 300-ms fixation display. Then, the letters were presented for 200 ms in the centre of screen.

Then, a blank screen was presented for 1500 ms, and participants were instructed to press the corresponding key during this period as quickly and accurately as possible. After another blank screen appeared for 1000 ms, the next trial started.

After the flanker task, participants were told that the feedback about their extraversion score were true but that the feedback about their future lives was a randomly assigned description. The experimenter also apologized for giving the random feedback.

2.3. Electrophysiological Recording

Brain electrical activity was recorded with a Brain Products ERP workstation. Ag/AgCl electrodes with 64 scalp sites fixed in a conductive cap were used; a reference electrode recorded the bilateral mastoid. The vertical electrooculogram (VEOG) was recorded with electrodes placed above and below the left eye. The impedance between the scalp and electrode is less than 5 kΩ. The signals were amplified using amplifier amplification, with a bandpass of 0.05 - 100 Hz and a continuously sampling frequency of 500 Hz/channel. The off-line analysis would reject all types of artefacts, including eye movement artefacts and amplifier clipping artefacts.

2.4. ERP Analysis

EEGs of congruent trials and incongruent trials were separately overlapped and averaged for both excluded and included participants. The epoch for ERP was started 200 ms before and ended 1000 ms after the onset of the letter arrays (**Figure 1**). The baseline was defined as the 200 ms that preceded the letter onset. Trials with incorrect responses were excluded, and at least 50 trials remained in each condition. Repeated-measure ANOVAs were used to compare the ERPs to congruent trials and incongruent trials in excluded and included participants, with congruency (congruent vs. incongruent) as a within-subjects factor, and exclusion (excluded vs included) as a between-subjects factor. For all analyses, p-values were corrected according to the Greenhouse-Geisser method for repeated-measures effects.

2.5. Time-Frequency Analysis

For time-frequency analysis, the preprocessing Brain Vision Analyzer 2.0 (Brain Products GmbH, Germany) and EEGLAB (Delorme & Makeig, 2004) procedures were used. The concrete procedure has been described previously (Wang et al., 2015). Due to the different stimulus material, the baseline interval of the present study was the time window of 450 to 50 ms before the appearance of the letters. We identified the spatial region of interest (S-ROI) and time-frequency region of interest (TF-ROI). Using an exploratory data-driven approach, we identified the fronto-central region [(Fz+FCz+Cz)/3] as a spatial region of interest (S-ROI) according to the scalp topographies (**Figure 2**) and the alpha band (8 - 13 Hz in frequency, 500 - 850 ms in latency) as a time-

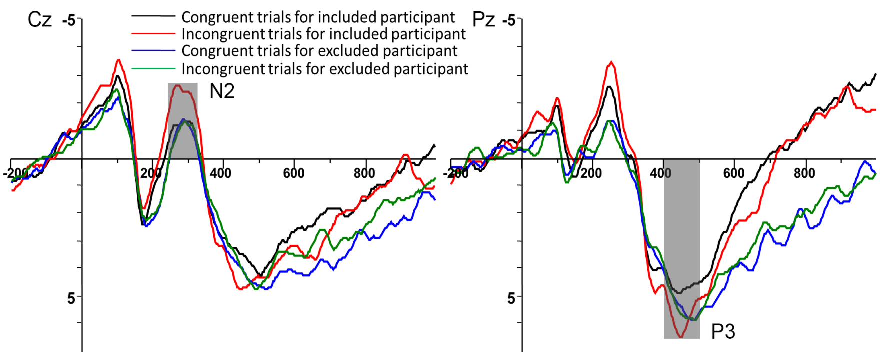

Figure 1. The scalp topographies reflecting the ERSP magnitude distributions of each condition within the defined TF-ROI (alpha band, 8 - 13 Hz in frequency, 500 - 850 ms in latency).

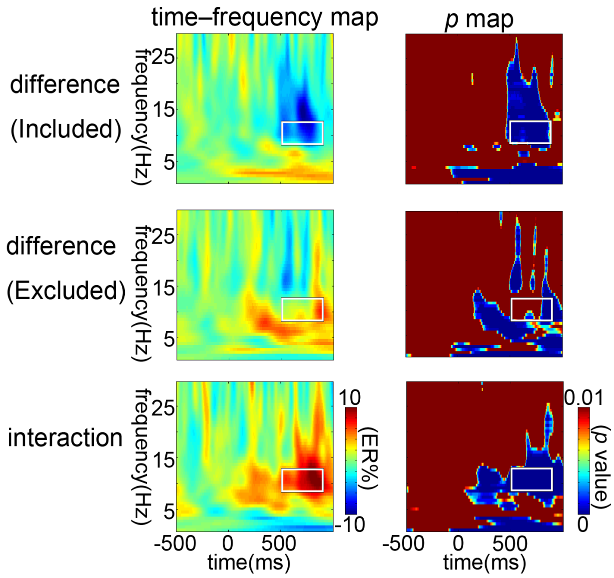

Figure 2. The grand-averaged time-frequency representations of the power difference (incongruent minus congruent) for the two groups and the interaction between exclusion and congruency within the fronto-central region [(Fz+FCz+Cz)/3]. The results of corresponding bootstrapping statistical analyses at the significance level of $p < 0.01$ (FDR corrected). The time-frequency pixels that exhibit a significant difference from the baseline are coloured in blue. The significant task-related TF-ROIs are outlined in the rectangles.

frequency region of interest (TF-ROI) according to the *p* map of interaction (**Figure 3**).

3. Results

3.1. Behavioural Data

The mean accuracies of congruent trials and incongruent trials were 95.9% ± 0.8% and 94.9% ± 1.2%, respectively, for included participants and 94.9% ± 0.8%

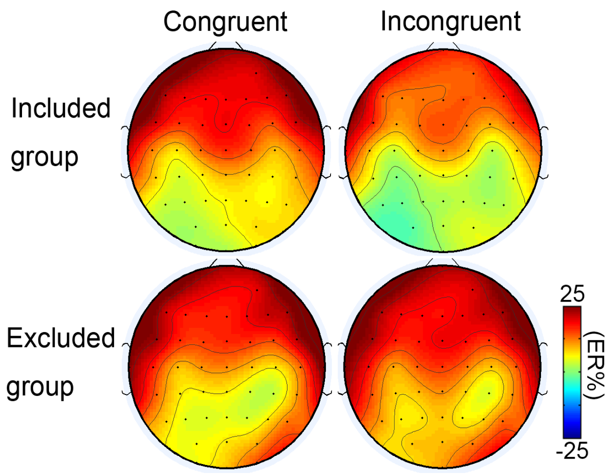

Figure 3. ERPs of congruent and incongruent trials for excluded and included participants.

and 92.2% ± 1.2%, respectively, for excluded participants. The mean RTs of congruent trials and incongruent trials were 523.8 ± 26.9 ms and 550.2 ± 29 ms, respectively, for the included participants and 525.3 ± 26.9 ms and 578.6 ± 29 ms, respectively, for the excluded participants. Repeated-measures analyses of variance (ANOVA) for mean accuracy and mean RTs showed that the main effects of congruency were significant (accuracy: $F(1, 28) = 9.18$, $p < 0.01$; RTs: $F(1, 28) = 57.26$, $p < 0.001$). There was no significant difference in mean accuracy or mean RTs between the included and excluded groups (accuracy: $F(1, 28) = 2.10$, $p > 0.05$; RTs: $F(1, 29) = 0.15$, $p > 0.05$). The interaction effect between the congruency and incongruency groups for RTs was significant ($F(1, 29) = 6.54$, $p < 0.05$), and the interaction between them for accuracy was not significant ($F(1, 28) = 1.98$, $p > 0.05$). A post hoc analysis for mean RTs was conducted and showed that there were significant congruency effects (the difference between incongruent and congruent trials) in the two groups, which were larger for excluded participants (mean = 53.31, $p < 0.001$) than for included participants (mean = 26.38, $p < 0.01$).

3.2. ERP Results

As shown in **Figure 1**, compared to congruent trials, incongruent trials evoked a larger negative potential between 250 and 300 ms after stimulus onset at the front-central site, which was the classical N2 component. Subsequently, a larger P3 component between 450 and 500 ms at the parietal lobe was evoked by incongruent trials compared to congruent trials. This finding clearly shows that the neural response patterns of cognitive control include two stages: conflict detection (N2) and response inhibition (P3).

Statistical analysis for the amplitude of N2, which was defined as the largest negative deflection within 250 - 300 ms post-stimulus onset, was carried out by means of repeated measures ANOVA with congruency (congruent vs. incongruent) and electrode (Fz, FCz and Cz) as within-subjects factors, and exclusion (excluded vs. included) as a between-subjects factor. The results showed that the main effect of congruency was significant (F (1, 28) = 4.92, $p < 0.05$) and that the main effect of exclusion was significant (F (1, 28) = 8.97, $p < 0.01$). There were no other significant main effects or interaction effects for the results of the N2 component.

Statistical analysis for the amplitude of P3, which was defined as the mean amplitude within 450 - 500 ms post-stimulus onset, was carried out by means of repeated measures ANOVA with congruency (congruent vs. incongruent) and electrode (Cz, CPz and Pz) as within-subjects factors and exclusion (excluded vs. included in Cyberball) as a between-subjects factor. The results showed that the main effect of congruency was significant (F (1, 29) = 31.18, $p < 0.001$), the main effect of electrode was significant (F (2, 56) = 13.23, $p < 0.001$) and the interaction between congruency and exclusion was significant (F (1, 28) = 10.65, $p < 0.05$). A post hoc analysis was conducted and showed that the difference between congruent and incongruent trials for included participants was significant ($p < 0.001$) but was not significant for excluded participants ($p > 0.05$). There were no other significant main effects or interaction effects in the results of the P3 component.

3.3. Time-Frequency Results

In the S-ROI [(Fz+FCz+Cz)/3], a time-frequency region of interest (TF-ROI) alpha band (8 - 13 Hz, 500 - 850 ms) showed the most pronounced task-related effect (in **Figure 3**, $p < 0.01$, FDR corrected). Statistical analysis for the ERSP magnitudes within the defined S-ROI was carried out by means of repeated measures ANOVA with congruency (congruent vs. incongruent) as a within-subjects factor and exclusion (excluded vs. included) as a between-subjects factor. The results show that the interaction between congruency and exclusion was significant (F (1, 28) = 5.94, $p < 0.05$). Post hoc tests revealed that for included participants, ERSP magnitudes were significantly smaller in incongruent trials than in congruent trials ($p < 0.01$), but this was not the case for excluded participants ($p > 0.05$).

4. Discussion

The purpose of this study was to explore the influence of social exclusion on cognitive control process. Behavioural results found that compared with included subjects, excluded subjects showed a larger congruency effect, which indicated that exclusion might decrease subjects' cognitive control. ERP results showed that compared with included subjects, the N2 component was smaller for excluded subjects in both congruent and incongruent trials, which indicated decreased neural responses to a conflict detection process. In addition, excluded subjects did not show a larger P3 effect in incongruent trials compared to congruent trials, which suggested that they did not attempt to inhibit the flanker stimuli. The time-frequency results found that ERSP magnitudes of the alpha band were significantly smaller in incongruent trials than in congruent trials for included participants, but this was not the case for excluded participants. Overall, social exclusion altered subjects' cognitive control and its neural response pattern.

We found a smaller N2 component for excluded subjects in both congruent and incongruent trials, which suggested that excluded subjects had decreased conflict detection. This finding is not consistent with a previous study (Otten & Jonas, 2013), which showed an increased conflict detection for excluded subjects. In their study, social exclusion was manipulated by the ostracism paradigm (Cyberball game), which could increase individuals' arousal levels. Additionally, the arousal level could improve subjects' conflict detection (Liu et al., 2013). However, the present study adopted the paradigm of future rejection, which did not alter subjects' arousal levels and led to a decline in conflict detection, which might be a purer effect of social exclusion on conflict detection. Actually, when being excluded, participants entered into a cognitive deconstructed state, which protected them against the negative experience of social exclusion (Twenge, Catanese, & Baumeister, 2003). The cognitive deconstructed state is characterized by a lack of emotion (Baumeister et al., 2002), lethargic behaviour (Schaafsma et al., 2015), and altered time perception (Twenge et al., 2003). Specifically, the smaller N2 in both congruent and incongruent trials might reflect the lethargy state of excluded subjects. In addition, after being excluded, participants needed to address the negative experiences, which would deplete the limited cognitive resources (Fishbach, Friedman, & Kruglanski, 2003). An imaging study has shown that social exclusion activates the anterior cingulate cortex (ACC), which is also involved in conflict detection (Eisenberger, Lieberman, & Williams, 2003). Therefore, the smaller N2 of excluded participants also reflected the lack of resources available to monitor conflicts.

The absence of a P3 effect for excluded participants indicated that they might not attempt to inhibit the flanker stimuli or that they had decreased response inhibition. This is in accordance with a previous study: Otten and Jonas (2013) found that an excluded participant showed a smaller P3 effect in a Go/No Go task. In another imaging study (Campbell et al., 2006), excluded participants showed decreased activation in the parietal and right prefrontal lobe, which are involved in the response inhibition process. After being excluded, people might enter into a cognitive deconstructed state and do not attempt to inhibit the flanker stimuli. Additionally, in order to address the negative experiences of social exclusion, the resources available to control the response conflict were consumed. Therefore, there was no motivation or resources for excluded subjects to inhibit the response conflict. This was also reflected by the behavioural results in the present study: excluded subjects showed a larger congruency effect compared to included subjects.

Compared to congruent trials, incongruent trials showed a significant alpha reduction for included participants, but this was not the case for excluded participants. The alpha band has been reported to be linked to mental arousal (Carp

& Compton, 2009) and attention processes (Kelly, Lalor, Reilly, & Foxe, 2006). As an inverse neural indicator, a reduced alpha power reflected the increasing demand of attention or mental arousal (Wang et al., 2015). For example, when completing a visual spatial attention task, subjects showed a decreased alpha in the attended location and an increased alpha in the ignored location (Kelly et al., 2006; Sauseng et al., 2005). In addition, the warning cue, which signals an impending stimulus, triggered a reduced alpha power (Yordanova, Kolev, & Başar, 1998). In the flanker task, more attention and mental effort is required to inhibit the flanker interference in the incongruent trials compared with the congruent trials. Therefore, decreased alpha power was observed in included subjects. However, for excluded subjects, there was no significant difference in alpha power between incongruent and congruent trials. This indicated that excluded subjects did not exert attention resources or had no available resources to resolve the conflict in incongruent trials.

5. Conclusion

In conclusion, the present study found that when adopting a future rejection paradigm, excluded subjects showed a larger congruency effect, a smaller N2 component, an absent P3 effect and alpha reduction in the flanker task. These results indicated that social exclusion decreased subjects' cognitive control, including conflict detection and response inhibition. In addition, this result indicated that compared to the ostracism paradigm, future rejection led to decreased conflict detection.

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Author Contributions

Ting conceived of the study, Hongmei collected and analysed the data, and Ting wrote the paper.

Conflict of Interest Statement

There are no conflicts of interest.

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